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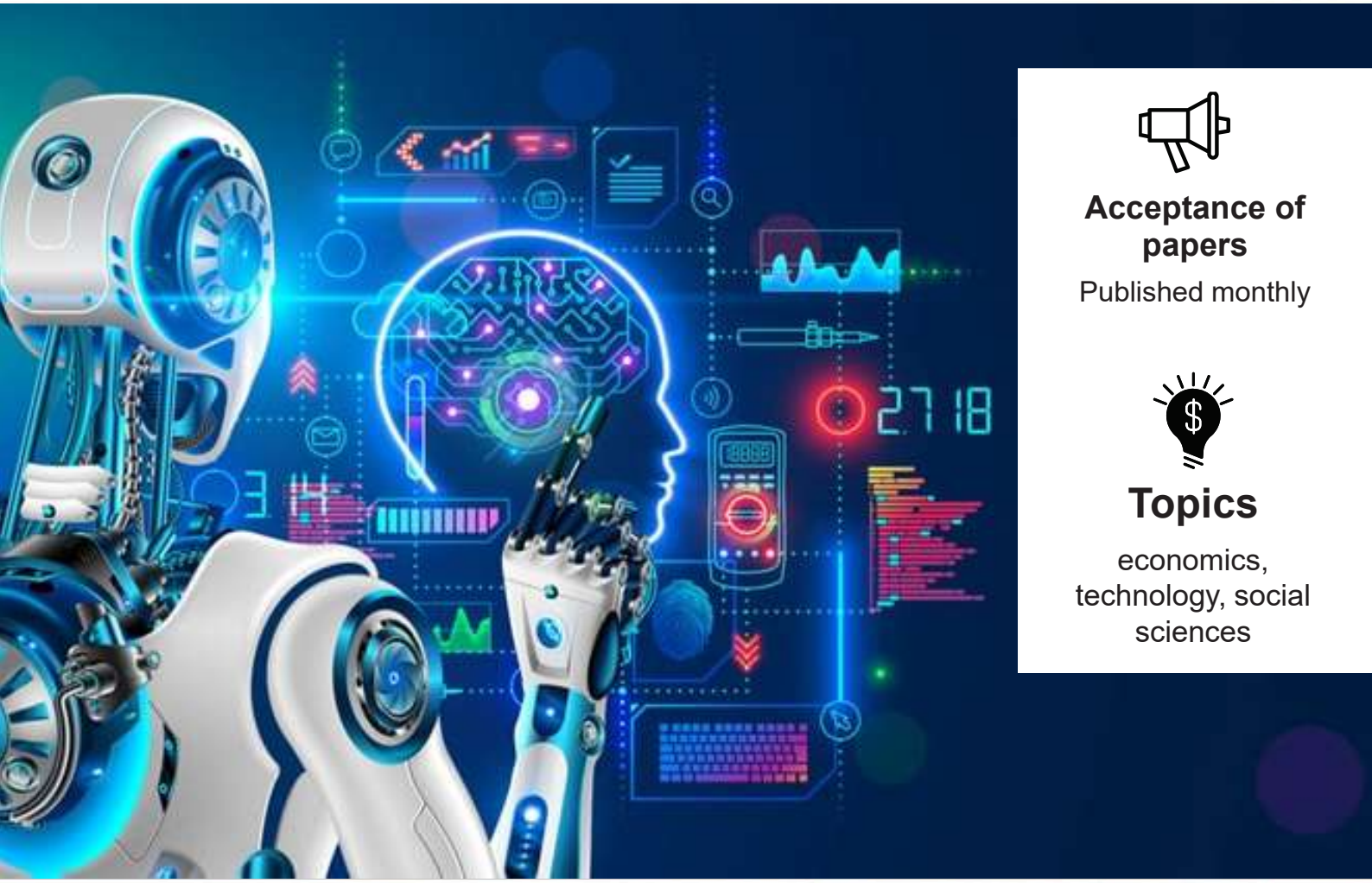

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THE THEORETICAL FOUNDATIONS OF APPLYING TAX INCENTIVES FOR INVESTMENTS DIRECTED TOWARD HUMAN CAPITAL

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Abstract: The state uses various tax incentives to develop human capital. From the perspective of human capital development, tax incentives are aimed at encouraging investments in education, healthcare, entrepreneurship, and improving living standards, which should ultimately lead to increased economic growth and competitiveness of the country. Insufficient financial resources, low efficiency of existing mechanisms, administrative barriers, low awareness, etc. In this article, the author classifies and analyzes the problems of using tax incentives for investments in human capital.

Key words: human capital, tax incentives, education, healthcare, innovative activities, investment, efficiency, income tax.

Annotatsiya: Davlat inson kapitalini rivojlantirish uchun turli xil soliq imtiyozlaridan foydalanadi. Inson kapitalini rivojlantirish nuqtayi nazardan soliq imtiyozlari ta'lim, sog'liqni saqlash, tadbirkorlik faoliyatini rivojlantirish va turmush darajasini oshirishga investitsiyalarni rag'batlantirishga qaratilgan bo'lib, bu pirovard natijada mamlakatning iqtisodiy o'sishi va raqobatbardoshligini oshirishga olib kelishi kerak. Moliyaviy resurslarning yetishmasligi, mavjud mexanizmlarning past samaradorligi, ma'muriy to'siqlar, past xabardorlik va boshqa omillar ushbu jarayonning samaradorligini pasaytirmoqda. Ushbu maqolada muallif inson kapitaliga yo'naltirilgan investitsiyalar uchun soliq imtiyozlaridan foydalanish muammolarini tasniflaydi va tahlil qiladi.

Kalit so'zlar: inson kapitali, soliq imtiyozlari, ta'lim, sog'liqni saqlash, innovatsion faoliyat, investitsiya, samaradorlik, daromad solig'i.

Аннотация: Государство использует различные налоговые льготы для развития человеческого капитала. С точки зрения развития человеческого капитала, налоговые льготы направлены на стимулирование инвестиций в образование, здравоохранение, предпринимательство и повышение уровня жизни, что в конечном итоге должно привести к ускорению экономического роста и повышению конкурентоспособности страны. Недостаток финансовых ресурсов, низкая эффективность существующих механизмов, административные барьеры, низкая информированность и т. д. В данной статье автор классифицирует и анализирует проблемы использования налоговых льгот для инвестиций в человеческий капитал.

Ключевые слова: человеческий капитал, налоговые льготы, образование, здравоохранение, инновации, инвестиции, эффективность, подоходный налог.

INTRODUCTION

The problems of applying tax incentives for the development of human capital are an important issue in the modern economy. Tax incentives can be an effective tool for developing human capital, but their application is often associated with a number of practical difficulties. In our country, the problems of applying tax incentives for the development of human capital can be classified as follows: economic problems, administrative problems, the social consequences of applying tax incentives, and problems related to obtaining information about tax incentives. This classification of problems in applying tax incentives for the development of human capital is necessary to better understand them, as well as to develop effective solutions for eliminating existing problems within the tax legislation and increasing the effectiveness of tax incentives aimed at developing human capital.

New developments in robotics and artificial intelligence are rapidly changing the ways people work and build their careers. Some scholars emphasize that technological unemployment poses a serious threat to the working-age population. This issue is further aggravated by the high spatial differentiation in the pace of introducing and adapting to new technologies, which may lead in the future to the formation of old industrial areas suffering from long-term high unemployment. Technological advances may also complement workers' skills, leading to changes in the composition of the employed population (by specialties and types of occupations). For instance, they contribute to the growth of the share of technical specialties in the labor market, which is clearly manifested in the rise in the number of IT specialists in Uzbekistan over the past five years.

In addition, the intensity of substitution efficiency may differ across professions and may depend on workers' qualifications [1]. Such discussions have led to a renewed academic interest in the important role of education and investments in human capital (hereafter referred to as HCI). Investments in human capital and a high level of education are the key to protecting workers from the negative effects of the third wave of automation. Moreover, the accumulation of human capital is closely related to income inequality and poverty levels in the process of economic development [2]. The accumulation of human capital has become a key factor in stimulating rapid economic growth [3].

REVIEW OF LITERATURE ON THE SUBJECT

Modern concepts of economic growth define the public sector as the main source of human capital accumulation. Issues of taxation of human capital have recently become a highly popular topic, since its development ensures sustainable economic growth. However, recognizing the importance of HCI does not guarantee the practical application of tax incentives for such investments, even in developed countries. The scientific community has not reached a consensus on the effectiveness of tax regulators aimed at developing HCI. Economists consider human capital to be the most important component of a nation's overall wealth, and their works contain conflicting views on how income tax affects the accumulation of human capital.

Issues related to the development of human capital are based on the works of foreign authors — G. Becker, R. I. Kapelyushnikov, A. Marshall, F. Neumann, R. M. Nureyev, W. Petty, A. Smith and others. These authors emphasize the importance of human capital in shaping a country's economy. Many researchers view human capital as a factor of economic growth and a factor of production; investments in human capital become a necessary condition for increasing human productivity in the process of performing labor activities.

R. V. Lavnik and M. V. Pyanova [4] highlight education and healthcare as the most prioritized areas for investing in human capital. Yu. V. Malkova [5] points out a wide range of tax instruments aimed at providing social support to certain groups of citizens. M. R. Pinskaya [6] emphasizes the relevance of professional income tax, which may cover every fourth working-age person. M. V. Pyanova [7] stresses that tax incentives for the development of education and healthcare are no less significant than direct budgetary expenditures in these areas. A. V. Tikhonova and A. Ya. Akulov [8] highlight the differences in existing tax incentives aimed at developing human capital in developed and developing countries. A. V. Tikhonova [9] identifies three directions of the influence of taxation on the formation of human capital: maintaining the current level of the human capital index, ensuring individual and corporate investments in human capital.

While King and Rebelo [10] identified a strong negative effect of taxation (particularly an increase in the tax burden) on human capital accumulation, other studies show that its impact is insignificant [11]. The effect of income tax primarily depends on the specifications of the technology for producing human capital. Differences in technological characteristics are explained by the influence of time allocated by a citizen for human capital accumulation, government expenditures on producing human capital, and the level of parental human capital. Thus, in the first specification, only time costs of education (arising in the case of free education) are taken into account, while in the second — both time and financial costs (arising in the case of paid education). When

time is the only input in the education technology, the decrease in net wages resulting from the application of a progressive income tax rate affects a citizen's economic benefits and the costs of investing in human capital equally. In this case, income tax does not actually affect the accumulation of human capital. However, if an individual's financial resources are invested in producing human capital, the income tax becomes an important factor influencing HCI. A review of the literature on this issue demonstrated the existence of both highly unrealistic proposals and very precise practical recommendations.

Pyanova and Lavnik conclude that the increase in tax incentives directed toward investments in human capital significantly exceeds the growth in indicators such as the population's education level, employment, income, and life expectancy, which indicates the low efficiency of the tax regulation tools being applied [12].

RESEARCH METHODOLOGY

The research methodology is based on collecting statistical data, normative-legal documents, and information from open sources on international experience to assess the effectiveness of tax incentives for investments in human capital. It includes comparing these data, contrasting them with approaches used in scientific works on the subject, and evaluating them through economic analysis methods.

ANALYSIS AND RESULTS

It is important to study the processes of investing in human capital that ensure economic growth in the country. In addition to the trade-off between consumption and investments in physical capital, an individual faces a trade-off between consumption and investments in human capital when making decisions regarding income allocation. The role of tax incentives for investments in education lies in the fact that when an individual's income decreases, he or she spends less on education because part of the tax payments is refunded (not paid). For example, a change in the income tax rate is more strongly associated with investments in human capital than with investments in physical capital. Thus, an increase in the tax rate leads to a significantly greater reduction in the volume of investments in human capital than in physical capital. It should be noted that the effectiveness of tax incentives provided to the population is not always achieved in all countries. In this regard, it is important to consider the following two factors that significantly influence an individual's inclination toward the "education" tax incentive:

— the stage of the human life cycle in which tax incentives are implemented. Numerous studies summarized by Carneiro and Heckman confirm that most investments in human capital occur in the early stages of human life [13]. Therefore, it is necessary to develop a system of tax incentives and benefits that compensate individuals' expenses for obtaining basic higher and secondary specialized education at the bachelor's and master's levels (we designate them as the "core" tax regulators of HCI);

— the inclination of the working-age population toward self-education. The literature on human capital has long acknowledged the difficulty of distinguishing investments in human capital from ordinary consumption expenditures [14]. This issue is most acute in countries where personal savings are minimal. Unfortunately, it is not possible to calculate more precisely the share of spending on education by the population.

Thus, maintaining the level of HCI is most closely related to the level of the income tax burden. It should be emphasized that even a slight increase in the burden for a small segment of taxpayers can have a significantly negative impact on the state of human capital. One should not fall for the "magic of small numbers," because it is precisely this "small segment of taxpayers" that finances the mass production of innovative products, integrates them into the production of goods, works, and services, and enables the transition to a more fiscally liberal state. The areas listed above represent only a part of the existing vectors for applying tax incentives. Given the multifaceted nature of the human capital concept, such areas may include investments in national health, pension provision, and social insurance. However, considering the research objective, which aims to identify factors ensuring economic growth, these areas primarily reveal the social sphere of state regulation. From the standpoint of this research methodology, based on the presented interpretation of the human capital category, it is appropriate to determine the scope of tax instruments analyzed to stimulate human capital.

The author considered human capital as a macroeconomic category, since state support for investments in human capital is not a direct incentive for citizens to invest in education, but rather an investment in the entire pool of human resources. Historical analyses show that early ideas about human capital were based solely on human education, in which investment tools aimed at education are treated as direct, while those aimed at other components are treated as indirect. This approach is broader and allows for the multiplicative effect of tax incentives on HCI. According to modern views on the components of human capital, tax incentives applied in different countries influence not only education but also other areas that contribute to its development (Figure 1).

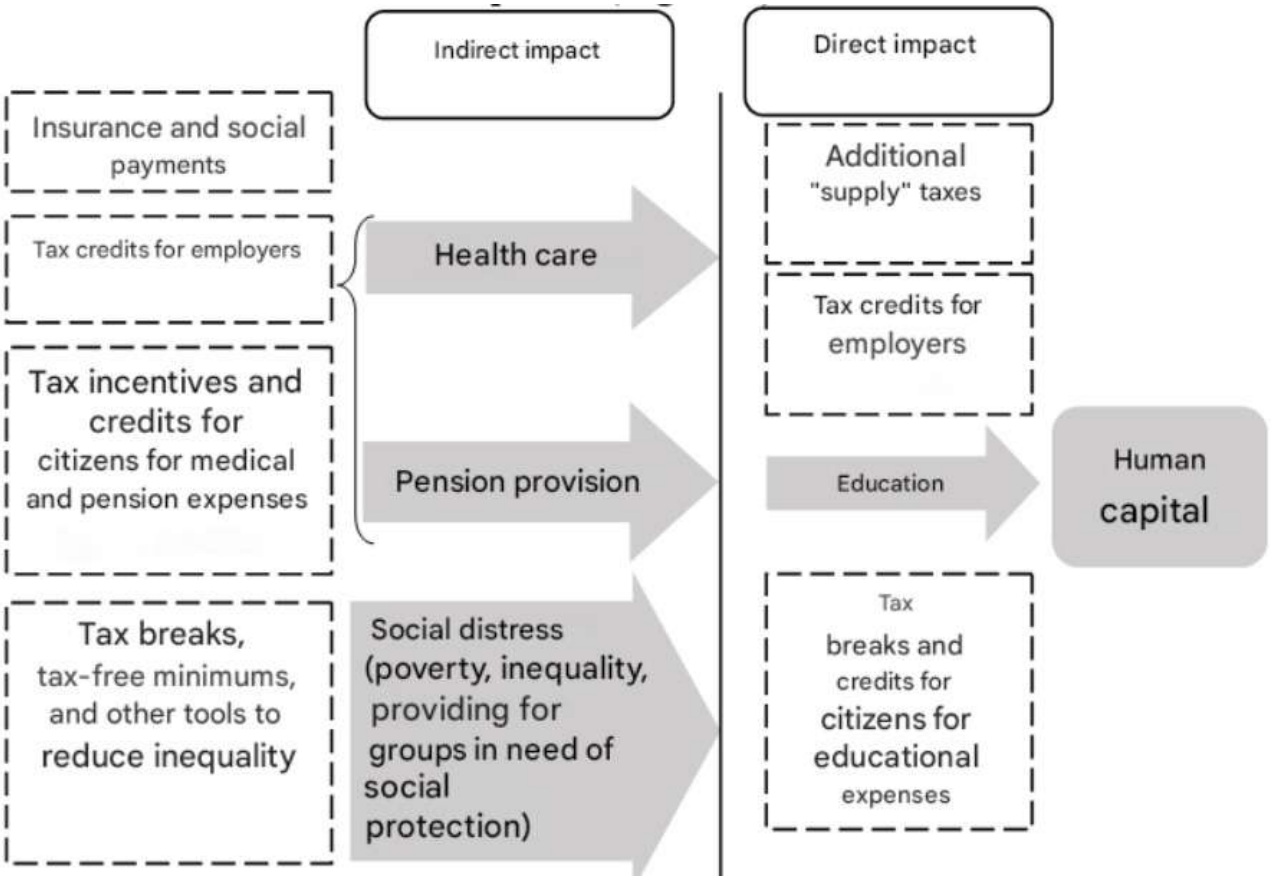

Figure 1. The system of tax incentives for HCI

In the context of this research, we identify the following key principles of tax incentives for investments in human capital:

1. The principle of risk minimization. Empirical studies show that the profitability of investments in human capital is associated with risk. In particular, initial investments in human capital are exposed to specific risks, while the accumulated level of human capital is subject to specific depreciation shocks. As soon as an individual's human capital faces a negative shock, his or her skill profile shifts to a deterministic, exogenous low-skill profile. In other words, such an individual works in an occupation or activity requiring a low level of qualification. Enterprises that invest in human capital also face the risk that workers may change jobs before the firm recovers its investments. Economists note that such firm-specific risk does not become a systemic threat to the entire economy, since the worker continues contributing to production and economic growth elsewhere. However, in conditions of external labor migration, the outflow of highly skilled human capital becomes a serious problem. Two possible methods for reducing this risk are as follows:

1. temporarily restricting the mobility of workers in whom the firm invests in training;
2. compensating the firm for possible losses on its investments when an employee decides to move elsewhere.

The first option is already a common practice in certain companies employing highly skilled labor. An employee is offered a contract that limits job mobility for a certain period in exchange for the employer funding specific training programs. Although this method of reducing investment risk is pragmatic, it contradicts the principle of free labor mobility in the economy. The second alternative may consist of providing tax incentives or credits for "unsuccessful/unrealized" investments. This reduces firms' losses in cases of workforce mobility without restricting the free movement of labor in the economy.

2. The principle of multidirectionality among incentive subjects. When forming a tax support system for HCI, it is recommended to consider its multidirectionality, meaning that it should be targeted both at employers and employees — individuals. This principle includes identifying differences between individual and corporate targeted incentives. Corporate tax incentives encompass all forms of tax benefits or credits applied to expenses incurred by employers for training their employees.

3. The principle of differentiation by types and forms of HCI. A differentiated approach to creating a system of tax incentives for HCI, based on specifying the types and forms of human capital, is considered the

most justified. Let us examine the forms of human capital in more detail for selecting priority tax instruments. Gary Becker defined human capital as a set of human knowledge and skills developed through investments in education and various forms of experience [15]. Thus, the first form of human capital is based on the presence of work experience. At the same time, another major form of human capital identified over the past decade is the "quantity" of formal education. The logical question is whether the human capital accumulated through formal education is as important as that accumulated through work experience, and which form of investment is more advisable to promote.

From this perspective, it should be noted that the value of a particular form of human capital is manifested in the level of development of the national economy. Work experience is often considered valuable because industry-specific knowledge increases with experience. However, the benefits of the second form are less clear for developing countries with underdeveloped institutions and rapid growth. Investments in children's family education are also extremely important for accumulating human capital and increasing future earnings.

4. The principle of systematicity in state support measures for HCI. It should be remembered that taxes are only one element of the system of state regulation of investments in human capital. Therefore, the impact of fiscal policy on stimulating HCI depends not only on taxes but also on state funding of educational institutions and direct subsidies provided to households and employers. For example, in most OECD countries, more than 80 percent of higher education expenditures are financed by the government. At the same time, Chile and Korea finance less than 25 percent, while Japan, the United Kingdom, and the United States finance less than 40 percent. In countries such as Japan, Korea, and Chile, this reflects the widespread use of education in private institutions, while in the United Kingdom and the United States it is reflected in public colleges and universities, but primarily on a commercial basis. Thus, the choice of tax incentives and the scale of their provision should consider the volume, structure, and composition of public expenditures on education and preferential lending. Due to imperfect credit markets, tax incentives for individuals and legal entities aimed at increasing the insufficient volume of investments in human capital should be provided in the form of tax benefits applied over several periods until they are fully utilized by households or business entities that otherwise lack access to credit.

It should be noted that if the problem of insufficient investment in human capital can be solved more effectively outside the tax system (for example, through lending or direct budget transfers), tax incentives may be undesirable. In this case, it is important to maintain tax neutrality regarding investments in human capital. Since decisions on such investments relate not only to their level, other aspects of tax neutrality also matter. Taking into account the principles described above and the identified directions of tax incentives for HCI, it is proposed to use three categories of tax incentives that ensure the preservation and development of human capital:

1. an incentive promoting corporate HCI;
2. an incentive promoting individual (private) HCI;
3. an incentive aimed at minimizing HCI risk.

If properly designed, there are two tax mechanisms that may stimulate corporate investments in human capital:

4. Using deferred tax liabilities on special taxes on human capital (if established). Foreign scholars have shown that deferring taxation on human capital is acceptable. The main conclusion here is that the marginal tax rate that determines deferred tax liabilities on human capital should depend on the current income of the economic agent. In particular, agents with low labor income are charged higher deferred taxes, while those with higher labor income pay lower deferred taxes relative to capital. Taxes must not only increase government revenues but also prevent the following situations from occurring if:

— highly skilled workers classify their labor as low-skilled for the purpose of more favorable taxation (in conditions of increasing tax burden on high-skilled labor). To prevent this, for example, in Russia, the income of foreign citizens with the status of highly skilled specialists is taxed at a rate of 13 percent, regardless of whether they are residents or non-residents;

— able-bodied citizens deliberately withdraw from employment (similar to "poverty trap" cases in certain developed European countries).

Thus, taxes should provide sufficient incentives not only to prevent the growth of "voluntary" unemployment but also to encourage adequate investment in human capital at the beginning of the life cycle. Governments around the world do not have sufficient grounds to introduce special taxes on human capital when one-time and undistorted taxes on labor income already exist.

5. Developing a system of tax incentives for employers to support their investments in employee training. It is relevant to support the development of a dual education system, which includes theoretical training at educational institutions and practical training at a specific company that forms general and firm-specific human

capital. This practice is widely used in Germany. In some cases, tax incentives are provided at a fixed amount not related to the actual expenses incurred by the taxpayer (education tax credits in Canada and the Czech Republic). This amount may conditionally reflect direct or indirect education expenses.

In Uzbekistan, income from educational services is subject to a zero income tax rate. To apply the benefit, revenues from educational services must constitute at least 90 percent of the taxpayer's total income. Educational services are also exempt from value-added tax. Property tax for educational institutions (buildings and structures) is paid at a reduced rate. Land plots occupied by educational institutions are exempt from land tax. Educational services include preschool, primary, secondary, technical, vocational, higher, and postgraduate education, as well as retraining and professional development services.

Medical services are subject to a zero income tax rate. To apply the benefit, revenues from medical services must constitute at least 90 percent of the taxpayer's total income. Medical services are also exempt from value-added tax. Property tax for medical institutions (buildings and structures) is paid at a reduced rate. Land plots occupied by medical institutions are exempt from land tax. Medical services include diagnostic, preventive, and therapeutic services, as well as dental and prosthetic services.

Technopark residents are exempt from all types of taxes and mandatory contributions to state target funds, including social tax, until January 1, 2028. Income earned by employees under employment contracts concluded with Technopark residents until January 1, 2028, is taxed at a rate of 7.5 percent (instead of the usual 12 percent) under personal income tax.

CONCLUSIONS AND SUGGESTIONS

Tax incentives for investments in human capital are one of the priority directions of state regulation aimed at ensuring economic growth. At the same time, research findings show that not all fiscal incentives function effectively as tools for promoting HCI, since both practitioners and academic literature express doubts about their effectiveness.

The economic problems of using tax instruments to develop human capital are primarily related to their inefficiency and budgetary costs, which highlights the need to design and evaluate tax incentives carefully. This ensures that resources are allocated efficiently and that contributions to human capital development are made without causing revenue losses or creating budget constraints. Solving all economic issues requires a balanced approach that takes into account both the direct and indirect effects of tax incentives on the entire economy and on public finances.

Effective implementation of tax incentives aimed at developing human capital requires coordination between the Tax Committee of the Republic of Uzbekistan, the Ministry of Higher Education, Science and Innovation, and the Ministry of Health. Ensuring continuous communication and cooperation among these institutions is often a complex task, but it does not end there. The existence of a reliable technological infrastructure for accounting and managing provided incentives also plays an important role in implementing tax incentives for human capital development. Developing and maintaining such infrastructure is costly and requires additional financial resources, reliable data management, and security.

Identifying the most effective tax incentives requires a solid methodology for evaluating the effectiveness of existing and proposed tax incentives, taking into account many non-tax factors. Linking changes in human capital development solely to tax incentives is difficult due to complex socio-economic factors. Therefore, it is important to analyze behavioral responses and identify the unintended consequences of tax incentives. To understand the reaction of organizations and individuals to tax incentives and to identify potential adverse effects, it is necessary to use elements of behavioral economics and conduct a comprehensive assessment of how tax incentives affect the behavior of economic agents.

Longitudinal studies, extensive socio-economic analysis, and econometric models should be used to assess the long-term impact and sustainability of tax incentives for human capital development. This makes it possible to determine the stable effects of tax incentives on human capital development and improve future forecasts.

The application of tax incentives for developing human capital in Uzbekistan is limited by several challenges, and eliminating them requires a comprehensive review of tax legislation and its improvement through the introduction of clear and inclusive rules. By simplifying administrative procedures and expanding the scope of tax incentives, Uzbekistan can create favorable conditions for organizations to use tax incentives effectively in human capital development. Addressing all these issues requires joint efforts from policymakers, tax authorities, and stakeholders. This, in turn, contributes to the formation of an enabling environment for using tax incentives to develop human capital.

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ECONOMETRIC MODELS OF CASHLESS SETTLEMENTS AMONG ECONOMIC ENTITIES

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Abstract: In the economy, the main part of monetary funds circulates through business entities. Payments between business entities are carried out in a cashless manner. When analyzing the movement of funds through cashless payments, it is important to develop econometric models that reflect the current state of these payments. If econometric models that accurately and adequately reflect the current state of cashless payments between business entities are not developed, it will not be possible to analyze the sequence of money flows through these payments or the degree of balance in the circulation of funds across economic sectors and regions of the country.

Key words: cashless payments between business entities, the current state of cashless payments, a unified database of completed cashless payments, econometric models of cashless payments.

Annotatsiya: Iqtisodiyotda pul mablag‘larining asosiy qismi xo‘jalik subyektlari orqali aylanadi. Xo‘jalik subyektlari o‘rtasidagi hisob-kitoblar naqd pulsiz tarzda amalga oshiriladi. Naqd pulsiz hisob-kitoblar orqali aylanayotgan pul mablag‘larini tahlil qilishda, mazkur hisob-kitoblarning joriy holatini aks ettiruvchi ekonometrik modellarni shakllantirilishi muhim ahamiyatga ega. Xo‘jalik subyektlari o‘rtasidagi naqd pulsiz hisob-kitoblarning joriy holatini to‘g‘ri, aynan mos tarzda ifodalovchi ekonometrik modellar shakllantirilmasa, mazkur hisob-kitoblar orqali aylanayotgan pul mablag‘lari ketma-ketligini yoki aylanayotgan mablag‘larni iqtisodiyot tarmoqlari va mamlakat hududlari bo‘yicha mutanosibligi qay darajada ekanligini tahlil qilish imkoniyati bo‘lmaydi.

Kalit so‘zlar: xo‘jalik subyektlari o‘rtasidagi naqd pulsiz hisob-kitoblar, naqd pulsiz hisob-kitoblarning joriy holati, amalga oshirilgan naqd pulsiz hisob-kitoblarga doir axborotlarning yagona bazasi, naqd pulsiz hisob-kitoblarning ekonometrik modellari.

Аннотация: В экономике основная часть денежных средств циркулирует через хозяйствующие субъекты. Расчёты между хозяйствующими субъектами осуществляются безналичным способом. При анализе движения денежных средств через безналичные расчёты важно формирование эконометрических моделей, отражающих текущее состояние этих расчётов. Если не будут сформированы эконометрические модели, точно и адекватно отражающие текущее состояние безналичных расчётов между хозяйствующими субъектами, то не будет возможности проанализировать последовательность движения денежных средств через эти расчёты или степень сбалансированности циркуляции средств по отраслям экономики и регионам страны.

Ключевые слова: безналичные расчёты между хозяйствующими субъектами, текущее состояние безналичных расчётов, единая база данных по проведённым безналичным расчётам, эконометрические модели безналичных расчётов.

INTRODUCTION

In today’s era of information technologies, the share of cashless payments is high in most developed countries that operate on market principles. Therefore, analyzing the current state of funds circulating through cashless payments carries significant importance.

Indeed, assessing the current condition of cashless settlements in the economy is crucial for economic governance, regulating economic relations, and making well-grounded decisions aimed at finding optimal solutions to existing macroeconomic problems. This is because a market economy is fundamentally based on “goods–money–goods” relations.

At the same time, throughout its long history of development, humanity has not created any settlement method that is more convenient and efficient than cashless payments.

During our research, we came to the conclusion that, in order to conduct macroeconomic-level analysis of the current state of cashless settlements across various criteria, special attention must first be given to constructing econometric models of these transactions.

If econometric models are developed that accurately, fully, and appropriately reflect the real situation of cashless settlements, it becomes possible to analyze these transactions in detail across different dimensions and criteria, as well as to make well-justified decisions when needed.

For this reason, the role and significance of econometric models that reflect the current state of cashless payments are invaluable today.

REVIEW OF LITERATURE ON THE SUBJECT

The economy is a complex and dynamic system composed of multiple elements. The system of cashless settlements is an integral part of this economy. To identify cashless settlement systems, the funds circulating through them, the parties involved, and to determine the sequence and direction of these financial flows, a systematic approach to cashless settlements is required.

Since our goal is to analyze cashless transactions and the funds circulating through them among economic entities, it is first necessary to form a unified database of electronic files related to these transactions and then process this information through several stages.

One of the important stages of data processing is the construction of economic-mathematical models that reflect the current state of cashless settlements carried out among economic entities.

In this regard, a Russian scholar has emphasized the importance of econometric models in economic research: “Mathematical models of the economy, by reflecting the main characteristics of economic processes and phenomena through mathematical relationships, serve as an effective tool for studying complex economic issues. Mathematical models of economic processes and phenomena are referred to as economic–mathematical models” [1].

Indeed, forming econometric models of economic processes and phenomena—processes that can often be fully understood only through abstract thinking—including cashless settlements between economic entities, is the most accurate and effective direction for studying and analyzing them.

The textbook Microeconomics states: “Economic theory deals with developing models of social phenomena. By ‘model’ we mean a simplified representation of reality. Here, the main emphasis is on the word ‘simplified.’ … The strength of a model lies in its ability to disregard details irrelevant to the issue being studied, while enabling the economist to focus on the essential characteristics of the economic reality they seek to understand” [2; pp. 15–16].

Thus, economic-mathematical models must fully reveal the essential, intangible characteristics of the phenomena and processes under study, including cashless settlements among economic entities.

Economist L. Terekhov also noted: “Economic-mathematical developments are extremely important for the optimal functioning of the economy. Based on the theory of optimal economic activity and modern mathematical methods, a set of economic-mathematical models must be formed to reflect the quantitative characteristics, relationships, and processes that constitute all the fundamental regularities of the economy” [3; p. 6].

Summarizing the grounded opinions of the scholars mentioned above, it can simply be stated that creating economic-mathematical models reflecting all the laws of economic processes and relationships is of vital importance for optimal economic management today.

It should be emphasized that the ultimate goal of constructing econometric models that reflect the current state of cashless settlements among economic entities is not limited to merely analyzing these completed transactions. Using economic-mathematical models, we seek to examine the chain-like sequence of funds circulating through cashless payments, determine where and in what amounts monetary resources circulate, and ultimately create a mechanism that enables well-justified and effective decision-making for ensuring the most balanced circulation of monetary funds in the economy.

Foreign scholars describe the link between economic-mathematical models and management as follows: “Effective decision-making is essential for performing management functions. Therefore, it is not surprising that the decision-making process lies at the core of management theory. The science of management strives to improve organizational effectiveness by enhancing managers’ ability to make well-justified, objective decisions, even in highly complex situations, using models and quantitative methods” [4; p. 219].

Indeed, if the econometric models we construct merely describe the current state of cashless settlements, our research would yield no practical outcome.

RESEARCH METHODOLOGY

At the initial stage of our research, the methods of analysis, synthesis, and classification were applied to process electronic file–based information reflecting the current state of cashless settlements.

In the second stage of processing this information, comparative analysis was carried out using methods such as comparison, induction and deduction, as well as expert evaluation. In addition, our study extensively employed comparative and systematic analysis methods. As a result, the econometric models constructed to reflect the current state of cashless settlements among economic entities were scientifically justified as being highly important for analyzing and regulating the movement of monetary resources in various dimensions. Furthermore, the possibilities of applying these econometric models in the context of Uzbekistan were also substantiated.

ANALYSIS AND RESULTS

In analyzing the current state of cashless settlements among economic entities, we placed special emphasis on constructing econometric models of these transactions.

For this purpose, we proposed organizing the information on cashless settlements among economic entities in a compact form within the following table (Table 1).

Table 1. Information on cashless settlements carried out among economic entities

Economic entities	B_1	B_2	B_3	...	B_j	...	B_f	...	B_n
A_1	S_{11}		S_{13}	...	U_{1j}	...	S_{1f}	...	U_{1n}
A_2	S_{21}	U_{22}		...	U_{2j}	...	S_{2f}	...	S_{2n}
A_3		S_{32}	U_{33}	...		...	U_{3f}	...	S_{3n}
:	:	:	:	:	:	:	:	:	:
A_i	S_{i1}	U_{i2}		...	U_{ij}	...	S_{if}	...	U_{in}
:	:	:	:	:	:	:	:	:	:
A_p		S_{p2}	U_{p3}	...	S_{pj}	...	U_{pf}	...	
:	:	:	:	:	:	:	:	:	:
A_m	S_{m1}		S_{m3}	...	U_{mj}	...		...	U_{mn}

Source: Author's elaboration.

Here:

$\mathbf{A_{(p)}, B_{(f)}}$ - the details of the paired participants involved in cashless settlements, namely:
a) the name of the economic entity;
b) the settlement account specified in the payment document;
c) the bank code (MFO) serving the respective account of the entity.

$\mathbf{U_{pf}}$ - the amount transferred via cashless settlement *by* entity B(f), whose details are located at the intersection of the first row and column f, *to* entity A(p), whose details appear at the intersection of the first column and row p.

$\mathbf{S_{pf}}$ - the amount transferred via cashless settlement *by* entity A(p), whose details appear at the intersection of the first column and row p, *to* entity B(f), whose details are located at the intersection of the first row and column f.

$A_{(P)}$ $p = \overline{1,m}$

$B_{(F)}$ $f = \overline{1,n}$

Number of rows in the table: $i = \overline{1,m}$

Number of columns in the table: $j = \overline{1,n}$

This Table 1 makes it possible to arrange and compactly structure information on cashless settlements carried out among m + n economic entities. The information placed in Table 1 serves as the unified and primary database for the subsequent stages of our research.

Now, based on the data in Table 1, we can construct the following econometric models reflecting the cashless settlements carried out among economic entities:

a) The economic–mathematical models of cashless settlements conducted by economic entities A(p) (p = 1…m), whose details appear in the first column of Table 1, can be expressed as follows:

$$\begin{cases} N(A_1) = S_{11}P_{11} + S_{13}P_{13} + \cdots + U_{1j}P_{1j} + \cdots + S_{1f}P_{1f} + \cdots + U_{1n}P_{1n} \\ N(A_2) = S_{21}P_{21} + U_{22}P_{22} + \cdots + U_{2j}P_{2j} + \cdots + S_{2f}P_{2f} + \cdots + S_{2n}P_{2n} \\ N(A_3) = S_{32}P_{32} + U_{33}P_{33} + \cdots + U_{3f}P_{3f} + \cdots + S_{3n}P_{3n} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(A_i) = S_{i1}P_{i1} + U_{i2}P_{i2} + \cdots + U_{ij}P_{ij} + \cdots + S_{if}P_{if} + \cdots + U_{in}P_{in} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(A_p) = S_{p2}P_{p2} + U_{p3}P_{p3} + \cdots + S_{pj}P_{pj} + \cdots + U_{pf}P_{pf} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(A_m) = S_{m1}P_{m1} + S_{m3}P_{m3} + \cdots + U_{mj}P_{mj} + \cdots + U_{mn}P_{mn} \end{cases} \quad (1)$$

In equation (1) and in all econometric models presented below, P_pf represents the existence of mutual relationships in cashless settlements between economic entity A_p, whose details are located at the intersection of the first column and row p of Table 1, and economic entity B_f, whose details appear at the intersection of the first row and column f of the table.

b) The economic–mathematical models of cashless settlements carried out by economic entities B(f) (f = 1…n), whose details are located in the first row of Table 1, can be expressed as follows:

$$\begin{cases} N(B_1) = S_{11}P_{11} + S_{21}P_{11} + \cdots + S_{i1}P_{11} + \cdots + S_{m1}P_{m1} \\ N(B_2) = U_{22}P_{22} + S_{32}P_{32} + \cdots + U_{i2}P_{i2} + \cdots + S_{p2}P_{p2} \\ N(B_3) = S_{13}P_{13} + U_{33}P_{33} + \cdots + U_{p3}P_{p3} + \cdots + S_{m3}P_{m3} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(B_j) = U_{1j}P_{1j} + U_{2j}P_{2j} + \cdots + U_{ij}P_{ij} + \cdots + S_{pj}P_{pj} + \cdots + U_{mj}P_{mj} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(B_f) = S_{1f}P_{1f} + S_{2f}P_{2f} + U_{3f}P_{3f} + \cdots + S_{if}P_{11} + \cdots + U_{pf}P_{pf} \\ \quad\vdots \qquad\qquad \vdots \qquad\qquad \vdots \\ N(B_n) = U_{1n}P_{1n} + S_{2n}P_{2n} + S_{3n}P_{3n} + \cdots + U_{in}P_{in} + \cdots + U_{mn}P_{mn} \end{cases} \quad (2)$$

c) In addition, based on the information in Table 1 regarding cashless settlements carried out among economic entities, it is also possible to conduct analytical work by isolating and constructing an economic–mathematical model for the cashless settlements involving a single economic entity of interest.

For example:

for economic entity A(p), whose model is presented within the group of econometric models in equation (1):

$$N(A_p) = S_{p2}P_{p2} + U_{p3}P_{p3} + \cdots + S_{pj}P_{pj} + \cdots + U_{pf}P_{pf} \quad (3)$$

or for economic entity B(f), whose model is presented within the group of econometric models in equation (2):

$$N(B_f) = S_{1f} + S_{2f} + U_{3f} + \cdots + S_{if} + U_{if} + \cdots + U_{pf} + \cdots + S_{mf} \quad (4)$$

we can analyze the model according to the relevant directions and criteria.

d) Furthermore, it is also possible to conduct analytical work by isolating the economic–mathematical model of cashless settlements involving a single economic entity of interest, based on:

- funds credited to the entity's bank account;
- funds debited or transferred from the entity's bank account.

For example, for economic entity A(p) in econometric model (3):

the econometric model representing the funds credited to its account through cashless settlements is as follows:

$$N(A_p) = U_{p3}P_{p3} + \cdots + U_{pf}P_{pf} \quad (5)$$

the econometric model representing the funds debited from its account through cashless settlements is as follows:

$$N(A_p) = S_{p2}P_{p2} + \cdots + S_{pj}P_{pj} \quad (6)$$

Thus, we can construct econometric models reflecting the current state of cashless settlements carried out among economic entities based on various dimensions and criteria of interest.

CONCLUSIONS AND SUGGESTIONS

The formation of a unified database of information on the current state of cashless settlements among economic entities, and the consolidation of this information into a compact, structured table, creates the foundation for developing econometric models that accurately and adequately reflect the actual condition of these settlements.

Regarding this, economist L. V. Kantorovich noted: “Difficulties in modeling and forming the necessary information base can be overcome by enriching the set of tools used in economic research through new, original findings, and by further developing mathematical apparatus, technology, and the integration of these tools through human sensitivity, consciousness, and experience.” [5].

Indeed, in an era where information technologies are rapidly advancing, conducting scientific research on the proportionality of funds circulating through cashless settlements—without constructing econometric models that reflect the current state of these transactions—will not yield the expected results.

Therefore, today, in conducting scientific research on any macroeconomic problem, one of the primary tasks is the correct, rigorous, and adequate construction of its economic–mathematical models.

Another important conclusion that can be drawn here is that analyzing cashless settlements does not simply involve studying the process of transferring money from one bank account to another or examining the form or method of the settlement itself. Because the current state of cashless settlements carried out among economic entities can be analyzed based on:

- the specific economic entities directly involved in the cashless settlements;
- the chain-like (multi-stage) sequence of cashless settlements among entities;
- the purposes indicated in the payment documents that serve as the basis for executing cashless settlements;
- the sector of the economy or the geographical region in which the entities involved in the settlements operate.

Thus, in order to perform the analytical tasks listed above, the primary requirement is to construct econometric models that reflect the current state of cashless settlements carried out among economic entities.

The results of our analytical work demonstrate that relying on indicators reflecting the current state is crucial in scientific research. Making decisions based solely on final indicators—calculated after the completion of a month, quarter, or year—does not produce the desired effect. This is because the economic system and its elements are constantly in motion, and therefore, the state of the economy continually changes.

For this reason, from the very beginning of our research, we focused on forming a unified database of electronic file–based information on the current state of cashless settlements among economic entities, and using this information to construct economic–mathematical models of these settlements across various dimensions and analytical perspectives.

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PROSPECTS FOR THE DEVELOPMENT OF TOURISM BRAND MARKETING IN MODERN CONDITIONS (UAE: DUBAI ON THE EXAMPLE OF A CITY)

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Abstract: This article provides a scientific analysis of the impact of brand marketing and tourism development on the socio-political and economic progress of a country. It examines the concept and essence of brand marketing, identifying the key factors influencing its effective implementation. Using the example of Dubai in the United Arab Emirates, the study highlights strategic territorial branding approaches, innovative tourism-development practices, and mechanisms aimed at enhancing national attractiveness. The findings demonstrate the crucial role of brand marketing in strengthening regional competitiveness and shaping a sustainable tourism environment.

Key words: tourism; brand marketing; territory; region; city; image; territorial branding.

Annotatsiya: Maqolada mamlakatning ijtimoiy–siyosiy va iqtisodiy rivojlanish jarayonida brend–marketing hamda sayohat industriyasining o‘zaro ta’siri ilmiy jihatdan tahlil etilgan. Unda brend–marketingning mazmuni, mohiyati va uni samarali shakllantirishga ta’sir ko‘rsatuvchi omillar yoritilgan. Shuningdek, Birlashgan Arab Amirliklarining Dubay shahri misolida hududiy brendingning strategik yondashuvlari, sayohatni rivojlantirish bo‘yicha ilg‘or tajribalar va mamlakat jozibadorligini oshirishga xizmat qiluvchi amaliy qarashlar keltirilgan. Tadqiqot natijalari hududlarning raqobatbardoshligini kuchaytirish hamda barqaror sayyohlik muhitini shakllantirishda brend–marketingning ahamiyatini ko‘rsatadi.

Kalit so‘zlar: sayohat; brend–marketing; hudud; mintaqa; shahar; imidj; hududiy brend–marketing.

Аннотация: В статье проведён научный анализ влияния бренд-маркетинга и туристической индустрии на социально-политическое и экономическое развитие государства. Раскрыты сущность и содержание бренд-маркетинга, а также факторы, определяющие его эффективную реализацию. На примере города Дубай Объединённых Арабских Эмиратов представлены стратегические подходы территориального брендинга, современные механизмы развития туризма и методы повышения привлекательности страны. Полученные результаты подчёркивают значимость бренд-маркетинга в укреплении конкурентоспособности регионов и формировании устойчивой туристической среды.

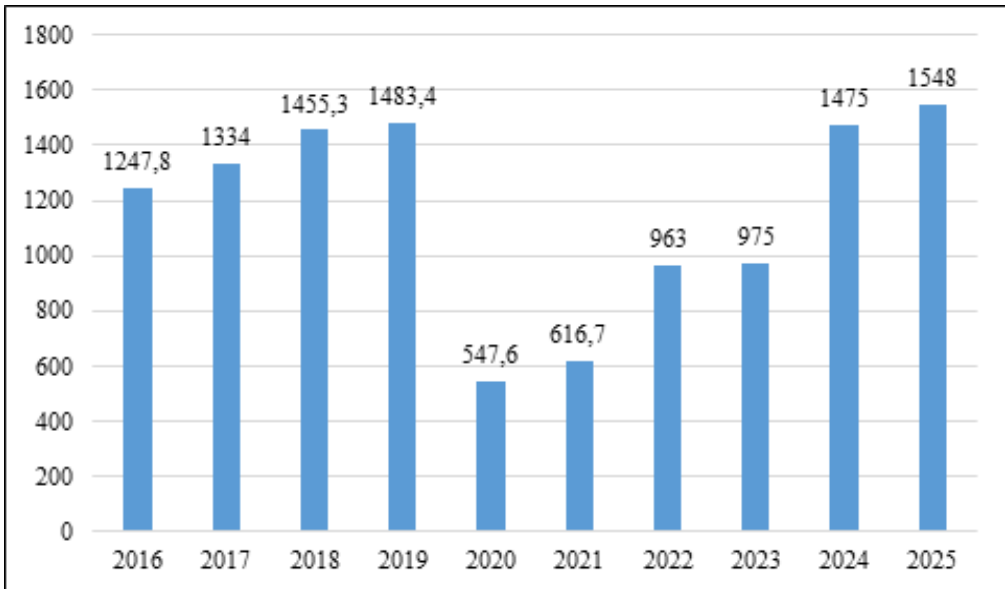
Ключевые слова: туризм; бренд-маркетинг; территория; регион; город; имидж; территориальный брендинг.

INTRODUCTION

Improve the level of living of the population in countries and regions of the world, the actual role has been the continuous development and increase wellbeing. Therefore, in many countries the introduction of new approaches in social and economic development of the region, the application of methods of effective management, sustainable financial resources of the area and to attract the tourist attractiveness defining specific brand-with special attention paid to the development and development of marketing strategy.

In particular, 2016-2024-the number of years in the range of 1 247,8 than 1 million international tourists in the world increased to 475 million, 118,2 percent. According to forecasts of experts, by 2025, from million by the end of the year 548 international tourists is expected to grow 1 percent of the number that have reached 124,1 (1-picture).

Also, in the year of 2025 sayyohat from international exports (receipts and expenses by size) is projected to be us $ 2.2 trillion. These forecasts, in turn, increased to 24 percent share of the gross domestic product, it means that the structure of travel [1].



1-picture. Travel in the world for years 2016-2025 dynamics,mln.the man[1]

Shavkat mirziyoyev of the republic of uzbekistan on 29 march 2023 sayyohat of the year in the country on the issues of capacity building opportunities for the development of additional travel videoselektor conducted at the meeting were identified. In particular, it would be allocated 100 billion soums, in order to attract tourists through marketing and advertising, he noted. Also, “visit uzbekistan on paper”to develop the brand to renew national travel, international tv channel about the platform and internet advertising stressed the need to increase the number of rollers in uzbekistan [2].

At present, uzbekistan is wide open to the world the election as a result of the number of foreign tourists compared to last year (2024–compared with the corresponding period of the year) 10 million people from that observed in the export of travel services had exceeded 3 billion us dollars [3].

In this context, the development of the region and points towards the growth of specialization, allowing to determine the dimensions of motivation plays an important role. Especially, in the field of travel, which is one of the fastest developing areas of the economy of the territory, the combination of climatic conditions, the stages of historical development, national customs and traditions, such as hospitality of specific factors of great importance [4]. Thus, not only the consumer of the product (goods or services), but also regional, local and regional sayyohat also pays attention to the brand.

“A glossary of economic terms”stated at marketing (marketing, English, market promotion, market activity) — the purchase of goods and services that would encourage exchange and accelerate the development process needs to meet in order to get fuller and higher income market activity is performed [5].

Branding (Latin brands — brand trade mark) marketing and communications within the system while the style of the firm, which distinguishes from its main competitors and the development of specific elements of their enterprise is the process of forming the image [5].

LITERATURE REVIEW

To increase the attractiveness of the territory, the formation of brand and branding tools as part of the marketing strategy, valuation, and the scientific basis of the process of applying them is of particular importance. The theoretical and practical aspects of the creation of the brand in the region, many of foreign and local have been widely studied by researchers. In particular, the theory of compatibility and standardization of international marketing by levi t. put forward direction [6], while the concept of territorial marketing in Kotlet F., Asplund, K., haider, and i. D. may be done by re of the territory (cities, regions and countries) to provide special services to consumers focused on progressing as you go to the commodity form was noted [7]. T. a new marketing term that would cover the concept of nation branding as Ataeva region, the population of the territory thus, the image, the infrastructure and the process is recorded charm designation as key strategic areas [8].

Also, Schwartz and s. g. hofstede cultural principles of the brand, [9], the development of brandy chernatony l. model [10], S. while traveling Anhu, export, investment, culture, and demographic indicators in areas such as international migration and systematic evaluation to create a national brand offers a model of [11]. Despite the fact that these studies exist, the travel brand on the scientific and practical approach to holistic marketing is still the priority.

We, the regional brand-marketing ideas, symbols, values and systemic expressed in the image, it is through the specific characteristics of the territory, which show a unique union. Term in its virtual form, or visual expression, in relation to the territory of a positive impression alarm consumers “paper visit” serves as. Travel brand while marketing the area’s natural, cultural and historical heritage, the sights, the flow of tourists, attracting major events, products and services is determined by a complex craft.

Travel in any area for the development of “brand travel options to create”if you can, the regional brand marketing strategy for the success of its attractive appearance and the formation of stable consumers about the uniqueness of the territory of the strengthening of the imagination, rational use of available resources, to attract the flow of tourists, enhancing the attractiveness of the investment, to increase the economic potential, is directly linked with national prestige and upgrades enable you to participate in the international arena.

Sayyohat management process and the identification of areas in the country should rely on a number of principles. Thus, the area of the territory and the importance of the suggested products (goods or services), the type of the integration process (historical, beach, each extra, business, sports areas)or the presence of development opportunities, the state and business activities of the association of tourism agencies and hotels yetarligi infrastructure available such as the size of the tourism potential of the territory and the service factors play an important role. Furthermore, the comfortable infrastructure and the effectiveness of the logistics chain was also among the important factors defining the competitiveness of the territory.

Travel brand of the territory-marketing it to pay attention to the socio–economic development will become one of the top priority sectors, which will serve to increase the income and welfare of the population and of living will set the strategic direction.

RESEARCH METHODOLOGY

This research brand-marketing the development of the theoretical and practical aspects of the role rendered travel from complex was studied. First of all, a systemic analysis of foreign and local literature on the subject, the brand-marketing, sexy charm regional, national brand and the image of the territory was based on the basic concept of a scientific clarification of the source of the content. In the process of research, compare, logical mushohada, content analysis, historical–analytical approach and induktiv–deduktiv use methods, with or without the combination of existing theories and practical experiences were assessed.

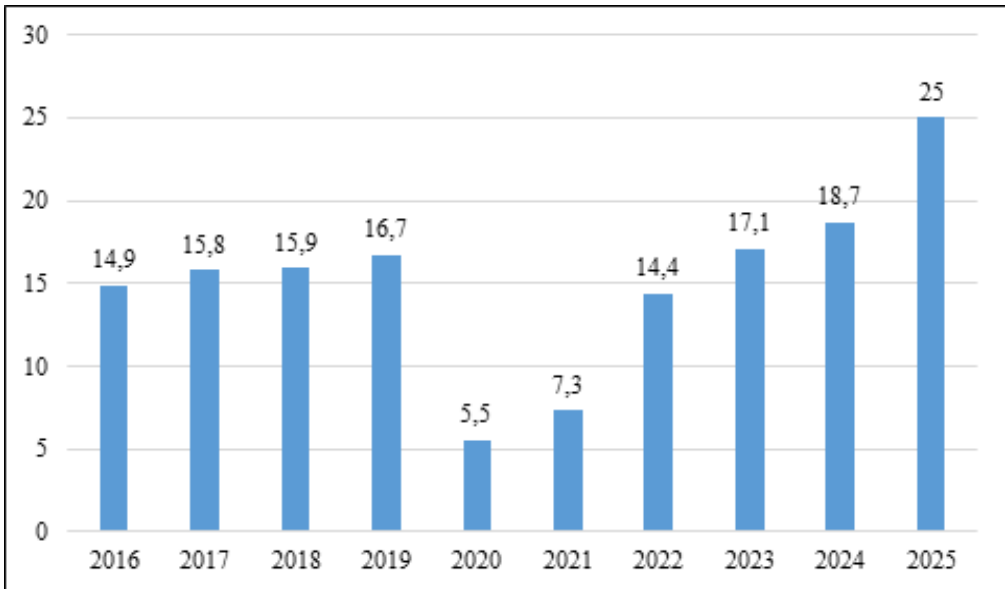
Also, on the example of the city of dubai in the uae travel brand statistical data related to the open marketing strategy, official reports, publications of international organizations was a critique of the scientific and expert analysis. As the factors which influence the formation of the brand of the territory, the dynamics of the tourist flow, potential infrastructure and marketing initiatives on the basis of practical examples analytical approach in determining the correlation between supports. As a result, the brand-marketing in travel and increase the competitiveness of regions of strategic importance was reflected in the capacity of strengthening the scientific basis.

ANALYSIS AND RESULTS

In the article the author, united arab emirates, particularly in the city of dubai travel significant in efforts to increase the attractiveness of the country and the development of a scientific critique lit. Today sayyohat the city of dubai, real estate, education centres in areas such as hotel management and is being raised to the high level of international market. The city did not repeat the achievements of tourists and investors compete for available readers, but stand out with innovative products and services to offer. Dubai brand image and increasing the attractiveness conducted on the marketing policy in the conditions of strong competition in the world market as an important factor in strengthening its position has been demonstrated [12].

Carried out every project in the city of brand marketing strategic approach is based on the example of the global scene and has been recognized as peculiar in unreal. Successful completion of dubai their brand-marketing consistent and effective implementation of the policy said it shows. The city of dubai brand of this analysis-marketing strategy for the country’s socio–economic development and confirmed that it had served to strengthen the global position in [12].

In particular, carried out within the framework of the strategy “in the wilderness each extra resort”, “the coast of dubai on a luxury seven-star hotel,” “the largest artificial island in the world”, “tallest buildings”, different and recreation areas and other projects in the city of the world community, the brand plays an important role in the formation of [12]. 2016-2024-over the years the number of tourists who visit Dubayga 125,5 percent have increased from 25 million people by the end of the year 2025 or have reached their number is projected to grow percent 167,7 [1] (2-picture).



2-picture. 2016-2025 years in the city of dubai travel dynamics,mln.the man [1]

The brand developed in the direction of travel in the city of dubai-regional marketing strategy sayyohat products — the production of goods and services, in particular to increase the competitiveness of the organisation hotel and tourism, to attract consumers new to the area and the local population “service mentality”represents a complex approach to the formation and aimed at strengthening. This strategy to effectively manage a steady growth in the number of tourists in the city, the improvement of a policy to regulate it, infrastructure development, improve the quality of the proposed products and services, as well as marketing initiatives and prioritizing as enhancing the flow of investment services. The main purpose of strategy at international level, dubai vacation, business trip and service for leading address is being presented as if the city of dubai and foreign interested parties — government organizations and business entities to use the collective of opportunities. In particular, the flow of tourists within the framework of the share of market and maintain a high potential is available, as well as the dubai corporation of Tourism & commerce marketing strategy to increase the number of repeated visits through activities is defined as an important component of [13].

CONCLUSION AND RECOMMENDATIONS

The results of research is of practical importance, cited above, the scientific results of the country’s brand-marketing the development of travel as a factor of increase, to strengthen the position in the new economic conditions in the domestic and foreign market and to increase access to a new segment in the market which serve an important competitive tool. This process, first of all, the territory of local scientists brand-marketing to be actively involved deep research of the concept of the brand on the formation of the territory of the approach in practice through the implementation and development of konseptual provides.

Also, measures aimed at enhancing the region into a safe and comfortable environment, on a competitive basis to increase the attractiveness of the territory provide, attract tourists and create new jobs and sources of income also plays an important role in the formation of sustainable. Thus, the country’s brand-marketing a strategic approach to the development of the travel process, socio–political and economic development to be taken out to a new stage in the international arena, its‘ and can significantly contribute to increase the prestige.

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CREDIT DEFAULT SWAPS AS A WAY TO HEDGE AGAINST FORTHCOMING FUTURE UNCERTAINTIES IN THE DEBT MARKET OF UZBEKISTAN

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Abstract: The main purpose of issuing this article is to underline a specific shortage in Capital Market of Uzbekistan. In greater detail, the absence of derivatives for debt instruments, in particular, corporate bonds as well as banking loans, and this could clearly reduce the entire attractiveness of Uzbek Capital Market for foreign investors. Besides, Uzbekistan’s international credit rating (based on S&P Global) is “BB-”, meaning “Non-investment grade or speculative”. For these reasons, it is advisable to take measures to introduce credit default swaps in order to protect not only investors’ portfolios but also commercial banks’ balance sheets from the defaults of borrowers. In our work, we have carried out some statistical researches in the following indicators of economy: NPLs ratio (non-performing loans) between 2020-2025; Annual inflation rate between 2016-2025 and National currency value between 2016-2025.

Key words: Credit default swaps (CDS), capital market, S&P global, annual inflation, banking loans.

Annotatsiya: Ushbu maqolani nashr etishdan asosiy maqsad O‘zbekiston kapital bozoridagi o‘ziga xos tanqislikni ta'kidlashdir. Batafsilroq aytganda, qarz vositalari, xususan, korporativ obligatsiyalar, shuningdek, bank kreditlari uchun derivativlarning yo‘qligi va bu O‘zbekiston kapital bozorining xorijiy investorlar uchun jozibadorligini sezilarli darajada pasaytirishi mumkin. Bundan tashqari, O‘zbekistonning xalqaro kredit reytingi (S&P Global asosida) "BB-" bo‘lib, "Investitsiyasiz daraja yoki spekulyativ" degan ma'noni anglatadi. Shu sabablarga ko‘ra, nafaqat investorlarning portfellarini, balki tijorat banklarining balanslarini ham qarz oluvchilarning defoltlaridan himoya qilish uchun kredit defolt svoplarini joriy etish choralarini ko‘rish tavsiya etiladi. Biz o‘z ishimizda iqtisodiyotning quyidagi ko‘rsatkichlari bo‘yicha ba'zi statistik tadqiqotlar o‘tkazdik: 2020-2025 yillar oralig‘ida muammoli kreditlar nisbati (muammoli kreditlar); 2016-2025-yillar oralig‘idagi yillik inflyatsiya darajasi va 2016-2025-yillar oralig‘idagi milliy valyuta qiymati.

Kalit so‘zlar: Kredit defolt svoplari (CDS), kapital bozori, S&P global, yillik inflyatsiya, bank kreditlari.

Аннотация: Основной целью данной статьи является выявление определённого дефицита на рынке капитала Узбекистана. Более конкретно, отсутствие производных финансовых инструментов на долговые инструменты, в частности, на корпоративные облигации, а также банковские кредиты, может, безусловно, снизить общую привлекательность узбекского рынка капитала для иностранных инвесторов. Кроме того, международный кредитный рейтинг Узбекистана (по данным S&P Global) составляет «BB-», что означает «неинвестиционный уровень или спекулятивный». По этим причинам целесообразно принять меры по внедрению кредитных дефолтных свопов (CDS) для защиты не только портфелей инвесторов, но и балансов коммерческих банков от дефолтов заёмщиков. В нашей работе мы провели статистические исследования следующих экономических показателей: уровень NPL (неработающих кредитов) в период 2020-2025 гг.; годовой уровень инфляции в период 2016-2025 гг. и курс национальной валюты в период 2016-2025 гг.

Ключевые слова: кредитные дефолтные свопы (CDS), рынок капитала, S&P Global, годовая инфляция, банковские кредиты.

INTRODUCTION

First and foremost, it is necessary to walk the reader through the crux of credit default swaps or briefly CDS, in other words, how they are generally structured, how they do function and other related factors. According to the Internet source a credit default swap (CDS) is a financial derivative that allows an investor to swap or offset their credit risk with that of another investor. A protection buyer buys a CDS from a protection seller, who agrees to reimburse them if the borrower defaults. Most CDS contracts are maintained via an ongoing premium payment, similar to the regular premiums due on an insurance policy. A lender who is worried about a borrower defaulting on a loan often uses a CDS to offset or swap that risk[1]. In more detail, the credit default swaps or CDS, function like insurance products and the main purpose is to protect an insurance buyer from the default of underlying asset, and mainly it could be any debt product such as corporate bonds, MBS (Mortgage-backed securities), CDOs (Collateralized debt obligations) even banking loans and others. Thus, Credit default swaps or CDS contracts are a tool for managing credit risk. Moreover, this derivative instrument could easily provide exposure to credit markets for investors to diversify own portfolios, that is to say, even without directly owning the underlying debt instruments. CDSs provide speculation opportunities for investors to generate profit, and consequently it is important mention that CDS contracts are customizable since they are flexible in terms of structuring to meet investors' needs. However, there are some disadvantages of credit default swaps, in particular, they might be complex for inexperienced investors, they are traded over-the-counter market, due to the absence of centralized clearinghouses the CDS market are less regulated compared with other financial markets. However, now it is time to introduce these credit derivatives to Uzbekistan since its debt market has been growing significantly which might result in higher risk of insolvencies by borrowers. Therefore, the construction of credit default swaps might ease the future probable insolvencies in the debt market.

LITERATURE REVIEW ON THE TOPIC

D.Duffie and K.Singleton[1] study perfectly summarizes the academic and practical foundations of pricing, measuring and managing credit risk. The authors analyze the intensity and structural approaches to modeling credit derivatives, including CDSs, propose methods for estimating model parameters using market data, and explain the methodology for separating the dominant liquidity and spread components. This work provides a theoretical foundation for evaluating CDSs as a risk hedging tool in the government or corporate debt market.

D.Lando[2] in his scientific work has summarized the theoretical and statistical approaches to modeling credit risk in a mature manner. The book covers in detail intensity-based (reduced-form) models, rating-transfer processes, and methods for calculating the correlation of several bonds. Lando offers practical formulas and dependency modeling methods for determining the value of CDS, CDOs and other credit derivatives, which serve as an invaluable tool for designing hedging strategies in emerging markets — for example, the debt market of Uzbekistan.

R.Merton[3] in his study explains the risk structure of corporate debt prices using a classical structural model. The elements of Merton's model are the main theoretical foundation for structurally assessing CDS pricing and default probability. Merton expresses the relationship between a firm's assets and debt obligations using option theory, which is useful in assessing the sustainability of government or corporate debt and the effectiveness of hedging instruments — including CDS. For emerging markets, Merton's approach allows for strategic analysis of credit structure.

F.Longstaff et al.[4] in their article separates the default and liquidity components of corporate spreads using the CDS market. They use CDS data to draw a clear empirical conclusion: in many cases, a large part of the spread is due to default risk, but liquidity conditions also change over time. These results are important for markets like Uzbekistan — CDSs not only help hedge against default, but also help measure and manage market liquidity shocks.

J.Hull[5]'s work on credit derivatives provides a practical overview of the construction of CDSs, forward CDSs, CDS options, and credit valuation (CVA/DVA). Hull's work presents how to use CDSs in the context of central clearing, counterparty risk, and market practices, and provides hedging strategies — essential for assessing the institutional and operational aspects of CDS implementation in emerging debt markets like Uzbekistan.

RESEARCH METHODOLOGY

In this part of our article, we are exploring meticulously how the credit default swaps are constructed in general. Most importantly, we are suggesting to engineer new type of CDS product that would not only

1 https://www.investopedia.com/terms/c/creditdefaultswap.asp

cover up the insolvencies of fixed-income products but also could be an appropriate hedging instrument in the loan market, in other words, nowadays there is a gradual increase in the number of non-performing loans (NPLs) in the balance sheets of commercial banks of Uzbekistan. Even, there have been mentioned in the Findings of Financial System Stability Assessment by the Financial Sector Assessment Program (FSAP) team (IMF): «However, stress tests indicate vulnerability to credit risk, which is amplified by the under-reporting of nonperforming loans. The capital adequacy ratio of many banks, especially state-owned banks, would fall below the required minimum under the adverse stress testing scenario resulting in significant recapitalization costs»[2]. Consequently, this is one of the main concerns why we are obsessed about this idea of engineering credit default swaps in Uzbekistan for the purpose of mitigating the risk of defaults not only in fixed-income debts products but also prevent insolvencies in retail banking loans. First and foremost, a roadmap of CDS implementation should be based on the following algorithm: 1) a group of state-owned insurance companies should allocate funds to create syndicated special purpose vehicle that would be in charge of generating credit default swaps targeting at debt instruments regardless of their features, in other words, these swap contracts would ensure not only the liquidity of a bond issuer, but also minimize the risk of insolvencies in retail banking loans. Certainly, this project should be led by the National Agency of Perspective Projects or briefly (NAPP). 2) Legislation could be backed by means of «Regulatory Sandbox» framework which was pointed in the Resolution of the President of the Republic of Uzbekistan RP № 291 «On Additional Measures for the Development of the Capital Market»[3]. 3) Initially, launching process should be done by selling those credit default swaps to the state financial institutions (state-owned banks, investment companies and others) in the experimental level. 4) After the succeeding in the experimental level, private financial institutions (banks, investment companies or brokerage firms) and retail local investors could also be allowed to take part in purchasing those credit insurance contracts. 5) Finally, foreign institutional investors would be permitted to invest into CDS products. In general, regarding the structure of credit default swaps, there should be engineered two different types of CDS contracts:

1) Credit Default Swaps for Fixed-income products or briefly (CDSF);
2) Credit Default Swaps for Banking loans or briefly (CDSB); (Figure 1).

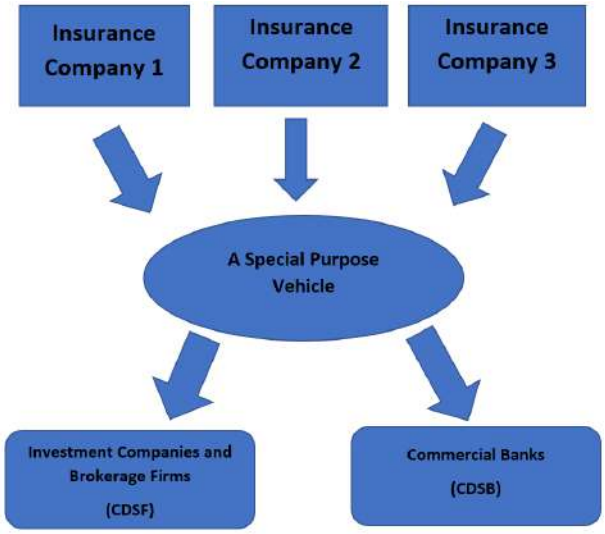

Figure 1. The hierarchy of the entire system

So, a short interpretation of the above Fig.1: let's say three state insurance companies would be responsible to establish A Special Purpose Vehicle that would be in charge of engineering Credit Default Swaps, as mentioned previously, only two types of CDS products such as CDSF credit default swaps for fixed-income products (corporate bonds) and CDSB credit default swaps for banking loans (both corporate as well as retail ones). A Special Purpose Vehicle considered as (Protection seller) and those entities which invest in CDS, regardless of their size, would be (Protection buyers). Certainly, all these procedures should be under the control of the National Agency of Perspective Projects by means of «Regulatory Sandbox». Corporate borrowers would be considered as «reference entities» and retail borrowers would be called as «reference individuals». The structure of each CDS product would be engineered based on the underlying debt instrument,

2 https://www.imf.org/-/media/Files/Publications/CR/2025/English/1uzbea2025003-print-pdf.ashx#:~:text=Policy%20advice:%20The%20authorities%20should,May%2027%2C%202025
3 https://lex.uz/ru/docs/7559507

for instance, an investor purchases X company's a 5-year corporate bond (in UZS) that yields 20.5% coupons annually, but the investor is concerned about X company defaulting. For this reason, A Special Purpose Vehicle would construct CDSF based on the request of the investor, and according to the international standards set by ISDA (International Swaps and Derivatives Association) a protection buyer would in charge of make quarterly payments till a credit event (default) happens, in our example above the investor would be responsible to make quarterly payments until a credit event happens, if the reference entity (X company) does not default on its a 5-year corporate bond, the investor would lose partially yields from the bond. The calculation would be run in the following form: 2.5% quarterly payments out of 20.5% yields of the X company's corporate bonds: 2.5% x (4 x 5) = 50%. In total, the investor should pay 50% out of 105.2% total return (20.5% annually x 5 years), and in case of default, the protection seller (SPV) would be obliged to offset a notional principal of the X company's corporate bonds to the investor. Regarding CDSB (Credit Default Swaps for Banking loans), a protection buyer (commercial bank) should make a quarterly payment from a loan interest that is paid monthly by a borrower.

ANALYSIS AND RESULTS

We gathered some historical statistics about annual inflation rate, exchange rate, a number of non-performing loans (NPL), to represent the necessity of CDS products to be engineered in Uzbekistan. Besides, we ran a Modified Poisson Regression model in Stata to find out risk ratios between economies with CDS market and economies without CDS market. Simultaneously, in Stata software, we managed to run Log Binomial Regression model to identify the relationship among Average Lending Rates (Y) with Inflation Rate (X_1), Interest Rates (X_2) between 2014-2025 years to display how far it is crucial to introduce CDSB (Credit Default Swaps for Banking loans) contracts for the purpose of eliminating insolvency problems in the banking sector of Uzbekistan. First and foremost, statistics about annual inflation rate between 2016-2025 in Uzbekistan, that clearly illustrates how far the inflation rate has been unpredictable, in other words, a monetary policy of Uzbekistan has not been effective to bring inflation down to a target, hence this could adversely affect macroprudential policy[4] of the economy. As a consequence, commercial banks have been charging higher interest for loans regardless of their types, corporate as well as retail ones, for instance, according to official statistics, in 2024, average corporate loans ranging from approximately 24% to 36% per annum (Figure 2).

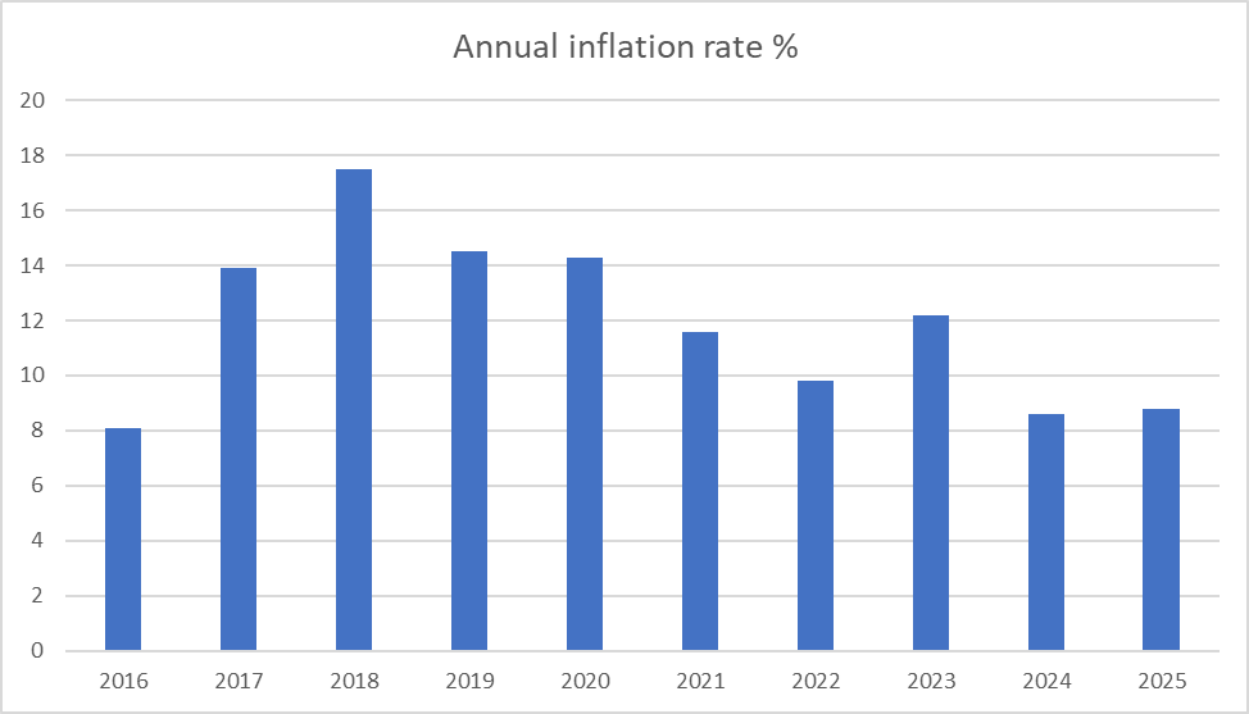

Figure 2. Annual Inflation Rate in Uzbekistan (2016-2025).

The bar graph above does illustrate annual inflation rate in Uzbekistan for almost a decade period between 2016-2025 years. Overall, what stands out from the graph is that in 2018 the economy experienced the highest

4 Macroprudential policy involves regulations and measures designed to reduce systemic risk and strengthen the overall resilience of the financial system to shocks.

inflation rate in the given chart, accounting for 17.5%. The lowest inflation rate transpired last year, in 2024, made up just over 8.5 percent, based on the bar graph. As it is clear that in 2016, our economy recorded exactly 8% of annual inflation rate, but abruptly this proportion reached 13.9 percent in the following year, by 2017, being remarkably more than a previous rate. And this growing trend was captured in 2018, that is to say, annual inflation rate peaked at 17.5 percent, as it was mentioned prior, it was by far the largest inflation rate recorded in the given chart. However, by 2019, Central bank could somehow have managed to decrease annual inflation rate to nearly 14% (14.5), and from that period our monetary policy succeeded to decline annual inflation rate till 9.8% by 2022. Nevertheless, suddenly, in 2023, annual inflation rate accelerated and grew 12.2 percent, and that is due to geopolitical tensions in the world, in other words, the entire global economy collided with a high inflation rate caused by rising oil prices in the world. All in all, the latest data shows that annual inflation rate made up 8.8% which is still higher than target rate (5%). To be more prices, the main purpose of depicting this data is to disclose how far is annual inflation rate plays a key role in borrowing cost of debt instruments which might lead to a high insolvency rate of debtors (borrowers) in the economy, consequently it results in the significance of developing Credit Default Swaps in the economy.

Next is a table of exchange rate or foreign currency value against national ones US dollars against Uzbek Soums (USD/UZS) between 2016-2025 (Table 1).

Table 1. Currency value USD/UZS (2016-2025)

Date	Currency value (USD/UZS)
01.09.2016	3,020.00
01.09.2017	8,076.00
01.09.2018	8,085.00
01.09.2019	10,321.21
01.09.2020	10,692.00
01.09.2021	11,004.94
01.09.2022	12,205.00
01.09.2023	12,734.99
01.09.2024	12,734.99
01.09.2025	12,160.00

This table is one the important datasets that shows why it is so necessary to introduce Credit Default Swaps so as to hedge against volatility in currency exchange since many businesses have issued USD-denominated bonds in the foreign Capital Markets such as (London Stock Exchange, Vienna Stock Exchange and others). Initially, in 01.09.2016 1 USD cost 3,020.00 UZS, but by next analogous year, 1 USD sharply appreciated by 8,076.00 UZS which caused by currency liberalization reforms in the country[5], and this rate remained stable around 8,085.00 UZS in the following year of 01.09.2018, only increasing to 9 UZS from the previous exchange rate. However, abruptly 1 USD remarkably appreciated to 10,321.21 UZS, making it difficult to serve USD-denominated debt instruments in the market of 01.09.2019. By 01.09.2020, US dollar increased to 10,692.00 UZS, which was expensive more that 370.79 UZS compared to the previous exchange rate in 2019. Again, it is visible how US dollar strengthened against national currency, and it reached 11,004.94 UZS for 1 USD, data as of 01.09.2021. Following this upward trend in USD, by 01.09.2022, 1 USD cost already 12,205.00 UZS, and this exchange rate stayed flat at 12,734.99 UZS between 01.09.2023 and 01.09.2024, respectively. Finally, by 01.09.2025, UZS gained value against USD, in other words, by this date, 1 USD = 12,160.00 UZS, but it is important to mention that there is a stable daily fluctuation in the exchange rate (Table 2).

5 https://www.worldbank.org/en/country/uzbekistan/publication/economic-update-summer-2019#:~:text=Uzbekistan%20is%20implementing%20ambitious%20market,for%20both%20firms%20and%20individuals.

Table 2. A number of Non-Performing Loans as of Total Loan Portfolio (2020-2025)

Years	Total loan portfolio	NPL
2020	249 756	5 887
2021	302 693	18 889
2022	346 390	16 936
2023	430 227	15 743
2024	500 644	20 820
2025	576 247	22 554

And this table provides a number of Non-performing loans as of Total loan portfolio in the commercial banks of Uzbekistan between 2020-2025 years. In general, it can be seen that there is a positive correlation between total loan portfolio as well as NPL numbers, in other words, as the loan portfolio has increased, and consequently there has been an upward trend in the number of non-performing loans in turn. Surely, this a normal trend, that is to say, many countries have been facing with this problem, but it is important to mention that the average lending rate differs from 22,5% to 30%, even some foreign banks in Uzbekistan might charge from 40% up to 49% for lending. Thus, it is about time to contemplate to engineer CDSB (Credit Default Swaps for Banking loans) instruments to hedge against the default of borrowers for their loans.

As we mentioned above, we also ran a couple of regression models by means of Stata software to analyze correlations between variables, in particular, we opted for two regression models: 1) Modified Poisson Regression model which combines a log Poisson regression model with robust variance estimation, it provides a robust method for estimating relative risks and prevalence ratios in binary outcome analyses. 2) Log Binomial Regression model which is a generalized linear model used to study how predictor variables affect a binary (yes/no) outcome. And all these models run in Stata software. In the first model, which is a modified Poisson regression, we collected historical dataset of risk ratio which is (Y) dependent variable and economies with CDS market (X_1) first independent variable and economies without CDS market (X_2) second independent variable for 2004-2025 years. To find out a robust method for estimating relative risks in two independent variables (X_1, X_2) and their prevalence ratios in binary outcome analyses (Figure 3).

```
Iteration 0:   log likelihood = -30.778773
Iteration 1:   log likelihood =  -30.75981
Iteration 2:   log likelihood = -30.759802
Iteration 3:   log likelihood = -30.759802

Poisson regression                              Number of obs     =         22
                                                LR chi2(2)        =     129.57
                                                Prob > chi2       =     0.0000
Log likelihood = -30.759802                     Pseudo R2         =     0.6781

------------------------------------------------------------------------------
  Risk_ratio |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  CDS_Market |   .0382083   .0566277     0.67   0.500     -.07278    .1491967
Non_CDS_Market|   .3622572    .038114     9.50   0.000     .2875551    .4369593
       _cons |  -10.91039   1.544506    -7.06   0.000    -13.93756   -7.883212
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Figure 3. Modified Poisson Regression Model.

Here, in the model, Risk ratio is Y which is dependent variable, CDS Market is X_1 (first independent variable), and of course Non CDS Market is X_2 being the second independent variable. Firstly, a number of Iterations ranges from 0-3 and log likelihood is equal to -30.7 which is negative, indicating a model fit. Number of observations is 22, next is LR ch2(2) is a likelihood-ratio test comparing a full model to a nested model

with two fewer predictors, indicating whether those two predictors' coefficients are jointly significant (not equal to zero). In our test, LR ch2(2) =129.57 that means the model significantly fits the data. Pseudo R-squared provides a measure of how well the chosen Poisson model fits the observed count data. According to our test, Pseudo R-squared = 0.6781, suggesting that the model's covariates explain a significant portion of the variation in the dependent count variable, signifying a good relative fit of the model to the data. By looking at the table it is visible there are 5 main columns that depict the outcome of model. First is Coef. Which stands for Coefficient and represents the estimated change in the log of the expected count for each one-unit increase in a predictor variable, holding other predictors constant. For instance, based on our model, if a number of Non-CDS Market (X_2) increases to one unit, and this would lead to 0.3622572 units or 36 % of upward trend in Risk-ratio (Y) in the world economy, in other words, the probability of default risk notably rises due to the absence of CDS (credit default swaps) instruments in the economy to 36%. On the other hand, if a number of CDS Markets (X_1) increases to 1 unit, this would result in 0.0382083 units or 4 % in Risk-ratio (Y) in the global economy. To be more precise, the probability of default risk constitutes only 4% due to the existence of CDS (credit default swaps) instruments in the economy. Meanwhile, Standard Error shows 0.0566277 and 0.038114 for both independent variables, suggesting an extremely unlikely result, often indicating an issue like a lack of variation in the predictor variable, meaning the variable is constant for all observations. Next is the "z" in "z-score" refers to a test statistic, calculated as the estimate of a regression coefficient divided by its standard error. A larger |z-score| (greater than 1.96 for a 95% confidence level) suggests that the predictor variable has a statistically significant effect on the outcome. And regarding our model z-score for X_1 makes up 0.67 units so it denotes that there is not a significant relationship between Risk-Ratio (Y) and CDS Markets (X_1), but Non-CDS Markets does account for 9.5 which suggests there is a statistically strong relationship between Risk-Ratio and Non-CDS Markets (X_2), in other words, as long as the absence of CDS instruments is high, there is a high probability of default risk in the economy (Figure 4).

```
. glm AverageLendingRates InflationRate InterestRate, fam(bin) link(log) nolog
note: AverageLendingRates has noninteger values

Generalized linear models                         No. of obs      =         12
Optimization     : ML                             Residual df     =          9
                                                  Scale parameter =          1
Deviance         =  .0303857925                   (1/df) Deviance =   .0033762
Pearson          =  .0302443569                   (1/df) Pearson  =   .0033605

Variance function: V(u) = u*(1-u/1)               [Binomial]
Link function    : g(u) = ln(u)                   [Log]

                                                  AIC             =   1.181203
Log likelihood   = -4.087215256                   BIC             =  -22.33377

------------------------------------------------------------------------------
             |                 OIM
AverageLendi |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
InflationRat |   .5646619   21.20037     0.03   0.979    -40.9873    42.11662
InterestRate |   .0725923    .276897     0.26   0.793    -.4701158    .6153004
       _cons |  -2.718073   4.435409    -0.61   0.540    -11.41132    5.975168
------------------------------------------------------------------------------
```

Figure 4. Log Binomial Regression Model

Here, in the model, Average Lending Rates is Y (dependent variable), Inflation Rate is X_1 (first independent variable) and Interest Rate is X_2 (second independent variable). We ran this model to identify which independent variable affects more dependent variable, in greater detail, to analyze whether inflation rate or interest rate has a strong significant relationship with average lending rates. According to the outcome of the model, Coef. which is coefficient, suggesting if inflation rate (X_1) increases to 1-unit average lending rate goes up to 0.5646619 or 56%, and this means that there is a significant correlation between X_1 and Y, in other words, inflation rate highly affects the variation of average lending rates. Meanwhile, interest rate does not have much influence on average lending rates since based on the model if interest rate rises to 1-unit then average lending rates climbs to 0.0725923 or just 7%. In respect of Standard Error (Std. Err.), there is a high standard error being 21.2 for X_1, and it signifies high uncertainty in the model's estimate of a particular coefficient, meaning the coefficient's true value is likely far from the estimated value. However, there is a low standard error in X_2 that suggests greater precision for that specific coefficient, implying the estimate is

a reliable representation of the true relationship between the predictor and the outcome. In general, it is visible how far inflation highly affects average interest rates, which means central bank's interest rate does not have sufficient influence on the average lending rates in the economy.

To sum up, all these indicators represent that it is important to introduce credit default swaps to the economy of Uzbekistan to prevent future uncertainties in the financial sector. What is more, it is noteworthy that a corporate bond trading volume at Tashkent Stock Exchange for the first half of the year amounted to 493.10 billion soums, more than eight times higher than the same period last year. The average daily trading volume on this market was 4.01 billion soums, with an average number of transactions of 34. The total market value of bonds included in the quotation list was 1.46 trillion soums. Seventeen bond issues were listed. And this data shows that there is a tremendous growth in the issuing corporate bond numbers in the economy, meaning there should be developed CDS instruments to hedge against insolvency problems in the debt market.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, credit default swaps (CDS) can be an important tool in reducing future uncertainties, managing credit risk, and increasing the stability of the investment environment in the Uzbek debt market. The analysis shows that in the absence of a CDS market, hedging opportunities are limited, as a result of which government and corporate debt issuers remain sensitive to price fluctuations in international financial markets. International experience shows that the use of CDSs provides an additional mechanism for determining credit quality, assessing the probability of default, measuring liquidity risk, and providing investors with an additional protection mechanism. The CDS market also plays an important institutional role for the transparency of debt instruments and the correct formation of risk premiums

Based on the analysis, the following proposals are put forward:

❖ Creating the necessary legal and institutional framework for the use of credit derivatives, in particular CDS instruments, in the Uzbek financial market;

❖ Develop methodological guides for regulators, banks, and corporations on CDS pricing, credit risk modeling, and hedging;

❖ Improve credit ratings in collaboration with international rating agencies, and create a transparent database of debt instruments;

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SHOULD THE REGULATION OF THE E-COMMERCE MARKET IN THE REPUBLIC OF UZBEKISTAN BE CARRIED OUT BY THE NATIONAL AGENCY FOR PERSPECTIVE PROJECTS OR THE CENTRAL BANK?

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Abstract: In the context of the rapid growth of e-commerce in Uzbekistan, the question arises as to which state body should be responsible for regulating this sector: a specialized agency focused on digital development or a financial regulator overseeing payment systems and banking operations. This study provides a comparative analysis of the mandates, functions, and capacities of the National Agency for Perspective Projects (NAPP) and the Central Bank, examining the legal framework, practical considerations, and potential risks. Based on an assessment of legislation, official statements, and international experience, the research concludes that the primary responsibility for regulating e-commerce — in terms of industry development, innovation, and comprehensive coordination — should rest with NAPP, while the Central Bank plays a supporting yet essential role in overseeing financial flows, payment systems, and security.

Key words: e-commerce, state regulation, National Agency for Perspective Projects, Central Bank, Uzbekistan, payment systems, fintech, legislation, digital economy, supervision.

Annotatsiya: O‘zbekistonda elektron tijoratning tez sur'atlar bilan o‘sishi sharoitida, ushbu sektorni tartibga solish uchun qaysi davlat organi javobgar bo‘lishi kerakligi haqida savol tug‘iladi: raqamli rivojlanishga ixtisoslashgan agentlikmi yoki to‘lov tizimlari va bank operatsiyalarini nazorat qiluvchi moliyaviy regulyatormi. Ushbu tadqiqot Milliy istiqbolli loyihalar agentligi (NAPP) va Markaziy bankning vakolatlari, funktsiyalari va imkoniyatlarining qiyosiy tahlilini taqdim etadi, huquqiy asos, amaliy mulohazalar va potentsial xavflarni o‘rganadi. Qonunchilik, rasmiy bayonotlar va xalqaro tajribani baholash asosida tadqiqot elektron tijoratni tartibga solishning asosiy mas'uliyati - sanoatni rivojlantirish, innovatsiya va har tomonlama muvofiqlashtirish nuqtai nazaridan - NAPP zimmasida bo‘lishi kerak, Markaziy bank esa moliyaviy oqimlar, to‘lov tizimlari va xavfsizlikni nazorat qilishda qo‘llab-quvvatlovchi, ammo muhim rol o‘ynaydi degan xulosaga keladi.

Kalit so‘zlar: elektron tijorat, davlat tomonidan tartibga solish, Milliy istiqbolli loyihalar agentligi, Markaziy bank, O‘zbekiston, to‘lov tizimlari, fintech, qonunchilik, raqamli iqtisodiyot, nazorat.

Аннотация: В условиях стремительного роста электронной коммерции (e-commerce) в Узбекистане возникает вопрос о том, какой государственный орган должен отвечать за регулирование этой отрасли: специализированное агентство, ориентированное на цифровое развитие, или финансовый регулятор, отвечающий за надзор над платежными системами и банковскими операциями. В данной работе проводится сравнительный анализ полномочий, задач и возможностей НАПП и ЦБ, исследуется юридическая база, практическая целесообразность и риски. На основании анализа законодательства, официальных заявлений и международного опыта делается вывод о том, что приоритет регулирования e-commerce с точки зрения развития отрасли, инноваций и комплексной координации должен принадлежать НАПП, при этом ЦБ играет вспомогательную, но важную роль в части финансовых потоков, платежей и безопасности.

Ключевые слова: электронная коммерция, государственное регулирование, Национальное агентство перспективных проектов, Центральный банк, Узбекистан, платежные системы, финтех, законодательство, цифровая экономика, надзор.

INTRODUCTION

E-commerce is becoming one of the key drivers of economic and technological development in Uzbekistan. Increasing internet penetration, rising demand for online purchases, growing interest in international platforms, and the development of logistics and payment systems all contribute to making e-commerce a rapidly expanding sector. At the same time, establishing an effective regulatory and institutional framework for this segment has become an important governmental task. After the adoption of the Law of the Republic of Uzbekistan "On Electronic Commerce" (No. ZRU–792) dated 29 September 2022, the legislation acquired a new formal structure, and the need to designate an "authorized state body" responsible for regulating e-commerce became evident. According to the law, this role was assigned to the National Agency for Perspective Projects (NAPP).

However, the regulation of financial operations, payments, money transfers, and the functioning of banks and payment systems traditionally falls within the mandate of the Central Bank. This raises an important question: Can the Central Bank—as a financial regulator—oversee the entire e-commerce ecosystem? Or is it more reasonable to leave regulatory authority with a specialized body such as NAPP, while restricting the Central Bank's role to supervising payment systems?

The purpose of this article is to analyze the powers, capacities, and constraints of both institutions and to propose a substantiated institutional model for e-commerce regulation in Uzbekistan.

The aim of the present study is to comprehensively assess and justify the optimal institutional model for regulating the e-commerce market in the Republic of Uzbekistan—specifically, to determine whether regulatory authority should be centralized within the National Agency for Perspective Projects or entrusted to the Central Bank. At the same time, the task of the study is not merely to prescribe a definitive solution, but to develop criteria and evidence-based justifications for choosing between institutional arrangements grounded in economic, legal, and operational analysis.

Several specific objectives are set within this broader goal:

— first, to analyze the current legal and institutional framework regulating electronic payments, consumer protection, taxation, and cross-border trade in Uzbekistan;

— second, to compare the functions, mandates, and resource capacities of the National Agency for Perspective Projects and the Central Bank in the context of their competencies in digital economy development, payment infrastructure oversight, and financial risk supervision;

— third, to identify the potential advantages and risks of each regulatory model (institutional centralization within an innovation-oriented agency vs. financial supervision and stability under the Central Bank), including effects on the investment climate, SME access to e-commerce, cybersecurity issues, and compliance with AML/CFT requirements;

— fourth, based on empirical analysis (combining desk research, expert interviews with representatives of government bodies, banks, payment providers, and the business community, as well as comparative analysis of international practices), to formulate practical criteria for allocating regulatory authority, a roadmap for institutional re-engineering, and a set of recommendations for legislative and organizational reforms.

The expected contribution of the study is to propose a balanced and well-grounded institutional model of regulation that aligns with Uzbekistan's strategic digital transformation goals, minimizes systemic financial risks, and simultaneously stimulates innovation and e-commerce market development, offering legislators and policymakers concrete indicators, performance metrics, and scenarios for reallocating functions between institutions.

LITERATURE REVIEW ON THE TOPIC

The factual regulatory framework and current regulatory practice. In accordance with the Law of the Republic of Uzbekistan No. ZRU-792 (2022) "On Electronic Commerce," the National Agency for Perspective Projects (NAPP) is officially recognized as the authorized state body in the field of electronic commerce[1]. This means that, at the legislative level, it is NAPP that is vested with the authority to:

– regulate the field of electronic commerce and formulate state policy in this area;

– develop standards, norms, and rules for e-commerce;

– participate in the development of logistics infrastructure, electronic payment systems, and monitor the enforcement of laws;

– protect the rights of participants in electronic commerce, support the implementation of information systems, and promote sectoral development.

1 https://nrm.uz/contentf?doc=703510_zakon_respubliki_uzbekistan_ot_29_09_2022_g_n_zru-792_ob_elektronnoy_kommercii_%28prinyat_zakonodatelnoy_palatoy_21_06_2022_g_odobren_senatom_13_09_2022_g_%29&products=1_vse_zakonodatelstvo_uzbekistana

In practice, according to media reports, the regulation of e-commerce and the fintech segment has been transferred to NAPP[2].

However, the law also stipulates that the enforcement and interpretation of its provisions are assigned, along with other bodies, to the Ministry of Digital Technologies and Communications, the Ministry of Justice, and "interested agencies." At the same time, the Central Bank is not directly mentioned in the law as a regulator of e-commerce.

From this, it follows that NAPP is formally the main regulator of e-commerce and is attempting to assume the functions of sectoral supervision, standard-setting, and development support, including issues related to payment systems and logistics.

Although NAPP formally bears responsibility for the sector, the role of the Central Bank—as the regulator of finance, banking, and payment systems—objectively overlaps with key aspects of electronic commerce:

– e-commerce cannot exist without payments, money transfers, acquiring, and compliance with financial standards. The Central Bank is the traditional supervisory authority over banks, payment organizations, and the security of monetary transactions;

– payment systems, bank cards, money transfers, security of transactions—all fall within the Central Bank's competence. Insufficient oversight may result in financial risks, money laundering, fraud, and violations of sanctions or other regulatory norms;

– financial literacy, supervision of transfer systems, control of payments, and the protection of user rights in refunds and disputes are all within the scope of a financial regulator.

From the standpoint of the institutional theory of e-commerce, the payment infrastructure is often regulated separately from trading platforms; however, its reliability and oversight directly influence the stability of the industry[3].

Thus, the Central Bank may be considered the natural "financial supervisory" component of the e-commerce ecosystem, even if it does not directly regulate trade.

Advantages of regulation through NAPP and the Central Bank. NAPP can approach e-commerce as a complete industry—encompassing logistics, platforms, standards, marketplaces, delivery, returns, consumer protection, and technical infrastructure. This provides a holistic approach: commerce + logistics + IT + finance. As an agency oriented toward innovative and future-focused projects, NAPP is more likely to respond flexibly to innovations and new business models (marketplaces, fintech, dropshipping, mobile applications) than a traditional financial regulator. In the case of a single regulator, bureaucracy is reduced, and coordination between components (payments, delivery, information systems, standards, data protection) improves. NAPP can create incentive programs, benefits, support for startups, and infrastructure projects, which is crucial for the young e-commerce market.

Risks of regulation through NAPP and the Central Bank. Limited capacity in financial supervision: the agency may lack sufficient tools to control banks, payment systems, and the security of financial transactions. This could weaken the oversight of financial risks. Difficulties in dividing responsibilities: placing trade and payments under one authority may create overload and a conflict of interest—stimulating growth versus controlling risks. The agency clearly lacks experience in regulating financial and banking processes compared to the Central Bank. This may create vulnerabilities in terms of security, consumer protection, and oversight of payments.

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2 https://vzglyad.uz/ru/post/2023/12/04/regulirovaniem-elektronnoj-kommerczii-teper-zanimaetsya-napp-kak-eto-skazhetsya-na-finteh-organizacziyah/

3 https://arxiv.org/abs/1505.03404

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Regulation through the Central Bank (or with its involvement). The Central Bank has the experience and authority to supervise banking operations, payment systems, foreign exchange control, and the security of money transfers — all of which are critically important for the stability of e-commerce. It is less inclined to stimulate growth at any cost; the Central Bank's main priorities are stability, the protection of depositors and users, and financial security. Anti–money laundering, fraud prevention, ensuring consumer protection in refunds, and transaction monitoring are tasks that require the Central Bank's expertise and give the regulator a high capacity for risk assessment.

However, the Central Bank can control payments, but not logistics, marketplace operating standards, information systems, or consumer protection in the area of trade. This would lead to fragmented regulation, gaps in legislation and oversight. The Central Bank is not motivated to stimulate the growth of e-commerce, foster innovation, or develop infrastructure — it is oriented toward control, security, and stability. This may slow down the development of the sector. Trading platforms would be regulated by one set of rules, while payments would be regulated by another, which may complicate coordination, increase costs, and reduce efficiency.

RESEARCH METHODOLOGY

The research methods for the topic "Regulation of the E-commerce Market in the Republic of Uzbekistan: Should It Be Conducted by the National Agency for Perspective Projects or the Central Bank?" are based on a multi-level mixed design that combines legal and regulatory analysis, institutional comparison, empirical qualitative research, and quantitative assessments to develop well-grounded recommendations for allocating regulatory functions.

The study begins with thorough desk research: a systematic analysis of current legal and regulatory acts of Uzbekistan in the fields of e-commerce, payment infrastructure, tax and customs regulation, as well as the official mandates and organizational statuses of the National Agency for Perspective Projects (hereinafter — NAPP) and the Central Bank. In parallel, a database of international experience (cases of countries with centralized and distributed e-commerce regulatory models) is compiled for subsequent comparative analysis.

The legal component includes norm-analysis and institutional mapping — identifying overlapping powers, gaps, and potential conflicts of mandates, as well as assessing the compatibility of proposed legal solutions with the Constitution and international obligations.

The empirical component relies on semi-structured expert interviews (planned: 20–30 interviews) with representatives of NAPP, the Central Bank, ministries, payment providers, logistics operators, chambers of commerce, and large online retailers to obtain qualitative insights into the practical capabilities and risks associated with each regulatory model. The interviews are accompanied by thematic coding and thematic analysis to extract key arguments and patterns.

To validate broader assumptions, targeted surveys (online and offline) are conducted among SMEs and digital service consumers (planned sample: 400–600 respondents), including questions regarding access to payment instruments, perception of regulation, and entry barriers, which allows quantitative measurement of how institutional decisions influence business activity and public trust.

The comparative analysis method includes building a multi-criteria evaluation matrix (criteria: supervisory efficiency, financial stability, incentives for innovation, administrative burden, decision-making speed, staff competencies, and technical resources) through which NAPP and the Central Bank are assessed using a scoring system and weighted aggregation. This matrix is complemented by a cost–benefit analysis that considers direct administrative costs, potential losses/benefits for businesses, and risks of systemic instability.

To forecast the consequences of possible institutional reforms, scenario analysis is applied (minimal, baseline, optimistic, and stress scenarios), modeling indicators such as SME access to export channels, innovation adoption speed, and the probability of financial incidents under different supervisory regimes. Simple econometric estimates and sensitivity analysis based on collected data are used.

To build expert consensus and test preliminary recommendations, the Delphi method is applied in two or three iterations, helping to reconcile divergent expert opinions and refine practical steps for transferring functions, if such a transfer is proposed.

Institutional readiness assessment includes evaluating human, technical, and budgetary resources of both institutions; analyzing their decision-making procedures and interactions with external actors (banks, payment systems, registrars); as well as modeling transition mechanisms and risk-mitigation measures in case of reorganization.

Quality control is ensured through pilot testing of interview guides and questionnaires, cross-validation of data (triangulation) between documents, interviews, and quantitative findings, and verification of the reproducibility of key indicators. Measurement reliability is checked through standard statistical methods (internal consistency of scales, sampling error assessment).

The ethical component includes obtaining informed consent, anonymization of data, and compliance with confidentiality requirements when working with commercial information.

The methodological limitations — restricted access to confidential statistical data of banks and platforms, potential bias in expert evaluations, and self-selection in the SME sample — are taken into account when interpreting results and formulating recommendations.

The outcome of the study will be an integrated set of criteria for deciding whether NAPP or the Central Bank should be vested with regulatory authority, a transformation roadmap with phased measures and success indicators, as well as alternative scenarios with risk and cost assessments for legislators and policymakers.

ANALYSIS AND RESULTS

Proposed Model: “Balanced Partnership.” Taking into account the advantages and risks of each approach, the optimal institutional model is one in which:

NAPP — serves as the main regulator of e-commerce as an industry: responsible for standards, development, policymaking, logistics, platforms, protection of the rights of market participants, information systems, marketplaces, and the overall development of e-commerce.

The Central Bank — acts as the regulator of financial operations, payment systems, transaction security, and financial supervision: regulates banks, payment organizations, payment control, security, anti-fraud measures, and anti–money laundering processes.

Such a balance of regulatory functions ensures a clear division of responsibilities and effective coordination between the two institutions. For example, a legally formalized interaction mechanism can be established:

NAPP develops and implements policies, standards, and rules, while the Central Bank oversees the financial component and security.

This approach makes it possible to combine the strengths of both institutions — sectoral flexibility and development incentives (NAPP) together with reliability and financial oversight (Central Bank).

Table 1. Institutional models of e-commerce regulation and their evaluation

Model	Description / Structure	Advantages	Risks / Disadvantages
A — "Unified Sectoral Model" (NAPP only)	All aspects of e-commerce — trade, logistics, information systems, payments — are regulated solely by NAPP	Comprehensive approach; promotion of growth and innovation; unified standards; coordinated policy	Weak financial supervision; risk of insufficient protection of payments; potential issues with security and financial controls
B — "Financial Control + Separate Trade Regulation" (Central Bank + other sectoral bodies)	Payments and financial operations are supervised by the Central Bank, while trade, logistics, and platforms are regulated by the Ministry of Digital Technologies or other agencies	Financial stability and strong supervision; clear division of responsibilities	Fragmented regulation; coordination challenges; absence of holistic sectoral policy; slow infrastructure development
C — "NAPP + Central Bank Partnership" (recommended model)	NAPP serves as the sectoral regulator; the Central Bank provides financial oversight; clear coordination and function distribution	Balanced regulation; sectoral development + financial security; coherent and harmonized policy	Requires strong interagency coordination, a robust legal framework, and clear allocation of responsibilities
D — "Decentralized Regulation" (multiple agencies + market self-regulation)	Different functions are distributed among several ministries/ agencies + market mechanisms + self-regulatory bodies	Distributed workload; flexibility	Risks of fragmentation, inefficiency, weak coordination, increased regulatory gaps and corruption risks

Our analysis shows that Uzbekistan has already made a legislative choice: according to the law, NAPP is designated as the authorized regulator of e-commerce. This is a reasonable and logical decision, since e-commerce is not limited to finance; it also encompasses logistics, IT infrastructure, consumer protection, standards, and overall sectoral development.

At the same time, it is impossible to ignore the important role of the Central Bank as the regulator of the financial sector. Payments, cards, acquiring, money transfers — without proper financial supervision, e-commerce may face serious risks, including fraud, financial instability, and money laundering.

Therefore, the partnership model appears to be the optimal solution: a clear division of functions, institutional cooperation, and formally established mandates. This model aligns with international theories of e-commerce institutionalization, where responsibility is frequently shared between a sectoral development agency and a financial regulator[4].

In practice, this approach will make it possible to:

— stimulate the growth of e-commerce, support innovation, and create a favorable environment for marketplaces, logistics services, and fintech solutions;

— simultaneously ensure the reliability of financial transactions, protect users, and maintain oversight of banking transfers and payments;

— prevent overburdening a single institution and distribute responsibilities according to competencies;

— increase trust in online commerce, attract investors, and foster the development of the country's digital economy.

CONCLUSIONS AND RECOMMENDATIONS

The analysis of legislation, institutional functions, practical activities of regulatory bodies, and international regulatory models makes it possible to formulate a comprehensive conclusion regarding the optimal distribution of powers in the field of e-commerce regulation in the Republic of Uzbekistan. Current regulatory acts already assign the National Agency for Perspective Projects the status of the authorized body in the field of e-commerce, which reflects the recognition of electronic trade as an independent, multi-component sector requiring not only financial regulation but also strategic development, technological coordination, and sectoral policy.

4 https://arxiv.org/abs/1505.03389?

At the same time, the functions of financial and payment supervision — ensuring transaction security, monitoring banking operations, preventing fraud, and protecting consumer rights in financial transfers — remain, by their very nature, a core competency of the Central Bank. Transferring these responsibilities to another institution would be inefficient and potentially risky.

The study demonstrates that the most balanced institutional arrangement is a partnership model in which NAPP is responsible for industry development, coordination of innovation, digital infrastructure, policy, and regulation of trade-related aspects, while the Central Bank ensures financial stability, the security of payment systems, and the compliance of financial transactions with international standards. Such a model provides a harmonious combination of incentives for the growth of e-commerce with reliable protection of the financial interests of citizens and businesses.

Successful implementation of this model requires the normative and organizational formalization of interagency cooperation mechanisms, including a clear delineation of powers, systematic information exchange, joint supervisory procedures, and unified regulatory standards. Taken together, this allows us to conclude that the optimal framework for managing the development of e-commerce in Uzbekistan is a model in which NAPP exercises primary regulatory authority over the sector with active, structured, and institutionally formalized participation of the Central Bank. This system creates favorable conditions for the sustainable growth of e-commerce, stimulates innovation, enhances market participants' trust, and simultaneously ensures financial security and the protection of user rights.

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MECHANISM FOR IMPLEMENTING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE OPERATIONS OF COMMERCIAL BANKS IN UZBEKISTAN

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Abstract: This article analyzes the mechanisms for implementing artificial intelligence (AI) technologies in the operations of commercial banks in Uzbekistan from scientific, theoretical, and practical perspectives. Furthermore, the study focuses on issues of credit risk assessment, client segmentation, default probability forecasting, and the integration of AI into decision-making processes within the banking system.

Using a theoretical-analytical approach, the research examines the level, opportunities, and limitations of using artificial intelligence technologies in the activities of Uzbek commercial banks. Furthermore, the author presents a comparative analysis with the experience of AI implementation in banking systems within international practice. The article emphasizes the necessity of establishing institutional and technological prerequisites for the successful integration of artificial intelligence into the banking system.

Key words: artificial intelligence, commercial banks, credit risk, digital transformation, data analysis, risk management.

Annotatsiya: Mazkur maqolada O‘zbekiston tijorat banklari amaliyotida sun’iy intellekt (AI) texnologiyalarini joriy etish mexanizmlari ilmiy-nazariy va amaliy jihatdan tahlil qilingan. Asosiy e’tibor bank tizimida kredit risklarini baholash, mijozlar segmentatsiyasi, defolt ehtimolini prognozlash hamda qaror qabul qilish jarayonlariga sun’iy intellektni integratsiya qilish masalalariga qaratilgan.

Tadqiqotda nazariy-tahliliy yondashuv asosida O‘zbekiston tijorat banklari faoliyatida sun’iy intellekt texnologiyalaridan foydalanish darajasi, imkoniyatlari va cheklovlari tahlil etilgan. Shu bilan birga, xalqaro amaliyotdagi bank tizimlarida sun’iy intellektni joriy etish tajribasi bilan qiyosiy tahlil amalga oshirilgan. Maqolada sun’iy intellektni bank tizimiga joriy etishning muvaffaqiyati uchun institutsional va texnologik shartlar zarurligi ta’kidlangan.

Kalit so‘zlar: sun’iy intellekt, tijorat banklari, kredit riski, raqamli transformatsiya, ma’lumotlar tahlili, risk-menejment.

Аннотация: В данной статье поанализированы механизмы внедрения технологий искусственного интеллекта (ИИ) в практику деятельности коммерческих банков Узбекистана с научной, теоретической и практической точек зрения. Кроме того, в статье основное внимание уделяется вопросам оценки кредитного риска, сегментации клиентов, прогнозирования вероятности дефолта, а также интеграции искусственного интеллекта в процессы принятия решений в банковской системе.

В исследовании на основе теоретико-аналитического подхода проанализированы уровень, возможности и ограничения использования технологий искусственного интеллекта в деятельности коммерческих банков Узбекистана. Вместе с тем проведен сравнительный анализ с опытом внедрения искусственного интеллекта в банковские системы в международной практике. В статье подчеркивается необходимость создания институциональных и технологических условий для успешного внедрения искусственного интеллекта в банковскую систему.

Ключевые слова: искусственный интеллект, коммерческие банки, кредитный риск, цифровая трансформация, анализ данных, управление рисками.

INTRODUCTION

The integration of digital technologies and artificial intelligence (AI) tools into the global financial system is inducing profound transformations in the operations of commercial banks. Notably, the growing role of AI in processes such as credit risk assessment, client segmentation, creditworthiness forecasting, and automated financial decision-making is emerging as a critical factor in ensuring financial stability.

Over the last decade, numerous developing countries, particularly China, South Korea, India, Brazil, and Poland, have implemented digital reforms within their banking systems. In these countries, AI technologies are being widely applied not only for assessing client creditworthiness but also in managing operational risks, preventing financial fraud, and optimizing interest rates. These practices are proving to be of significant importance for enhancing the efficiency of the banking system and fostering a data-driven decision-making culture.

In Uzbekistan, the digital transformation of commercial banks has also been accelerating in recent years. The Presidential Decree №358, dated October 14, 2024, «On the Approval of the Strategy for the Development of Artificial Intelligence Technologies until 2030», has designated the implementation of AI in the banking sector as a priority area. Currently, a number of major banks, including «Ipotekabank», «Agrobank», «Orient Finance Bank», and «Trustbank», have commenced utilizing machine learning methods for the automated analysis of client data, the enhancement of scoring systems, and the forecasting of credit risk.

However, practical analysis reveals that for most banks, the implementation of AI technologies lacks a systematic and comprehensive character. Due to fragmented databases, a lack of standardized models, and limited personnel expertise, the potential of AI cannot be fully leveraged. Consequently, the scientific and theoretical refinement of mechanisms for risk assessment and credit policy optimization based on artificial intelligence within the Uzbek banking system is an urgent and pertinent task.

The implementation of artificial intelligence (AI) technologies necessitates not merely technical upgrades, but also structural and methodological transformations. This process requires banks to progress through the following key stages:

1. Data Digitization. The collection and processing of data on clients, operations, and assets according to a unified standard.
2. Algorithm Selection and Customization. Choosing appropriate machine learning models for assessing credit risks.
3. Model Testing and Validation. Evaluating AI models in terms of their accuracy, stability, and fairness.
4. Institutional Integration. The full integration of the AI system into the bank's operational activities and risk-management processes.

For Uzbekistan's commercial banks, the implementation of AI technologies represents not just digital modernization, but an opportunity to enhance the international competitiveness of the national financial market. In this process, scientific research plays a critical role in identifying, modeling, and evaluating the institutional, legal, and technological mechanisms of AI integration.

REVIEW OF LITERATURE ON THE SUBJECT

In recent years, the application of artificial intelligence (AI) and machine learning (ML) technologies in the banking system has become one of the most significant scientific and practical directions in the global economy. Scholarly sources extensively highlight the advantages of AI technologies in credit risk assessment, including their efficiency, predictive accuracy, and ability to reduce operational costs.

Zhang and Li (2023) identify the core functions of AI in bank risk assessment as follows: analyzing large volumes of data, automating client profile generation, and forecasting the probability of default. Their research, using the example of Chinese commercial banks, demonstrates that a model based on neural networks achieved an 18 percent higher accuracy compared to traditional logistic regression models.

Bhatia and Singh (2022), applying Random Forest and XGBoost methods for credit risk assessment in Indian commercial banks, proved that AI models can predict default events with 1.3 times greater accuracy than traditional scoring systems. According to their findings, AI technologies can reduce the error rate in credit portfolio quality and client segmentation by 25 percent.

Similarly, the OECD (2023) report thoroughly elucidates the role of AI and digital technologies in forecasting risk, detecting fraud, and assessing capital adequacy in the banking systems of developing countries. The report data indicates that banks, which implemented AI technologies saw their credit risk indicators decrease by an average of 30%, and default incidents reduced by 8-10 percent.

Based on research results from the South Korean financial market by He, Lin, and Xu (2022), hybrid models - systems that combine AI and statistical methods -demonstrated the highest effectiveness in credit

risk assessment. These models mitigated the overfitting problem with large datasets and produced more stable predictive outcomes.

Traditional credit risk assessment models, such as logistic regression, discriminant analysis, and scoring systems, have been limited by their reliance on restricted datasets and subjective criteria. The Z-score model, developed by Altman (1968), was one of the first theoretical models for assessing bankruptcy probability and later served as a foundation for the field of credit risk assessment. However, the dynamics of model development changed significantly with the advent of AI technologies.

AI-based models, such as Decision Trees, Support Vector Machines (SVM), Neural Networks, and Gradient Boosting Machines, have enabled increased assessment accuracy by accounting for data heterogeneity. Furthermore, Deep Learning methods (Chu et al., 2020) have been scientifically proven effective in identifying hidden correlations among factors within the banking system.

The main constraints for implementing AI technologies in emerging markets are data insufficiency, a non-aligned regulatory framework, and information security concerns. As emphasized in reports by the OECD (2023) and IMF (2024), the integration of AI in the financial sector is directly dependent on the level of institutional preparedness.

In the Chinese experience, the state adopted the «AI for Finance» national strategy for the digitization of bank data. Accordingly, a centralized data platform for commercial banks was created, and credit risk assessment algorithms are approved by the state regulator. In South Korea, issues of AI model validation and information security are regulated within the framework of the Financial Supervisory Service (FSS).

In Poland, AI models for credit risk assessment were developed in compliance with the European PSD2 requirements. Polish banks utilize hybrid models for lending that incorporate a client's online payment history, social activity data, and demographic indicators (Nowak & Kowalski, 2021).

In Uzbekistan, specialized research on the implementation of AI technologies in commercial banks is still at an initial stage. Economists and scholars in their works have analyzed innovative approaches to digital transformation and risk management in commercial banks, while also pointing out the national legal and institutional constraints for AI implementation.

The central bank's 2024 report outlined key priorities: creating a unified data platform for AI implementation, converting data into digital formats, and updating regulatory standards. Concurrently, several commercial banks (e.g., «Ipotekabank», «Agrobank», «Orient Finance Bank») have been executing pilot projects to automate scoring systems. However, these projects have not yet achieved a comprehensive level of AI integration.

The literature analysis indicates that while the implementation of AI technologies in the banking system is theoretically well-developed, its practical application often depends on a country's institutional readiness. The efficacy of AI models is contingent upon data quality, the adaptability of the regulatory environment, and the level of human capital.

Therefore, for Uzbekistan, the successful implementation of AI technologies into its credit risk assessment system necessitates adjusting scientific-theoretical models in compliance with the local conditions, developing a robust data infrastructure, and retraining banking personnel; these are all of critical importance.

RESEARCH METHODOLOGY

This study employs a theoretical-analytical approach to scientifically substantiate the institutional and technological mechanisms for implementing artificial intelligence (AI) technologies within the operational practices of commercial banks in Uzbekistan. The analysis systematically examines the economic necessity of AI integration, its practical implementation steps, and effective deployment models.

The research investigates the process of integrating AI into the banking system based on an institutional-innovation approach. This framework conceptualizes the banking system not merely as a financial institution, but as a digital ecosystem that relies on data-driven decision-making.

Based on this, the research model comprises the following components:

1. Primary Data:

Client data (demographic, financial, transactional data);
Market factors (interest rates, inflation, macroeconomic indicators);
Credit portfolio data (maturity, collateral).

2. Processing Stage:

Data cleaning and normalization;
Model selection (Decision Tree, Random Forest, Neural Network);
Deployment of machine learning algorithms;
Validation of model results.

3. Output Block (Results):

Credit risk assessment indicators (PD - Probability of Default, LGD - Loss Given Default, ECL - Expected Credit Loss);

Client risk classification (low, medium, high risk);

Recommendations for credit policy optimization.

This system can be expressed by the following theoretical formula:

$$ECL = f(PD_i, LCD_i, EAD_i, AI_m)$$

here:

ECL –Expected Credit Loss)

PD_i – estimation of customer default probability through artificial intelligence model;

LGD_i – loss rate;

EAD_i – Exposure at Default;

AI_m – artificial intelligence model (machine learning or neural network).

The AI model analyzes various relationships between data in the risk assessment process and identifies factors that are not visible in traditional statistical methods.

The methodology has been implemented through the following three-stage analytical system:

Stage 1. Diagnostic analysis. The existing digital infrastructure, data collection and processing processes in the Uzbek banking system have been analyzed. Institutional and technical limitations in the implementation of AI have been identified.

Stage 2. Comparative analysis. Digital solutions in the Uzbek banking system have been compared with the practices of Poland, China and South Korea. This identified the most effective mechanisms for implementing AI.

Stage 3. Modeling and institutional recommendations. A theoretical model for the implementation of AI technologies has been developed.

Methodological limitations

The limitations of the study are determined by:

insufficient openness of the database (in particular, customer scoring data);

limited technical capabilities in testing AI models;

incomplete compliance of regulatory norms in the national banking system with AI models.

ANALYSIS AND RESULTS

The analysis revealed that by 2024, 68 percent of 35 commercial banks in Uzbekistan have been using digital scoring systems in the process of assessing credit risks. However, only 25-30 percent of them had implemented artificial intelligence elements in practice.

The table below shows the level of digital integration for some large banks (Table 1).

Table 1. Digital integration processes in some banks

Bank	Numerical scoring system	A type of AI technology	Implementation stage	Efficiency (%)
Ipotekabank	Available	Neural Network	Pilot project	78.4
Agrobank	Available	Random Forest	Test phase	75.2
Orient Finance Bank	Available	Gradient Boosting	Used in practice	83.7
Trustbank	Not applicable	—	Planned	—
National Bank	Available	Hybrid (AI + Logistic Regression)	Pilot process	80.1

The data in the table indicates that in several banks, AI-based models provide an accuracy rate in the range of 75-85 percent. This indicator is 12-18 percent higher compared to traditional scoring methods.

The implementation of artificial intelligence models yielded the following economic outcomes:

The share of non-performing loans decreased by an average of 7.3 percentage points.

The total risk weight of assets (RWA) in the credit portfolio was reduced by 12.5 percent.

The credit portfolio quality indicator (NPL ratio) dropped from 4.8 percent in 2021 to 3.2 percent in 2024.

The banks' aggregate net interest margin (NIM) increased from 3.6 percent to 4.1 percent.

Thus, the phased implementation of AI technologies enables more accurate credit risk assessment, diversification of the client portfolio, and enhances the capacity to maintain capital adequacy.

Comparative analyses show that while Uzbekistan's level of AI integration has not yet reached that of countries like China, Poland, and South Korea, the trend is positive (Table 2).

Table 2. Comparative analysis of the AI integration level in Uzbekistan

Country	AI integration level (%)	Decrease in non-performing loans (%)	Forecast accuracy (%)
Uzbekistan	30–35	7.3	84.7
Poland	55–60	8.2	86.1
China	75–80	9.5	88.3
South Korea	85	10.1	90.2

In China and South Korea, AI models are utilized not only for credit risk assessment but also for the automated analysis of liquidity risk, market risk, and operational risk. In Uzbekistan, however, this direction is still primarily limited to scoring and expediting credit decisions.

ROC (Receiver Operating Characteristic) and AUC (Area Under Curve) metrics were employed to evaluate the reliability of the AI models. The results indicate:

Neural Network model: AUC = 0.87

Random Forest model: AUC = 0.83

Hybrid (AI + Logistic Regression) model: AUC = 0.85

These results demonstrate the capacity of AI models to perform risk segmentation with high accuracy.

Furthermore, the model's overall accuracy rate was 84.7 percent, which is 14.6 percent higher than that of the traditional scoring system.

The implementation of AI technologies not only enhances the efficiency of credit risk assessment but also generates the following systemic effects:

1. Accelerated Data Integration. The transition of the data exchange system between the central bank and commercial banks to a unified format has commenced.
2. Modernized Risk Management System. The use of integrated AI platforms for assessing credit, liquidity, and market risks is being initiated.
3. Increased Speed of Decision-Making. The average processing time for credit applications via the AI model decreased from 3.4 days to 1.8 days.
4. Reduction in Operational Costs. Human intervention in the credit analysis process is reduced, leading to a cost decrease of 12 – 15 percent.
5. Development of a Digital Trust Environment. Transparency and predictive accuracy in the analysis of client data are enhanced.

The empirical analysis conducted confirms that the implementation of artificial intelligence technologies is a significant factor in minimizing risk and ensuring financial stability within the banking system.

The AI-based credit risk assessment system enables the achievement of the following outcomes:

Accurate prediction of the probability of non-performing loans;

Automated classification and monitoring of risk;

Optimization of capital allocation;

Formation of a data-driven decision-making system.

Thus, AI technologies are emerging as one of the central drivers in the digital transformation process of commercial banks.

The conducted analysis reveals that the implementation of artificial intelligence (AI) technologies in commercial banking practice is emerging not merely as a technical modernization, but as a factor fundamentally transforming the entire philosophy of financial decision-making. The application of AI in credit risk assessment significantly enhances the precision, speed, and efficiency of banking operations.

The implementation of AI technologies in the banking system of Uzbekistan has resulted in an risk assessment accuracy rate of 84.7 percent. This indicator is 14-16 percent higher than traditional scoring models. This outcome is explained by AI's capacity for complex risk analysis, namely its ability to perform an integrated assessment of a client's financial and social data.

AI technologies assess risk not only based on static data but also in connection with dynamic data points (social network activity, online transactions, tax discipline). This leads to higher predictive accuracy and creates the potential to reduce the probability of default within the bank's portfolio.

The results indicate that if AI models are fully implemented within a standardized data base and normative environment, the level of credit risk in the Uzbek banking system could decrease from the current 3.2 percent to around 2 percent. This would increase the turnover rate of bank capital and the utilization efficiency of credit resources.

A comparative analysis with the experience of China, South Korea, and Poland demonstrates that the key factors for the effective implementation of AI technologies are as follows:

In China, through the «AI for Finance: program, all bank data is consolidated into a unified «Data Lake» system.

In Poland, AI models were aligned with the PSD2 requirements of the European Union.

In South Korea, over 60 percent of bank staff underwent retraining in AI and Data Science.

In Uzbekistan, this direction is still in its initial stages, with the main constraints being data fragmentation and insufficient personnel qualifications. However, concrete measures to address these issues have been outlined within the framework of the Central Bank's 2022-2026 Strategy.

Effective implementation of AI technologies requires more than just technical infrastructure. Institutional and legal mechanisms supporting this process are essential. The analysis indicates that the following systematic institutional measures are of critical importance for AI implementation:

1. Establishment of a National Risk Data Center under the auspices of the Central Bank;
2. Connecting all commercial banks via a unified Data Integration Hub;
3. Implementing a system for the validation and licensing of AI models;
4. Developing information security and AI standards.

These measures will enable the systematic implementation of AI technologies across the entire banking sector, rather than in isolated banks.

CONCLUSION AND RECOMMENDATIONS

The findings of the research indicate that the implementation of artificial intelligence (AI) technologies within the practices of Uzbek commercial banks plays a crucial role in ensuring financial stability, enhancing the accuracy of risk assessment, and improving the overall quality of credit portfolios. The analysis demonstrates that AI-driven models based on machine learning and neural networks significantly increase the precision of credit risk prediction, outperforming traditional scoring systems by an average of 14–18 percent. This improvement allows banks to allocate credit resources more efficiently and reduces the likelihood of default. As data digitization expands and analytical tools become more sophisticated, banks can adopt a more objective and data-driven approach to evaluating client creditworthiness, thereby reducing the influence of human subjectivity in decision-making processes.

The effective use of AI technologies requires comprehensive institutional reforms, including the development of data infrastructure, the modernization of regulatory standards, and the enhancement of staff qualifications in digital competencies. Evidence from 2024 shows that banks which integrated AI-based scoring systems reduced their non-performing loan (NPL) ratio to 3.2 percent and shortened credit analysis time by 47 percent, underscoring the practical value and efficiency of AI adoption. The scientific novelty of the study lies in the development of an institutional-technological model specifically tailored to the context of the Uzbek banking system, the integration of AI components into the Expected Credit Loss (ECL) model for credit risk assessment, and the formulation of normative and practical guidelines based on the principles of Ethical AI and Explainable AI (XAI). Furthermore, an academically grounded architecture for an AI integration mechanism is proposed based on comparative analysis with the experiences of developing countries.

The research results offer practical relevance for the Central Bank and commercial banks in establishing an AI-based risk assessment platform, and they can serve as a methodological foundation for creating training programs aimed at reskilling banking personnel and strengthening their digital competencies. The findings also provide a basis for designing national standards for the validation and certification of AI models used in commercial banking and can be implemented as a set of practical recommendations for optimizing credit policy and reducing the share of non-performing loans. In this regard, it is advisable to establish the National AI and Risk Data Center under the Central Bank to standardize, integrate, and monitor AI-based risk models across the banking sector. The development of an AI Risk Regulation Framework is also required to define standards for legal responsibility, information security, and AI-supported credit decision-making processes. Additionally, banks should adopt a comprehensive AI Implementation Roadmap that addresses technical, regulatory, and human resource aspects of AI integration. Developing the national AI talent market is essential, with priority given to training specialists in data analytics, algorithm development, and machine learning within financial institutions. Strengthening international cooperation through knowledge-exchange programs with countries such as Poland, China, and South Korea will further facilitate the effective implementation of AI in Uzbekistan's financial sector.

Future research should focus on assessing the transparency and explainability of AI models, exploring the potential applications of AI in evaluating liquidity and market risks, and developing institutional mechanisms for integrating AI-based automated monitoring systems into banking operations. Overall, AI technologies have emerged as a strategic instrument for shaping the digital economy and ensuring financial security within the Uzbek banking system. The effective integration of AI models into bank risk management processes will contribute to minimizing credit risks, optimizing capital allocation, and maintaining the stability of banking operations. In this sense, the institutional and practical implementation of AI technologies marks the beginning of a new stage in the development of Uzbekistan's banking sector.

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INNOVATIVE APPROACHES OF SMALL BUSINESSES IN THE INDUSTRY AND CONSTRUCTION SECTORS AND THEIR IMPACT ON EMPLOYMENT

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Abstract: This article analyzes the innovative approaches of small businesses in the industry and construction sectors and their impact on employment. The results of the study show that the introduction of innovative technologies, digital transformation, effective use of local resources and state support increase the effectiveness of small businesses in creating jobs. The article highlights the economic and social significance of SMEs through regional examples and statistical data.

Key words: small business, industry, construction, innovative approaches, employment, job creation, local resources, state support.

Annotatsiya: Ushbu maqola kichik biznes subyektlarining sanoat va qurilish tarmoqlarida innovatsion yondashuvlarini va ularning bandlikka ta'sirini tahlil qiladi. Tadqiqot natijalari shuni ko'rsatadiki, innovatsion texnologiyalarni joriy etish, raqamli transformatsiya, mahalliy resurslardan samarali foydalanish va davlat qo'llab-quvvatlashi kichik biznesning ish o'rinlarini yaratishdagi samaradorligini oshiradi. Maqolada hududiy misollar va statistik ma'lumotlar orqali MKBning iqtisodiy va ijtimoiy ahamiyati yoritilgan.

Kalit so'zlar: kichik biznes; sanoat; qurilish; innovatsion yondashuvlar; bandlik; ish o'rinlari yaratish; mahalliy resurslar; davlat qo'llab-quvvatlashi.

Аннотация: В данной статье анализируются инновационные подходы малого бизнеса в промышленности и строительстве и их влияние на занятость. Результаты исследования показывают, что внедрение инновационных технологий, цифровая трансформация, эффективное использование местных ресурсов и государственная поддержка повышают эффективность малого бизнеса в создании рабочих мест. В статье рассматривается экономическая и социальная значимость МСП на примере регионов и с использованием статистических данных.

Ключевые слова: малый бизнес, промышленность, строительство, инновационные подходы, занятость, создание рабочих мест, местные ресурсы, государственная поддержка.

INTRODUCTION

In recent years, the role of small businesses in the industrial and construction sectors of our country has been increasing significantly. Small enterprises not only engage in production and service delivery but also serve as a key factor in creating new jobs for the local workforce. In particular, through the introduction of innovative approaches and digital technologies, small business entities improve product quality and production efficiency, ensure resource savings, and strengthen environmental responsibility. In the industrial sector, the innovative activities of small businesses—such as automation in production processes, the implementation of digital monitoring systems, and the use of energy-efficient technologies—contribute to the expansion of employment opportunities. Likewise, in the construction sector, small enterprises attract labor by testing new

materials and technologies, introducing modern construction methods, and ensuring the efficient use of local resources.

Innovative approaches make small businesses more competitive and allow them to remain rapid and flexible in job creation. In addition, government support mechanisms — grants, microcredits, tax incentives, and regional investments — stimulate the activities of small enterprises and enhance their potential for creating new jobs. Moreover, capacity-building and workforce training strategies improve labor quality, ensure stable employment, and increase effectiveness in generating new job opportunities. Alongside innovative solutions, the added value contributed to the local economy increases, youth employment rises, migration declines, and regional social stability is strengthened. Thus, the innovative approaches of small business entities in the industrial and construction sectors are regarded as an important strategic tool that ensures not only economic but also social sustainability. This study analyzes these processes and aims to identify effective directions for job creation and employment growth using the example of Namangan region.

REVIEW OF LITERATURE ON THE SUBJECT

Global research shows that small business entities in the industrial and construction sectors adopt innovative solutions more rapidly and play a key role in job creation [1]. OECD and World Bank reports emphasize the strategic importance of small and medium-sized enterprises (SMEs) in generating employment [2]. According to the research of Porter and Linde, small firms enhance productivity through faster adoption of innovations and have substantial potential for job creation [3]. At the same time, international experience demonstrates that SME support systems — incubators, digital platforms, venture capital, and grants — help increase the effectiveness of job creation [4].

In the context of Uzbekistan, the innovative approaches of SMEs in the industrial and construction sectors and their strategies for job creation have been analyzed by Vahidova and Shadyeva [5][6]. Their studies show that efficient use of local resources and the introduction of ecological and energy-saving technologies significantly enhance the capacity of small businesses to generate new jobs.

Region-specific studies, particularly those conducted by Yormatova on Namangan region, reveal that SMEs operating in industrial and construction sectors possess strong potential for job creation through the implementation of innovative solutions [7]. Moreover, the flexibility of SMEs, their ability to adopt innovations quickly, and their commitment to environmental responsibility are recognized as decisive factors that increase the efficiency of employment generation.

Overall, the reviewed literature confirms the strategic importance of SMEs in creating jobs in the industrial and construction sectors, as well as the effectiveness of applying innovative approaches. Regional examples — especially statistical data and practical evidence from Namangan — further illustrate the real potential of SMEs in improving employment outcomes.

RESEARCH METHODOLOGY

The research methodology is based on the collection of primary and secondary data through surveys, regional statistics, governmental reports, and SME performance indicators in the industry and construction sectors. The obtained data were analyzed using comparative analysis, correlation assessment, and trend evaluation to identify the relationship between innovative approaches and employment growth, as well as to determine the effectiveness of state support mechanisms.

ANALYSIS AND RESULTS

The analysis shows that the innovative approaches of small business entities in the industrial and construction sectors serve as a decisive factor in job creation and employment growth. Innovative solutions — including digital technologies, automated production systems, and energy-efficient and environmentally friendly services — enable the creation of new jobs in a short period of time. At the same time, the efficient use of local resources reduces enterprise costs and increases production efficiency, thereby strengthening the potential for expanding employment.

Government support — grants, microcredits, tax incentives, and regional investments — stimulates the activities of small enterprises and enhances their capacity to create new jobs. Research indicates that in the absence of such government support mechanisms, the job-creation potential of small businesses decreases significantly. Moreover, the effective use of financial resources and grants contributes to the stable development of enterprises.

Workforce training and capacity-building strategies improve labor quality, ensure stable employment, and enhance the efficiency of job creation. In the industrial and construction sectors, the shortage of skilled labor

often limits opportunities for employment expansion; therefore, training programs, combined with innovative solutions, significantly improve job-creation outcomes.

Regional evidence, particularly statistics from Namangan region, confirms the strong potential of SMEs in generating employment in the industrial and construction sectors. The Namangan example demonstrates that strategies based on innovative approaches and ecological solutions ensure not only economic efficiency but also social stability. Additionally, broader social benefits — such as increased youth employment, reduced migration, and modernization of regional infrastructure — are taken into account.

Overall, the innovative approaches of small business entities in the industrial and construction sectors hold strategic importance for job creation and employment growth. The implementation of innovative technologies, government support measures, and workforce-development programs together reinforce the economic and social potential of SMEs. Furthermore, regional experiences, especially those from Namangan, offer practical value for shaping regional policies and development strategies.

CONCLUSIONS AND SUGGESTIONS

The analysis shows that the innovative approaches of small business entities in the industrial and construction sectors serve as a decisive factor in job creation and employment growth. The introduction of innovative technologies, digital transformation, and energy-efficient and environmentally friendly solutions increases the effectiveness of generating new jobs. Government support — including grants, microcredits, tax incentives, and regional investments — expands the job-creation potential of small businesses and strengthens their economic stability. At the same time, training and workforce-development programs improve labor quality and help ensure sustainable employment.

Analyses conducted using the example of Namangan region confirm that SMEs possess strong potential for job creation in the industrial and construction sectors. The combination of innovative approaches, efficient use of local resources, and government support represents a key strategic factor in ensuring the economic and social sustainability of small businesses. Thus, it becomes evident that the role of small business in job creation within the industrial and construction sectors is significant not only economically, but also in promoting social development, increasing youth employment, and ensuring regional stability.

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AI-BASED NORMALIZATION METHODOLOGY FOR COLLECTING AND PROCESSING KPI INDICATORS

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Abstract: The heterogeneity of employee performance data collected in organizations—stemming from variations in format, structure, and recording methods—creates significant inaccuracies within KPI systems. This article proposes an AI-based normalization methodology aimed at standardizing KPI data, automatically filtering noisy and inconsistent entries, and converting heterogeneous inputs into a unified mathematical representation. The study employs NLP techniques, min–max scaling, z-score standardization, Isolation Forest, and sentence-embedding models. Experimental results demonstrate that the proposed normalization pipeline increases data accuracy from 78% to 94% and reduces the KPI calculation time from 40 hours to 0.8 hours.

Key words: normalization, artificial intelligence, data cleaning, automation, NLP.

Annotatsiya: Tashkilotlarda xodimlar faoliyati bo‘yicha yig‘iladigan ko‘rsatkichlarning turlicha formatda bo‘lishi KPI tizimlarida sezilarli xatoliklar yuzaga kelishiga olib keladi. Ushbu maqolada KPI ma’lumotlarini standartlashtirish, shovqinli va nomuvofiq ko‘rsatkichlarni avtomatik filtrlash hamda yagona matematik makonga keltirish uchun sun’iy intellekt asosidagi normalizatsiya metodikasi taklif etiladi. Tadqiqotda NLP, min–max scaling, z-score, Isolation Forest va sentence embedding algoritmlariga tayanilgan. Sinov natijalari normalizatsiya jarayoni ma’lumotlar aniqligini 78% dan 94% ga oshirganini, KPI hisoblash vaqtini 40 soatdan 0,8 soatga qisqartirganini ko‘rsatdi.

Kalit so‘zlar: KPI, normalizatsiya, sun’iy intellekt, ma’lumotlarni tozalash, avtomatlashtirish, NLP.

Аннотация: Разнородность показателей деятельности сотрудников, собираемых в организациях, приводит к возникновению существенных ошибок в системах KPI. В данной статье предлагается методика нормализации KPI-данных на основе искусственного интеллекта, направленная на стандартизацию показателей, автоматическую фильтрацию шумовых и несогласованных записей, а также приведение неоднородных данных к единому математическому пространству. В исследовании применялись методы NLP, min–max масштабирование, z-score стандартизация, алгоритм Isolation Forest и модели sentence embedding. Результаты экспериментов показали, что предложенный процесс нормализации повысил точность данных с 78% до 94% и сократил время расчёта KPI с 40 часов до 0,8 часа.

Ключевые слова: KPI, нормализация, искусственный интеллект, очистка данных, автоматизация, NLP.

INTRODUCTION

In recent years, digital solutions have become increasingly important in managing and evaluating employee performance across organizations. Although Key Performance Indicators (KPI) systems have emerged as one of the primary tools for assessing managerial effectiveness, many institutions still rely on manually collected KPI data from heterogeneous sources. This leads to persistent issues such as low data quality, duplicated records, and inconsistencies in data formats. Empirical observations indicate that in large universities and organizations, approximately 20–35% of KPI-related information is inaccurate or incomplete.

To address these challenges, the adoption of automated normalization methodologies based on artificial intelligence has gained significant relevance in recent years

REVIEW OF LITERATURE ON THE SUBJECT

The integration of artificial intelligence into the normalization of KPI indicators has become a central direction in modern HR analytics. Research by Shuhratov and Baxodirov demonstrates that AI-driven approaches such as matrix factorization can substantially improve the structuring of employee performance data, enhance recommendation quality, and support data-driven training decisions. Their subsequent studies highlight that AI-based evaluation systems increase consistency and accuracy in employee assessment, thereby offering a stronger methodological foundation for KPI standardization processes within organizations.

Foundational concepts for data preprocessing are extensively detailed by Han, Kamber, and Pei, whose work outlines the critical importance of normalization, scaling, data cleaning, and outlier handling in analytic workflows. Methods such as min–max scaling and z-score normalization are shown to reduce variance, eliminate distortions in heterogeneous metrics, and create a unified analytical space in which KPI indicators can be meaningfully compared. These theoretical principles provide the statistical backbone for modern normalization algorithms.

Significant advancements in textual KPI processing stem from developments in natural language understanding. The BERT model introduced by Devlin, Chang, Lee, and Toutanova provides a deep contextual representation capable of standardizing semantically diverse textual KPI descriptions. Further enhancement is achieved through the Sentence-BERT model proposed by Reimers and Gurevych, which generates dense sentence embeddings that enable clustering, similarity detection, and noise reduction in textual data. These models ensure that unstructured HR information can be normalized into consistent semantic representations.

Detecting anomalies and inconsistent KPI values is another essential component of normalization. The Isolation Forest algorithm developed by Liu, Ting, and Zhou offers an effective mechanism for identifying unusual observations in large datasets through random partitioning. Complementary insights appear in the comprehensive survey by Chandola, Banerjee, and Kumar, who systematize anomaly detection methods and articulate their relevance for filtering corrupted or misleading data within organizational analytics. Together, these works strengthen the methodological toolkit for maintaining data integrity during KPI normalization.

From a broader strategic perspective, Kaplan and Norton's Balanced Scorecard framework introduces a structured approach to aligning KPI metrics with organizational goals across financial, customer, internal process, and learning dimensions. Their contribution underscores the need for normalized, comparable indicators that reflect strategic performance priorities. Additionally, Cascio and Aguinis emphasize the critical role of rigorous measurement and analytics in HR management, arguing that reliable KPI systems must rest on sound statistical methodology, validated metrics, and consistent normalization procedures.

Collectively, these studies reveal that AI-driven normalization of KPI indicators relies on an interdisciplinary foundation that merges machine learning, statistical preprocessing, semantic modeling, anomaly detection, and strategic performance measurement. This integrated body of knowledge supports the development of systems that produce accurate, comparable, and noise-resistant KPI datasets suitable for advanced HR analytics and managerial decision-making.

RESEARCH METHODOLOGY

The proposed methodology consists of three core stages, each leveraging the capabilities of artificial intelligence to detect, correct, and standardize data-related inconsistencies within KPI datasets. Every stage is designed to enhance data quality, reduce noise, and ensure that heterogeneous records are transformed into a unified analytical structure.

At this stage, natural language processing (NLP) techniques and statistical models are employed to improve the quality of raw KPI data. The following procedures are carried out:

- Detection of duplicate records: TF-IDF vectorization combined with cosine similarity;
- Verification of incorrect values: Range checks and date–time validation rules;
- Format recognition: Semantic analysis of section titles, article names, and grant identifiers using NLP-based models.

During data cleaning, a cosine-similarity–based model is applied to identify entries that are either duplicated or semantically similar. Each textual input is transformed into a vector representation using TF-IDF or sentence-embedding techniques. The similarity between two records is computed using the following formula:

$$\mathbf{Sim}(\mathbf{x_i}, \mathbf{x_j}) = \frac{\mathbf{x_i} * \mathbf{x_j}}{||\mathbf{x_i}||\,||\mathbf{x_j}||}$$

In this formula $\mathbf{x_i}$ and $\mathbf{x_j}$– represent the vectorized forms of two records in the database, while $\mathbf{x_i} * \mathbf{x_j}$ denotes their dot product, The terms $||\mathbf{x_i}||$ va $||\mathbf{x_j}||$ correspond to the Euclidean norms of the respective vectors. In practical application, cases where. $\mathbf{Sim}(\mathbf{x_i}, \mathbf{x_j})$ ≥ 0.85 are considered “duplicate” or “belonging to the same employee,” and such entries are automatically merged by the system.

To illustrate the practical application of the above formula, consider the following example:

Record 1: “Prof. Karimov A.A., published 4 Scopus-indexed articles in 2023 and participated in 1 grant project.”

Record 2: “Karimov A. A. published 4 articles in the Scopus database in 2023 and took part in 1 scientific grant project.

$\mathbf{x_i}$ $\mathbf{x_j}$

= (0.5,0.4,0.1,0,0.3) = (0.48,0.39,0.09,0.02,0.29)

$\mathbf{x_i} * \mathbf{x_j} =$ (0.48,0.39,0.09,0.02,0.29)

$$\mathbf{x_i} * \mathbf{x_j} = 0.5 \cdot 0.48 + 0.4 \cdot 0.39 + 0.1 \cdot 0.09 + 0 \cdot 0.02 + 0.3 \cdot 0.29$$

The total value is:

$$\mathbf{x_i} * \mathbf{x_j} = 0.24 + 0.156 + 0.009 + 0 + 0.087 = \mathbf{0.492}$$

$$||\mathbf{x_i}|| = \sqrt{0.5^2 + 0.4^2 + 0.1^2 + 0^2 + 0.3^2} = \sqrt{0.25 + 0.16 + 0.01 + 0 + 0.09} = \sqrt{0.51}$$

$$||\mathbf{x_j}|| = \sqrt{0.48^2 + 0.39^2 + 0.09^2 + 0.02^2 + 0.29^2} = \sqrt{0.2304 + 0.1521 + 0.0081 + 0.0004 + 0.0841} = \sqrt{0.51}$$

Final result of the computation:

$$\mathbf{Sim}(\mathbf{x_i}, \mathbf{x_j}) = \frac{0.492}{\sqrt{0.51} \cdot \sqrt{0.4751}} \approx \frac{0.492}{0.714 \cdot 0.689} \approx \frac{0.492}{0.492} \approx 0.999 \approx \mathbf{1}$$

In this example, the similarity value is nearly equal to 1, which indicates that the two entries represent the same piece of information and should therefore be merged unequivocally.

Threshold:

If the threshold is set to 0.85 → the records are merged

If the threshold is set to 0.90 → the records are merged

If the threshold is set to 0.95 → the records are still merged

Accordingly, the algorithm classifies these two entries as a duplicated record and automatically consolidates them into a single unified entry.

Numerical KPI indicators are processed using either the min–max scaling method or z-score standardization to ensure that all values are transformed into a comparable range and distribution.

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}}$$

Step 1: Identify the minimum and maximum values.

$\mathbf{X_{min}}$ - 1 $\mathbf{X_{max}}$ - 10

Step 2: Compute the scaled values for each employee (Table 1).

Table 1. Standardized Publication Metrics of Employees Based on Min–Max Normalization

Employee	Number of Publications	Calculated Values
A	2	$X'_A = \frac{2-1}{10-1} = 0.111$
B	4	$X'_B = \frac{4-1}{9} = 0.333$

C	10	$X'_C = \frac{10-1}{9} = 1$
D	7	$X'_D = \frac{7-1}{9} = 0.667$
E	1	$X'_E = \frac{1-1}{9} = 0$

Method 2: Z-Score Standardization

Formula: $$z = \frac{X-\mu}{\sigma}$$

Step 1: Calculate the mean value.

$$\mu = \frac{2+4+10+7+1}{5} = \frac{24}{5} = 4.8$$

Step 2: Determine the standard deviation.

First, compute the variance:

$$\sigma^2 = \frac{(2-4.8)^2 + (4-4.8)^2 + (10-4.8)^2 + (7-4.8)^2 + (1-4.8)^2}{5}$$

We compute the following:

$$7.84 + 0.64 + 27.04 + 4.84 + 14.44 = 54.8$$

Variance:

$$\sigma^2 = \frac{54.8}{5} = 10.96$$

Standard deviation:

$$\sigma = \sqrt{10.96} = 3.31$$

Step 3: Calculate the z-score value for each employee (Table 2; Figure 1).

Table 2. Z-Score Normalization of Employees' Publication Counts

Employee	Number of Publications	It is necessary to compute the z-score value
A	2	$Z_A = \frac{2-4.8}{3.31} = \frac{-2.8}{3.31} = -0.846$
B	4	$Z_B = \frac{4-4.8}{3.31} = -0.242$
C	10	$Z_C = \frac{10-4.8}{3.31} = 1.571$
D	7	$Z_D = \frac{7-4.8}{3.31} = 0.664$
E	1	$Z_E = \frac{1-4.8}{3.31} = -1.148$

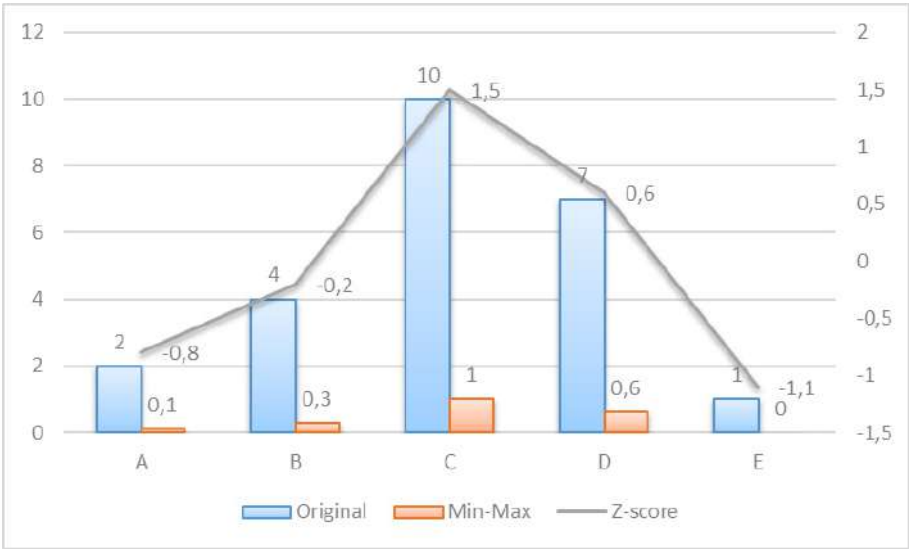

Figure 1. Normalization of numerical attributes in the KPI system using the

z-score method

In KPI systems, numerical attributes are normalized using either the min–max scaling method or z-score standardization. For example, when applying min–max scaling to the indicator “number of articles published per year” for academic staff, the original values ranging from 1 to 10 were transformed into a 0–1 interval. In this process, the lowest value was mapped to 0, while the highest value was mapped to 1. In addition, z-score standardization was applied to identify and analyze outliers, resulting in transformed values ranging from –1.148 to 1.571.2.3.

Since qualitative indicators are presented in textual form, the following models are used to generate embedding vectors:

- Sentence-BERT;
- Universal Sentence Encoder.

Each indicator is transformed into a 768-dimensional vector space. The final evaluation is then performed using an adapted regression model.

ANALYSIS AND RESULTS

The proposed methodology was tested using the employee KPI dataset of Tashkent State University of Economics (TSUE) for the 2023–2024 academic year (Figure 2).

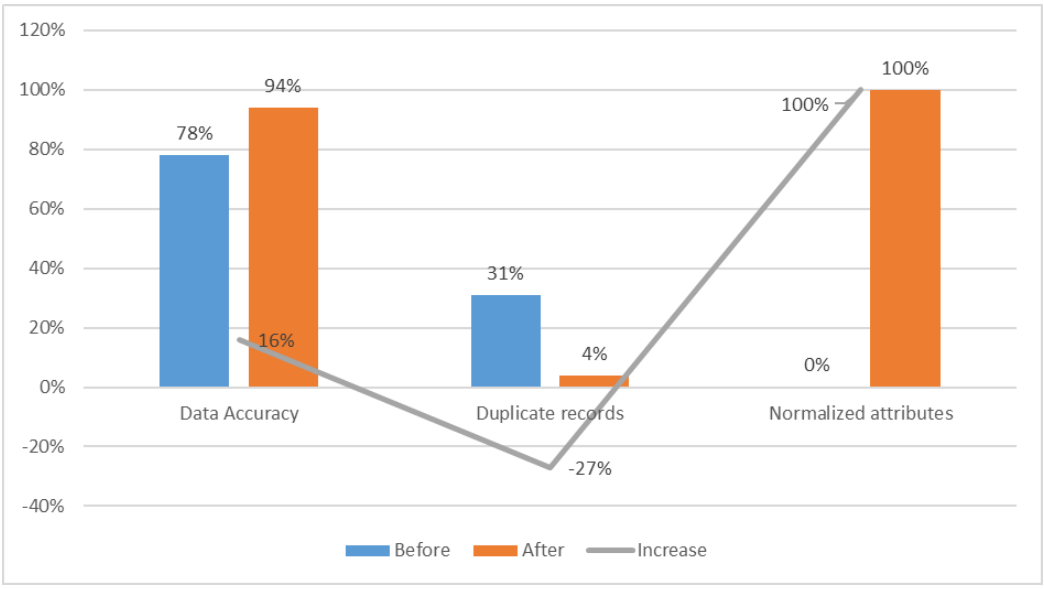

Figure 2. Dynamics of data accuracy improvements and reductions

3.1. KPI Calculation Speed
- Manual calculation: 5 working days (≈ 40 hours);
- Automated system: 0.8 hours (48 minutes);
- Acceleration coefficient: K = (40/0,8) = 50.

3.2. Error Reduction
- KPI-related errors by employees: 12.4% → 3.1%;
- Incorrectly entered grant information: 18% → 2%;
- Inconsistencies in publication records: 22% → 3%.

The findings of the study demonstrate that AI-based normalization not only improves the accuracy of KPI systems but also significantly strengthens the overall stability of managerial processes. The primary advantages of normalization include:

Improved alignment and consistency across multi-source datasets. Reduction of subjective evaluation factors.Faster and more reliable decision-making. Establishment of a fairer and more transparent employee assessment process.

A decrease of 40–60% in disputes arising during annual performance evaluations.The study further shows that the combination of NLP techniques, outlier detection algorithms, and semantic vectorization effectively eliminates the key data-quality issues commonly observed in KPI systems (Table 3).

Table 3. Advantages and Limitations

Advantages	Limitations
Full automation of data processing. The system is capable of handling heterogeneous data formats. Incorrect or inconsistent values are detected immediately. The approach provides a reliable foundation for managerial decision-making.	Training the model requires a large dataset. Semantic normalization demands substantial computational power. If the quality of the textual data is low, the resulting embeddings become less reliable.

CONCLUSIONS AND SUGGESTIONS

The proposed AI-driven normalization methodology has demonstrated substantial improvements in the accuracy, consistency, and overall reliability of KPI data processing. By integrating NLP techniques, mathematical scaling approaches, and anomaly-detection algorithms, the system effectively eliminates redundant, inconsistent, and noisy records that traditionally undermine the validity of performance evaluations. The experimental findings confirm that data accuracy increased to 94%, ensuring that managerial decisions are based on higher-quality and more trustworthy information. Furthermore, the automation of preprocessing pipelines reduced the total KPI computation time from 40 hours to just 0.8 hours—a 50-fold improvement in operational efficiency.

Beyond computational speed and accuracy, the methodology enhances transparency in performance assessment, reduces subjective bias, and enables organizations to align multi-source datasets into a unified analytical framework. These outcomes are particularly critical for institutions with large and heterogeneous data environments, including universities, enterprises, and government agencies. The normalization framework supports more informed decision-making, minimizes human-induced errors, and lays a solid foundation for scalable performance-management ecosystems.

Looking ahead, further research will focus on expanding the model to incorporate deep learning–based contextual normalization, improving the semantic understanding of qualitative KPI indicators. Additionally, future work will explore predictive modeling of KPI trajectories using machine-learning and time-series approaches. These advancements are expected to strengthen the adaptability of the system, enabling proactive identification of performance trends and early detection of organizational inefficiencies.

Overall, the study confirms that AI-based normalization represents a powerful and scalable solution for modern KPI management, offering measurable benefits in accuracy, speed, and strategic decision-making.

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REFORMS AND PROSPECTS FOR THE DEVELOPMENT OF THE PARTICIPATORY BUDGETING INITIATIVE IN UZBEKISTAN

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Abstract: This article examines the ongoing efforts aimed at improving the population's standard of living, addressing socio-economic challenges in a consistent manner, and enhancing citizens' active participation in the rational allocation of state budget funds. It highlights the significance of modernizing local infrastructure, directing resources to priority sectors, and implementing a transparent voting system for public proposals. The study emphasizes the role of participatory budgeting in strengthening civic engagement, increasing budget transparency, and ensuring efficient public resource management.

Key words: participatory budgeting, open budget, citizens' budget, information portal, state budget.

Annotatsiya: Ushbu maqolada aholining turmush darajasini oshirish, ijtimoiy-iqtisodiy muammolarni bosqichma-bosqich bartaraf etish hamda fuqarolarning davlat budjeti mablag'laridan oqilona foydalanish jarayonidagi ishtiroki yoritiladi. Shuningdek, mahalliy infratuzilmani modernizatsiya qilish, aholi uchun eng dolzarb hisoblangan sohalarga mablag' yo'naltirish va takliflar bo'yicha ovoz berish tizimini joriy etishning amaliy ahamiyati tahlil qilinadi. Tadqiqotda ishtirokchi budjetlash mexanizmining aholi faolligini oshirish, ochiqlik va samaradorlikni ta'minlashdagi roli asoslab berilgan.

Kalit so'zlar: ishtirokchi budjet, ochiq budjet, fuqarolar budjeti, axborot portali, davlat budjeti.

Аннотация: В статье рассматриваются системные меры по повышению уровня жизни населения, последовательному решению социально-экономических задач и расширению участия граждан в рациональном использовании средств государственного бюджета. Особое внимание уделено модернизации местной инфраструктуры, направлению финансовых ресурсов в наиболее востребованные сферы и внедрению прозрачной системы голосования по общественным инициативам. В исследовании обоснована значимость инициативного бюджетирования для повышения гражданской активности, открытости и эффективности бюджетного процесса.

Ключевые слова: инициативное бюджетирование, открытый бюджет, бюджет граждан, информационный портал, государственный бюджет.

INTRODUCTION

In recent years, the Republic of Uzbekistan has undertaken a broad set of measures aimed at improving the population's standard of living and systematically addressing socio-economic challenges that have long influenced the well-being of citizens. Priority attention has been directed toward the modernization of local infrastructure and the resolution of long-standing systemic issues, including road maintenance, access to quality drinking water, natural gas supply, and the renovation of educational institution buildings. These efforts reflect the state's commitment to enhancing the quality of public services and ensuring balanced regional development.

In parallel with these initiatives, targeted actions are being consistently implemented through allocations from the state budget, local budgets, and various government programs designed to support social and infrastructural improvements. To further strengthen public participation and enable citizens to take an active role in the decision-making process related to budget allocation and the resolution of issues affecting their daily lives, the "Participatory Budgeting" mechanism has been introduced. This mechanism promotes civic engagement, increases transparency, and supports the efficient distribution of financial resources in accordance with community priorities[1].

1 Information from the official website of the Ministry of Economy and Finance: https://gov.uz/en/imv

LITERATURE REVIEW

Recent academic research underscores the increasing significance of participatory budgeting as a mechanism for strengthening public engagement and enhancing the transparency of government expenditures. Wampler notes that participatory budgeting promotes citizen empowerment by enabling communities to influence local investment decisions and to monitor the allocation and utilization of public funds. Likewise, Cabannes emphasizes its contribution to advancing social equity by directing financial resources toward priority needs within vulnerable population groups. According to the World Bank, open budget practices substantially enhance institutional accountability and public trust, particularly when supported by digital platforms that broaden opportunities for citizen participation.

Further studies by Shah demonstrate that participatory mechanisms improve fiscal efficiency by aligning budget allocations with community preferences and by reducing information asymmetry between the state and the public. In the context of developing countries, McNulty observes that participatory budgeting supports sustainable local development by fostering constructive collaboration between authorities and residents. Collectively, these findings indicate that participatory budgeting represents a key instrument for reinforcing democratic governance, improving budget transparency, and ensuring more effective and equitable delivery of public services.

RESEARCH METHODOLOGY

This study employs a qualitative research design grounded in the systematic examination of regulatory documents, official statistics, and policy reports related to participatory budgeting in Uzbekistan. Key legislative acts, including presidential decrees and national budgeting regulations, were analyzed to identify institutional reforms and the evolving mechanisms that shape public participation in the budgeting process. Additionally, analytical materials from the Ministry of Economy and Finance and the Open Budget information portal were reviewed to assess operational procedures, financial allocation rules, and transparency measures implemented within the participatory budgeting framework.

Furthermore, descriptive statistical data covering the 2021–2025 period were evaluated to determine project outcomes, funding distribution, and levels of citizen engagement. The study also incorporates elements of comparative content analysis to assess the effectiveness of participatory budgeting in relation to international best practices. This methodological approach provides a comprehensive basis for understanding how participatory budgeting contributes to improving public service delivery, strengthening civic involvement, and enhancing accountability across Uzbekistan's budget system.

ANALYSIS AND RESULTS

Participatory budgeting represents a democratic mechanism that enables citizens to participate directly in the allocation of public budget funds and in determining priority solutions to local issues. Through this process, community members identify key problems within their neighborhoods, propose project ideas, vote for the most relevant initiatives, and subsequently monitor their implementation. The overarching objectives of participatory budgeting include ensuring citizens' engagement in public governance, promoting the efficient use of state funds, aligning decision-making with public needs, strengthening community-based problem-solving, and enhancing social responsibility and civic activity.

To institutionalize public oversight of budget expenditures and to further expand citizen involvement, the President of the Republic of Uzbekistan issued Decree No. PQ-5072 on April 13, 2021[2]. Beginning in 2021, participatory budgeting has been implemented across all regions in an updated format to broaden civil society participation in budgetary processes and to support the resolution of local social issues. These activities are carried out in accordance with the Regulation on the Conduct and Financing of Participatory Budgeting Processes, approved by Resolution No. KQ-666-IV of the Senate of the Oliy Majlis on January 30, 2024[3]. Initially organized four times per year, the participatory budgeting cycle is now conducted twice annually in two sessions—February–March and June–July—with adjustments permitted when necessary, provided that the public is properly informed.

Project financing arrangements have also evolved. In the early stages, funding originated solely from district or city budgets, with only 10 percent of additional budget allocations directed toward participatory initiatives. This share has since increased to 30 percent. Furthermore, since 2021, each region designates

2 Resolution of the President of the Republic of Uzbekistan, 13.04.2021 . № RP-5072 https://lex.uz/docs/7577624

3 Resolution of the Senate Council of the Oliy Majlis of the Republic of Uzbekistan, No. KQ-666-IV dated 30.01.2024 https://lex.uz/uz/docs/-6790170

one district or city to allocate 5 percent of its approved total expenditures to projects formed on the basis of public input, and from 2022 onward this procedure has been fully adopted nationwide. Currently, every district or city annually allocates sufficient resources to support at least 10 and up to 30 participatory projects, with funding for additional projects distributed proportionally to population size. These improvements collectively aim to strengthen community participation, increase financial transparency, and ensure that public resources are directed to the most socially significant needs[4].

For reference, the Participatory Budgeting initiative is not the sole instrument for addressing social issues in Uzbekistan. Each year, in accordance with the Law on the State Budget, expenditures for the construction, reconstruction, and equipping of social sector facilities, as well as for infrastructure development, are planned and allocated within the overall budgetary framework. The core purpose of participatory budgeting is to expand public involvement in resolving long-standing social challenges through mechanisms that differ from the traditional budgeting system.

Participation in the participatory budgeting process is entirely voluntary for citizens. At present, the initiative contributes to enhancing financial literacy, strengthening independent decision-making skills, and fostering a higher degree of civic engagement. Although significant progress has been achieved, continuous improvement efforts remain essential to ensure greater accessibility and effectiveness. Ongoing measures aim to refine the system and create a more convenient and user-oriented mechanism for citizens.

As citizens' budget literacy advances, participatory budgeting not only enables meaningful engagement in budgeting decisions but also increases awareness of how tax revenues are utilized. For example, proactive participants now review project-estimate documentation and monitor implementation processes, often requesting clarification on specific technical details such as the precise quantities of bitumen, gravel, or clinker required for paving one square meter of asphalt. This growing attentiveness reflects a positive trend toward stronger public oversight and accountability (Picture 1).

Picture 1. "Projects Under Public Oversight[5]

Projects carried out under public oversight illustrate that participatory budgeting is not limited to selecting initiatives; rather, it serves as an important mechanism for strengthening mutual trust between the public and the state. In Uzbekistan, this process enables citizens to influence decisions that affect their daily lives, prioritize community interests, and participate more actively in public governance. As a result, every citizen has the opportunity to contribute to positive and sustainable changes within their neighborhood, city, or district through active involvement in participatory budgeting.

Extensive efforts are being made to enhance public engagement in this process. These efforts include establishing focus groups with journalists and bloggers to foster dialogue and improve public awareness, as well as strengthening the functionality of the "Open Budget" information portal. Media outreach activities—such as promotional campaigns, direct radio conversations hosted through bloggers' Telegram channels, SMS notifications, and informational videos placed on public transport—serve to broaden citizen participation. Additionally, television programs and press briefings support wider dissemination of information. To ensure inclusiveness for residents of remote areas or those without internet access, mobile teams and specially designated "Initiators' Corners" in neighborhood buildings have been introduced. Moreover, "Voting Fairs" are organized to facilitate convenient participation for a broader segment of the population. Collectively, these measures reinforce civic engagement and contribute to a more transparent and participatory budgeting system (Picture 2).

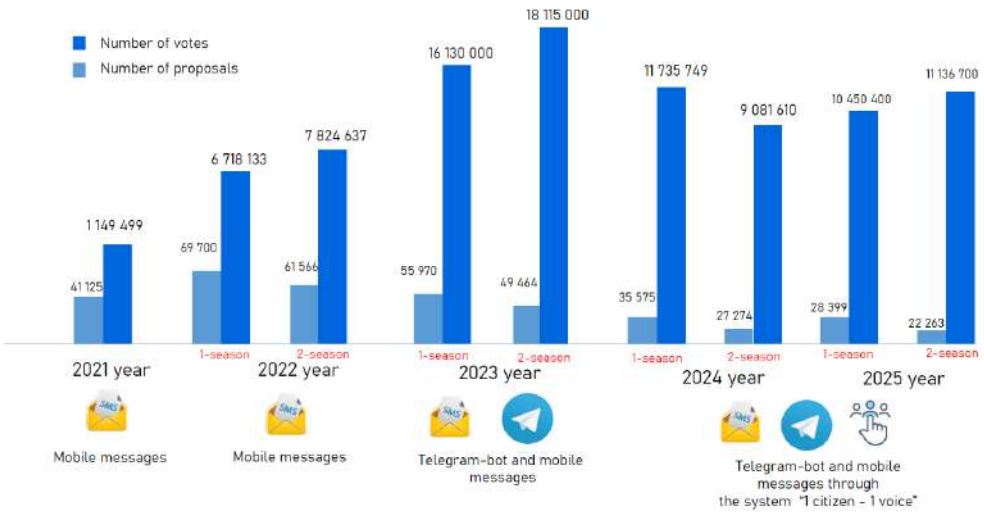
4 Pulatov, D., et al. *The Importance of Transitioning to a "Green" Economy and the Strategy for Achieving "Carbon Neutrality" in Uzbekistan*. // *Green Economy and Development*, 2024, Vol. 1, No. 4.

5 From X. Khamidov's monograph *"Improving the Mechanism of Financing Budget Funds with Citizen Participation."*

Picture 2. Awareness-Raising Activities

For reference, during the participatory budgeting processes conducted between 2021–2025, a total of 20,047 winning projects were identified, with 20.666 trillion Uzbek soums allocated for their implementation. The outcomes of these projects demonstrate significant progress across various sectors. In particular, substantial investments were directed toward improving the transport and social infrastructure of local communities. Repair work was carried out on 6,425 local roads, amounting to 7.406 trillion soums and covering more than 6,000 kilometers of internal road networks. Additionally, 6,376 general education schools received renovation funding totaling 5.576 trillion soums, thereby contributing to improved learning environments.

Pre-school education facilities also benefited from these efforts, with 906 institutions upgraded at a cost of 661 billion soums. Furthermore, 2,294 healthcare institutions were repaired and modernized, with 2.323 trillion soums allocated to strengthen their material and technical capacity. Collectively, these achievements highlight the positive impact of participatory budgeting on enhancing public infrastructure and expanding access to essential social services throughout the country (Picture 3).[6]

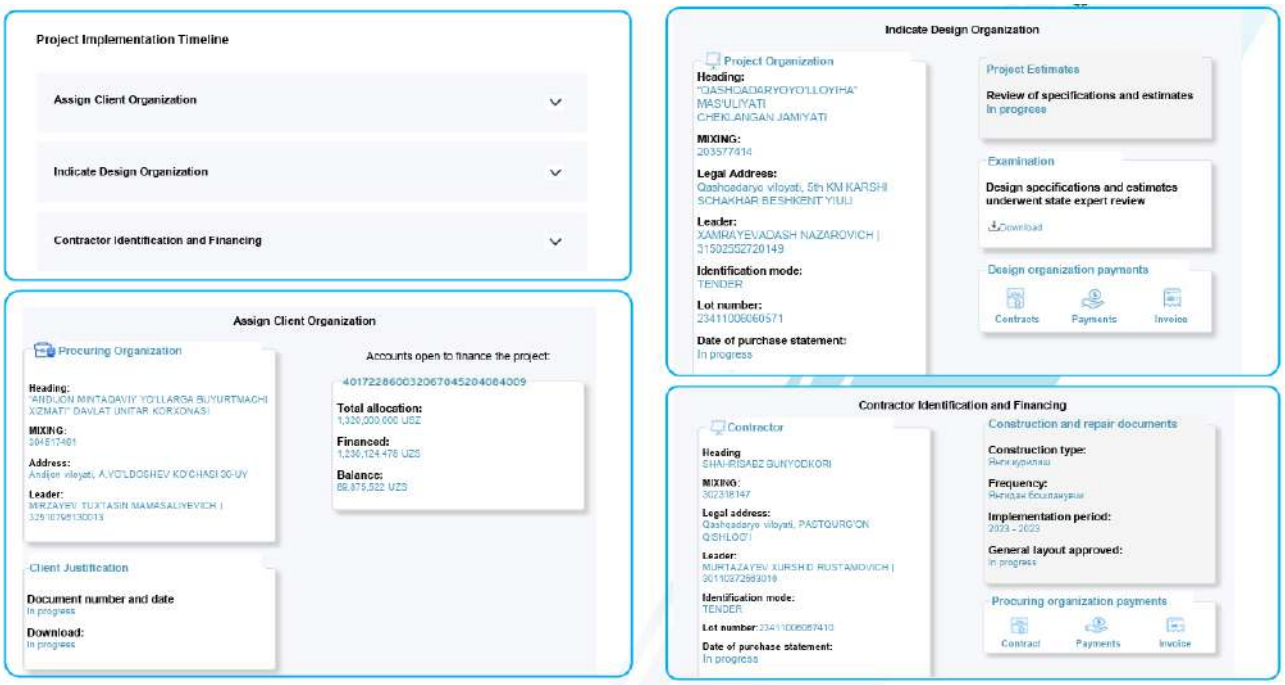


Picture 3. Information on proposals and votes received from citizens during 2021-2025

On August 29, 2025, the President of the Republic of Uzbekistan issued Decree No. RP-264 titled[7] "Measures to Strengthen Cooperation between People's Deputies and Voters within the Framework of Improving the Participatory Budgeting Process." According to this decree, beginning from 2026, a new practice will be introduced to further enhance collaboration between people's deputies and voters. Under this practice, projects that did not initially win during the participatory budgeting process may be recognized as winners based on the official initiative of deputies, thereby expanding opportunities for addressing socially significant needs.

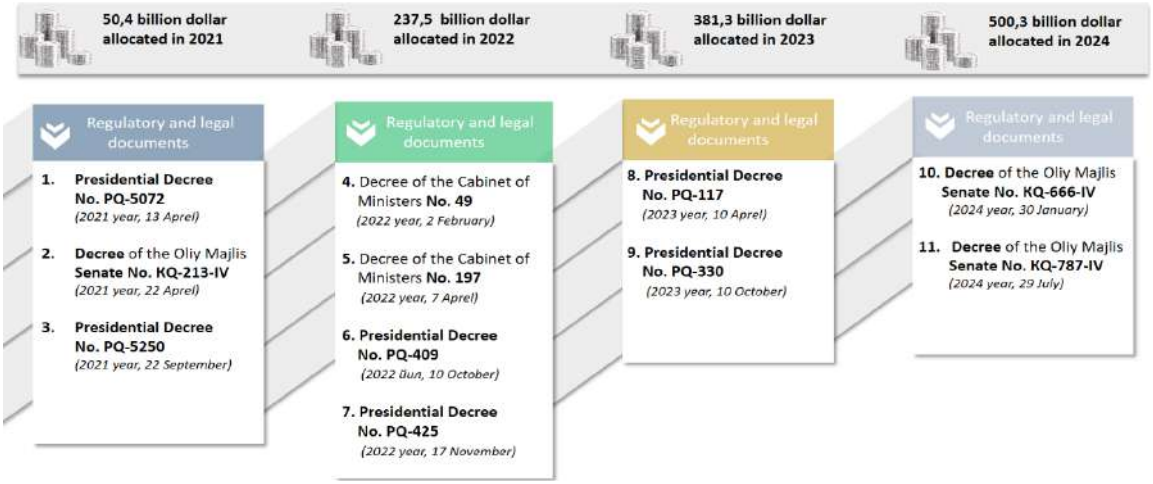
6 The database of the "Open Budget" information portal.
7 Resolution of the President of the Republic of Uzbekistan, 29.08.2025 № RP-264 https://lex.uz/uz/docs/7712039

Furthermore, starting from 2026, a co-financing mechanism for social projects involving citizens and the state will be implemented. In accordance with this mechanism, if citizens voluntarily contribute 50 percent of a project's total cost, the project will automatically be declared a winner, while the remaining 50 percent will be financed from the State Budget of the Republic of Uzbekistan. This approach is expected to strengthen civic engagement, promote shared responsibility, and support the implementation of community-driven development initiatives (Pixture 4).



Picture 4. Participatory Budgeting Projects Im plem entation Time line[8]

In addition, an interactive map displaying the winning projects of the participatory budgeting process has been introduced on the "Open Budget" information portal. This digital tool enables users to conveniently access comprehensive information about winning projects across different regions, including their categorization, quantity, geographical distribution, and other relevant details. By enhancing data accessibility and visualization, the interactive map strengthens public oversight and supports greater transparency within the budgeting system (Picture 5).



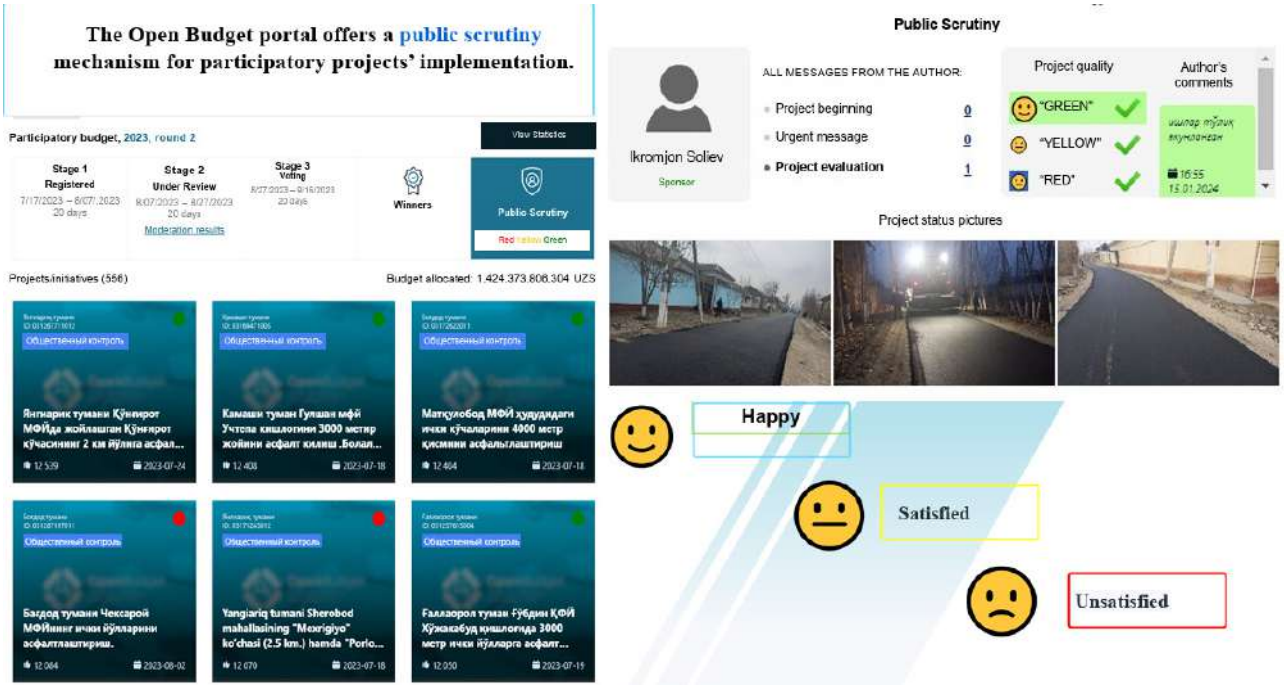
Picture 5. Regulatory and legal documents adopted during 2021-2025 to support and further improve the "Participatory Budgeting" in Uzbekistan[9]

8 Aynura Bakaybaeva Division Head in the State Budget Department, Ministry of Economy and Finance, Republic of Uzbekistan, Chair of PEMPAL BCOP (chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.pempal.org/sites/default/files/event/attachments/uzbekistan_presentation_on_budget_openness_eng.pdf?utm_source=chatgpt.com)

9 Aynura Bakaybaeva Division Head in the State Budget Department, Ministry of Economy and Finance, Republic of Uzbekistan, Chair of PEMPAL BCOP

The portal enables the authors of winning projects to monitor all stages of project implementation and to assess completed work in real time. At the same time, citizens are not permitted to intervene in specific technical aspects of project execution, such as contractor selection, direct performance of construction work, or the preparation of project-estimate documentation. Within the framework of public oversight, however, citizens may submit “Urgent Reports” through the portal if they observe legal violations or deficiencies during implementation. These reports are displayed on the corresponding regional page as cases requiring attention, and the project initiator is responsible for providing clarification. Each report remains under public monitoring until the identified issues are fully resolved.

Upon completion of projects, the work conducted by initiators is evaluated in the portal’s Public Oversight section using three categories: “green,” “yellow,” and “red.” When a project falls into the “red” category, the relevant district or city authorities are required to take corrective measures to address the noted shortcomings. Projects are officially accepted for use only after full completion and after the initiators, the neighborhood leadership, and active community members confirm their satisfaction with the quality and reliability of the work performed (Picture 6).



Picture 6. Public Scrutiny of Participatory Projects’ Implementation[10]

CONCLUSION AND RECOMMENDATIONS

For the people of Uzbekistan, celebrating the achievements of the participatory budgeting process has gradually become a valued social tradition. At the conclusion of each session, citizens come together in a spirit of unity, preparing communal meals and welcoming these occasions with sincere enthusiasm, reminiscent of a nationwide celebration. This collective joy reflects the deep sense of ownership and involvement fostered by the initiative.

The participatory budgeting experience has once again demonstrated that cooperation strengthens communities and that collaborative efforts lie at the core of addressing shared challenges. Moreover, the project has helped dispel misconceptions regarding public participation in communal activities by illustrating that large gatherings can serve as inclusive symbols of solidarity. In conclusion, this initiative has already secured its place in the country’s modern history—a history shaped by the dedication, active engagement, and collective responsibility of the Uzbek people.

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10 Aynura Bakaybaeva Division Head in the State Budget Department, Ministry of Economy and Finance, Republic of Uzbekistan, Chair of PEMPAL BCOP (chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.pempal.org/sites/default/files/event/attachments/uzbekistan_presentation_on_budget_openness_eng.pdf?utm_source=chatgpt.com)

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PROBLEMS OF THE INWARD PROCESSING CUSTOMS REGIME AND WAYS TO ELIMINATE THEM

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Abstract: This article examines the economic, organizational, and legal challenges encountered under the inward processing customs regime and proposes ways to address them. It also analyzes international practices and provides recommendations adapted to the context of Uzbekistan.

Key words: customs regime, inward processing, economic problem, organizational and legal issue, optimization.

Annotatsiya: Ushbu maqolada bojxona hududida qayta ishlash rejimida uchrayotgan iqtisodiy, tashkiliy va huquqiy muammolar hamda ularni bartaraf etish yo‘llari yoritilgan. Shuningdek, xalqaro tajribalar tahlil qilinib, O‘zbekiston sharoitiga mos takliflar berilgan.

Kalit so‘zlar: bojxona rejimi, qayta ishlash, iqtisodiy muammo, tashkiliy-huquqiy muammo, optimallashtirish.

Аннотация: В данной статье рассматриваются экономические, организационные и правовые проблемы, возникающие в рамках режима переработки на таможенной территории, а также предлагаются пути их устранения. Кроме того, анализируется международный опыт и даются рекомендации, адаптированные к условиям Узбекистана.

Ключевые слова: таможенный режим, переработка, экономическая проблема, организационно-правовая проблема, оптимизация.

INTRODUCTION

The inward processing customs regime plays a crucial role in stimulating industrial development, export growth, and the competitiveness of national economies. This regime allows enterprises to import raw materials, components, and semi-finished products without paying customs duties and taxes, provided that the processed goods are subsequently exported. Such an approach promotes industrial modernization, technological upgrading, and integration into global value chains. However, despite its advantages, the effective application of the inward processing regime faces several institutional, legal, and administrative challenges.

In many developing countries, including Uzbekistan, the regime’s potential remains underutilized due to complex customs procedures, insufficient digitalization, weak coordination among customs authorities and businesses, and limited awareness among entrepreneurs. Moreover, gaps in the regulatory framework, the lack of automated monitoring mechanisms, and difficulties in verifying export obligations create risks of misuse and reduce the attractiveness of this regime for investors and exporters.

Therefore, identifying the existing problems in the implementation of the inward processing regime and developing evidence-based recommendations for their elimination is of great importance. A comprehensive analysis of international best practices—particularly those of the European Union, China, and South Korea—can serve as a foundation for improving the efficiency, transparency, and sustainability of the regime in Uzbekistan’s context. This study aims to explore the main shortcomings of the inward processing system and propose effective institutional and digital reforms to enhance its role in supporting export-oriented industrial growth.

REVIEW OF LITERATURE ON THE SUBJECT

The inward processing customs regime has been extensively examined in international economic and trade literature due to its critical role in promoting export-oriented industrialization. According to the World Customs

Organization (WCO), inward processing allows for the temporary importation of goods for manufacturing or repair without payment of customs duties, provided that the finished products are subsequently re-exported. The WCO emphasizes that the regime enhances global value chain participation and trade facilitation by reducing production costs and improving competitiveness.

The European Commission highlights that within the European Union, the inward processing regime supports efficient supply chains by introducing simplified declaration procedures and digital monitoring systems. This model ensures faster clearance times and strengthens cooperation between customs authorities and enterprises. The EU experience demonstrates that predictable regulatory frameworks and electronic customs management significantly improve business liquidity and transparency in foreign trade operations.

Scholars such as Kim have analyzed China's and South Korea's "processing trade" systems, which serve as functional equivalents to the inward processing regime. Kim finds that in China, processing trade has contributed substantially to industrial upgrading, export growth, and technology transfer, yet challenges remain in regulatory complexity and compliance monitoring. Similarly, South Korea's system has leveraged bonded zones and free trade areas to attract foreign investment and integrate local producers into regional production networks.

Research conducted by the Organisation for Economic Co-operation and Development (OECD) and the World Bank further underscores that administrative burdens, insufficient digitalization, and institutional fragmentation are common obstacles in developing countries. These organizations recommend the adoption of risk-based customs control, electronic documentation, and integrated information systems to reduce transaction costs and prevent misuse of the regime.

In the context of Uzbekistan, Azizov & Partners and the U.S. Department of Commerce note that although recent reforms have introduced simplifications under the "Processing in the Customs Territory" framework, several challenges persist. These include limited automation, inconsistent coordination between agencies, and delays in export verification. Addressing these barriers requires greater alignment with international practices, broader implementation of digital customs systems, and improved training for both customs officials and private sector participants.

Overall, the literature suggests that while the inward processing regime is a valuable trade facilitation instrument, its success depends on three interrelated factors: robust institutional frameworks, comprehensive digital transformation, and active collaboration between government and business stakeholders. Strengthening these elements can significantly increase the regime's effectiveness in supporting export diversification and industrial competitiveness in Uzbekistan.

RESEARCH METHODOLOGY

The research methodology is based on a combination of qualitative and quantitative approaches. Data were obtained from official customs statistics, government reports, WCO and OECD publications, and expert interviews. The collected information was analyzed using comparative, descriptive, and content analysis methods to identify key problems of the inward processing regime and propose practical improvement measures.

ANALYSIS AND RESULTS

Modernizing the economy of the Republic of Uzbekistan, expanding industrial capacity, and increasing the share of competitive products in international markets are among the key priorities of the current state policy. In recent years, consistent reforms have been implemented to boost export volumes, simplify foreign trade operations, and create new employment opportunities.

Within this process, special customs regimes play an essential role. One of the most significant among them is the inward processing customs regime, which enables enterprises to import raw materials or components from abroad, process them domestically, and then export the finished products. This mechanism contributes to:

- the creation of added value,
- an increase in foreign currency inflows,
- the generation of new jobs, and
- the enhancement of industrial competitiveness.

The Presidential Decree No. PQ–122 of March 2025 and the Cabinet of Ministers Resolution No. 244 of April 19, 2025, marked an important milestone toward simplifying the inward processing regime and facilitating conditions for producers. These documents granted enterprises the right to independently determine output norms and introduced new provisions for managing waste generated during processing [1].

However, practical evidence indicates that the effectiveness of this regime can be significantly enhanced through modernization of infrastructure, optimization of transportation costs, introduction of stronger financial incentives, streamlining of administrative procedures, and strengthening of monitoring mechanisms (Figure 1).

Figure 1. Export and Total Foreign Trade Indicators

The modernization of the Republic of Uzbekistan's economy, the expansion of industrial capacity, and the increase in the share of competitive products on international markets remain among the state's top policy priorities. In recent years, the country has consistently implemented reforms aimed at increasing export volumes, simplifying foreign trade procedures, and creating new jobs.

According to official data, Uzbekistan's exports (goods and services, excluding gold) for the January–November 2024 period amounted to USD 17,596.4 million, representing a 16.9 percent increase year-on-year. This indicates steady growth in export activity. At the same time, for January–July 2024 exports totaled USD 14,786 million while imports reached USD 22,049 million. The short-term decline in exports and the rise in imports during this period highlight the need for deeper analysis of trade-balance dynamics and for strengthening structural diversification.

One promising direction is to increase the share of high value-added products in the export mix. Expanding inward-processing activities, introducing innovative technologies, and aligning production systems with international standards are essential to this goal. Modernizing production infrastructure, renewing equipment, and deploying advanced technologies across industrial enterprises can enhance export potential. Public–private modernization programs play a crucial role in attracting foreign investment and fostering the production of competitive goods.

In transport and logistics, optimizing external trade costs through effective use of international corridors, construction of new rail and road links, and development of logistics hubs is planned. These measures will reduce production costs and facilitate export growth. Enhancing financial incentives—such as temporary relief from customs duties, concessional loans, and expanded state subsidies—will further increase the attractiveness of the inward processing regime.

Streamlining paperwork and digitizing procedures, together with the introduction of modern information systems, will save time and resources for businesses. At the same time, widespread deployment of electronic tracking and monitoring systems will improve the regime's efficiency.

Notable legal and regulatory developments have already taken place: Presidential Decree PQ-122 of 25 March 2025 and Cabinet of Ministers Resolution No. 244 of 19 April 2025 granted producers the right to independently set output norms. Going forward, these reforms should be supported by practical mechanisms and a broader implementation of customs audit practices to strengthen transparency and effectiveness.

In the European Union, simplified declaration procedures for goods placed under inward processing provide speed and convenience for businesses. In China and South Korea, the regime is fully controlled through electronic systems, which not only improve efficiency but also help prevent illicit operations. Adapting these international best practices to the Uzbek context will assist in the effective implementation of the inward processing regime. [5]

CONCLUSION AND RECOMMENDATIONS

In conclusion, the inward processing customs regime plays a vital role in the national economy. However, existing economic, organizational, and legal challenges hinder its full-scale implementation. Therefore, a comprehensive approach is required—first and foremost, by developing transport and logistics infrastructure to reduce external trade costs. Simplifying customs clearance procedures, minimizing bureaucratic barriers, and expanding the use of electronic systems will significantly enhance operational efficiency.

Implementing automated control systems for processing operations will ensure transparency in monitoring and reduce human-related errors. Aligning the regulatory framework with international standards will strengthen Uzbekistan's reliability in foreign trade. Moreover, increasing entrepreneurs' awareness of the benefits of the inward processing regime will foster their active participation.

If these measures are consistently implemented, Uzbekistan's export potential will expand, the efficiency of the customs system will improve, and the country's overall economic competitiveness will grow stronger.

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FINANCIAL ANALYSIS OF SMALL BUSINESS AND PRIVATE ENTREPRENEURSHIP IN CONSTRUCTION

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Abstract: This article considers the calculation of various profitability indicators characterizing certain levels of efficiency in the use of fixed assets in the analysis of the economic activities of a construction enterprise, including the profitability of sales of products of interest to each construction enterprise and investors, the profitability of fixed assets, the profitability of own investments, the profitability of costs.

Key words: Construction enterprise, efficiency, business, profitability, investment, profit.

Annotatsiya: Mazkur maqolada qurilish korxonasi xo‘jalik faoliyatini tahlil qilishda asosiy vositalardan foydalanish samaradorligining muayyan darajalarini tavsiflovchi turli rentabellik ko‘rsatkichlarini hisoblab chiqish, ulardan har bir qurilish korxonasi va investorlarni qiziqtiradigan mahsulotni sotish rentabelligi, asosiy sarmoya rentabelligi. o‘z sarmoyasi rentabelligi, xarajatlar rentabelligi ko‘rib chiqilgan.

Kalit so‘zlar: Qurilish korxonasi, samaradorlig, biznes, rentabellik, sarmoya, foyda.

Аннотация: В данной статье рассматривается расчет различных показателей рентабельности, характеризующих отдельные уровни эффективности использования основных средств при анализе хозяйственной деятельности строительного предприятия, включая рентабельность реализации продукции, представляющую интерес для каждого строительного предприятия и инвесторов, рентабельность основных средств, рентабельность собственных инвестиций, рентабельность затрат.

Ключевые слова: Строительное предприятие, эффективность, бизнес, рентабельность, прибыль.

INTRODUCTION

In order to support small businesses and private entrepreneurs in the global communityIn accordance with the Resolution of the President of the Republic of Uzbekistan No. PQ-2663 dated November 29, 2016, “On measures to implement the project “Support for the Development of Small Business and Private Entrepreneurship” with the participation of the Asian Development Bank, in order to expand lending to small business and private entrepreneurship, further stimulate microfinancing and increase the credit resources of commercial banks, as well as create favorable conditions for their development by expanding cooperation with the Asian Development Bank, “the Asian Development Bank has allocated $ 100 million for a period of 15 years to support small business and private entrepreneurship.” Such support programs are being implemented to further develop the activities of businesses in all sectors.

Small business and private entrepreneurship are an important sector of the economy, especially in developing countries, playing a major role in creating jobs, ensuring the stability of the local economy, as well as introducing new technologies and implementing innovative ideas. The development of small business and private entrepreneurship is directly related to the effective organization of the state’s economic policy, financial and legal system.

Analysis of literature on the topic. Small business and private entrepreneurshipanalysis of existing literature onentrepreneurshipIt shows the need to improve modern principles of marketing, brand promotion methods, and a flexible approach to consumer demands.Entrepreneurshipmodern principles of GISMany economists have been engaged in the development and application of these concepts. Among them, we can include such famous scientists as F. Kotler, David Aeker, Clayton Christensen, Seth Godin, Kevin Keller, Byron Sharp, and Jay Bayer.

For many years in our countrySmall business and private entrepreneurship In the field of research, which is based on national characteristics, it is also necessary to recognize scientists who have made a significant contribution. These include R. Ibragimov, YO. Abdullaev, A. Saliev, M. Sharifkhodjaev, D. Rakhimova, Sh. Ergashkhodjaeva, Sh. Musayeva and others.

RESEARCH METHODOLOGY

The study used a systematic approach, marketing analysis, benchmarking, and digital metrics. Mass surveillance methods were used to collect and analyze data from social media platforms.

Analysis and results. The effectiveness of small businesses and private entrepreneurship plays an important role in the economy, as it plays a significant role in creating new jobs, supporting economic growth, introducing innovations, and developing the local economy. The effectiveness of this type of business is associated with many factors, among which economic indicators, efficient use of resources, and foreign experience are of great importance.

Indicators for assessing the effectiveness of small businesses and private entrepreneurship:

Profitability: The profitability of a small business shows how its costs and profits are distributed in relation to its revenue. A high level of profitability means that the business is operating efficiently.

Production efficiency: This indicator is related to how effectively the resources (labor, materials, time) used in the production process are managed. If a small business uses resources efficiently, this indicates its high efficiency.

Job creation: Small businesses play an important role in creating new jobs and ensuring employment. The growth of this indicator indicates economic activity and successful business operations.

Implementing innovations: By introducing innovations, small businesses have the opportunity to adapt to changing market demands and develop new products or services. This increases their competitiveness.

Reinvestment rate: The degree to which small businesses expand their operations and invest in new projects is also an important indicator of efficiency.

Financial stability and liquidity: A small business's financial stability, ability to repay debts, and ability to raise the necessary funds to continue its operations affect its long-term success.

"Profitability" (or "returnability") is a term used in economics and finance to describe the profitability of a business or project, that is, the effectiveness of investments. This indicator helps determine the ratio between income and expenses.

Table 1. The volume of preparation of design and estimate documentation completed by KK "TECHNOLOGY" in 2024

No.	Naming objects	Estimated cost of objects, thousand soums
1	Reconstruction of school No. 3 in the Garib Primary Educational Service Area of Kattakurgan city.	90 934 000.00
2	Reconstruction of school No. 32 in the "Soygus" MFE of the Urgut district	90 934 000.00
3	Providing the municipal waste landfill in Gulistan district, Syrdarya region, with appropriate infrastructure.	45 524 000.00
4	Reconstruction of school No. 49 in the Kamangaron MFE of Urgut district	87 685 000.00
5	Reconstruction of school No. 56 in the "Mangitobod" MFE of Pastdarg'om district	81 415 000.00
6	«We set a goal to build a new line from the water station with the residents of our business district. It will create convenience for business districts. We will install high-voltage cables on concrete poles for a distance of 6.0 km, two 160-volt transformers, replace the unusable wooden wires on the streets with concrete poles, and install night lighting.»	38 760 000.00
	Total:	435 252 000.00

According to the Regulation on the composition of costs for the production and sale of products (works, services) and the procedure for forming financial results, approved by the Ministry of Finance of the Republic of Uzbekistan, the following profit indicators are distinguished.

-gross profit from the sale of the product;

-profit from main activity:

-profits from general economic activities:

-profit before taxes:

-net profit:

Gross profit (GPP) describes the income of an enterprise from the sale of a product and is determined as the difference between net revenue from the sale of a product and the cost of goods sold, using the following formula:

GPP =ST-MT

Net sales revenue (ST) is the net revenue from sales of products after deducting value added tax and excise tax. This indicator is the profit that the enterprise receives from the sale of products.

Cost of goods sold (MT) is the company's costs of producing a product, including direct and indirect material and labor costs for its production.

Table 2. Report on financial results for 3 years (in thousand soums)

No.	Names	2022.	2023	2024
1	Proceeds from sales	538 133.00	1,606,887.17	1,056,800.05
2	Net proceeds from sales	538 133.00	1,606,887.17	1 0568 00.05
3	Cost of goods manufactured	195,758.00	883,787.95	453 452.90
4	Administrative expenses	304 232.00	346 460.00	431 437.90
5	Other expenses	1 780,00	754.51	24,494.60
6	Profit before tax on income	36 363.00	375,884.71	147,414.65
7	Profit tax	-	29,475.17	22 112.19
8	Net profit	19,764.00	325,884.71	147,414.65
	From this:			
8.1	By main activity	19,764.00	325,884.71	147,414.65
8.2	On general economic activities	0.00	0.00	0.00
9	Damage	0.00	0.00	0.00
	From this:			
9.1	By main activity	0.00	0.00	0.00
9.2	On general economic activities	0.00	0.00	0.00

Profit from main activities (As. ff) - describes the profit received by the enterprise from its main activities (construction work completed, etc.).

To determine this profit, period expenses and other extraordinary expenses are deducted from gross profit. Period expenses include administrative expenses, selling expenses, other operating expenses, and expenses of the reporting period that will be deducted from the taxable base in the future. In addition, other income from the main activity is added to this result, which is expressed in the form of a formula as follows:

As.ff = GPP – Dhar. + Bdar. - Bhar.

Table 3. Balance sheet of "TALIB BOBO AKT" LLC for 2022-2024

Balance (2021-2023)	2022.	2023	2024
ASSETS			
Long-term assets			
Fixed assets	7 477.00	7 477.00	7 477.00
Of which, production funds	0.00	0.00	0.00
residual value	0.00	0.00	0.00
Capital investments	0.00	0.00	0.00
Incomplete production	0.00	0.00	0.00
Current assets			
Working capital	44 154.24	0.00	149,985.78

Of which production reserves	0.00	0.00	0.00
Accounts receivable	402,861.49	683,865.40	115,958.94
It has expired.			
By total balance sheet asset	454 492.73	683,865.40	265,944.72
PASSIVE			
Source of equity funds			
Authorized capital	300.00	300.00	300.00
Retained earnings	1006.66	296,434.30	147,414.65
Obligations			
Loans	452,060.93	226 426.1	88,000.80
Accounts payable	6,052.55	12,080.44	12,046.97
Overdue debts	0.00	0.00	0.00
Of which, budget debts	14760.38	73,685.43	679.22
From this, wage arrears	0.00	73,813.99	17,503.08
On the liabilities side of the total balance sheet	452,060.93	683,865.40	265,944.72

Based on the information provided by the organization's accounting department and financial statements, the profit from the main activity was equal to the profit before tax. Net profit is calculated using the following formula:

Sf = As.ff – Profit tax – Other taxes

When assessing financial results, the efficiency ratio should also be calculated. This includes profitability indicators that show the ratio of profit to economic activity indicators.

When analyzing the economic activities of a construction enterprise, various profitability indicators are calculated that characterize certain levels of efficiency in the use of fixed assets. The main ones that are of interest to each construction enterprise and investors are: profitability of product sales; profitability of fixed assets; profitability of own investments; profitability of expenses.

An analysis of the organization's financial results, conducted using the data in Table 3 and the formulas above, is presented in Table 4.

Table 4. Analysis of financial results of "Technology" LLC for 2022-2024 (thousand soums)

No.	Indicators	2022.	2023	2024	Change, %
1	Gross profit or financial result from product sales	342 375.00	723,099.22	603 347.15	83.4
2	Profit from main activity	36 363.00	375,884.71	147,414.68	39.21
3	Profit before income tax	36 363.00	375,884.71	147,414.68	39.21
4	Net profit	19,764.00	325,884.71	147,414.68	45.23
5	Return on equity	15.2	109.8	99.7	90.8
6	Product sales profitability	69.19	81.81	60.2	73.58
7	Cost-effectiveness	18.57	36.82	32.5	88.26
8	Payback of own investment	6.61	9.11	8.24	90.4

Table 4 analyzes the financial results of "Technology" LLC for 2022-2024. We can see that all indicators of our enterprise had the lowest indicators in 2022. In this case, gross profit or financial result from product sales was 342,375 thousand soums in 2022, 723,099.22 thousand soums in 2023, while in 2024 it was 603,347.15 thousand soums, which is a decrease of 119,752.07 thousand soums compared to the previous year, and an increase of 260,972.15 thousand soums compared to 2022. While the profit from the main activity amounted

to 375,884.71 thousand soums in 2023, in 2024 it decreased by 228,470.03 thousand soums compared to the previous year, amounting to 147,414.68 thousand soums. Net profit, accordingly, recorded the highest indicator in 2023. While the return on equity was 15.2 percent in 2022, it increased to 84.5 percent in 2024 and amounted to 99.7 percent. The main reason for this is the significant increase in net profit and other indicators in 2023-2024. Due to this, the payback period of the investment had the shortest period in 2024, which was 6.61 years in 2022 and 6 years in 2023, which increased by 2.5. In 2024, it decreased by 0.87 units compared to the previous base year and amounted to 8.24 years.

To improve all economic indicators of the organization, it will be necessary to find ways to reduce costs, carry out design work on high-yield construction, and develop a program of expenses and income for the company.

Analysis of the financial stability and soundness of a project enterprise in construction.An enterprise that covers the funds invested in assets with its own funds, does not allow inappropriate receivables and payables, and pays its obligations on time is considered a financially stable enterprise. Financial stability is determined by the ratio of own and borrowed funds and is calculated using a number of indicators: independence, financial stability, and financial dependence coefficients.

In the specific case, according to Table 4, the organization's own funds over the years are equal to the following (in thousand soums): OS1 = 1,306.66; OS2 = 296,734.3; OS3 = 147,714.65. Operating funds: S1 =44 154.24; S2 =0.00; S3 =149,985.78. Debt funds: JS1 = 452,060.00; JS2 = 376,055.96; JS3 = 106,188.93. IshS1 = 0.00; IshS2 = 0.00; IshS3 = 0.00. Based on this data, we have presented in Table 5 the results of the analysis of the financial stability of the organization for 2022-2024:

Table 5. Assessment of the financial stability of "Technology" LLC in 2022-2024

No.	Indicators	2022.	2023	2024	Change, %
1	**Independence coefficient (Must.k)**	0.02	0.00	0.98	0.98
2	**Financial stability coefficient (Mbar.k)**	0.002	0.78	1.39	1.78
3	**Financial dependency ratio (Mqar.k)**	33.79	0.00	1.01	1.01
4	**Equity mobility ((Uzsar.har.)**	0.00	0.00	0.00	0.00

As shown in Table 5, we can see that the financial stability of TECHNOLOGY LLC has deteriorated overall. The independence coefficient was 0.02 in 2022, decreased by 0.00 points in 2023 to 0.02, and also increased by 0.98 points in 2024, which is an increase of 0.98 points compared to the base year. The financial stability indicator was 1.39 in 2024, an increase of 1.78 points compared to 2023. The financial dependence coefficient was 0.00 in 2023, and increased by about 1.01 percent in 2024 to 1.01. The equity mobility coefficient was 0.00 in 2022, 2023, and 2024.

CONCLUSION AND SUGGESTIONS

In conclusion, we can say that based on the data, the financial situation of KK "TECHNOLOGY" is deteriorating, the reason being that the financial dependency ratios have been increasing over the last two years.

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MEASURES TO ENHANCE THE ROLE AND EFFECTIVENESS OF SMALL BUSINESS IN REGIONAL ECONOMIC DEVELOPMENT

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Abstract: This article provides a scientific analysis of the role and significance of small business in regional economic development. It examines the impact of small entrepreneurship on regional economies, its role in job creation, its contribution to increasing household incomes, and its potential for improving the investment climate. The paper also analyzes mechanisms aimed at enhancing the efficiency of small business entities, including the introduction of digital technologies, state incentives, and support measures. Based on the research findings, practical recommendations were developed to promote the development of small business at the regional level and increase its economic activity.

Key words: small business, regional development, economic growth, business environment, innovation, efficiency.

Annotatsiya: Ushbu maqolada kichik biznesning hududiy iqtisodiy rivojlanishdagi roli va ahamiyati ilmiy jihatdan tahlil qilingan. Shu bilan birga kichik tadbirkorlik faoliyatining hududlar iqtisodiyotiga ta'siri, yangi ish o'rinlarini yaratish jarayonidagi o'rni, aholi daromadlarini oshirish hamda investitsion muhitni yaxshilashdagi imkoniyatlari yoritilgan. Shuningdek, kichik biznes subyektlarining samaradorligini oshirishga qaratilgan mexanizmlar, raqamli texnologiyalarni joriy etish, davlat tomonidan berilayotgan imtiyozlar va qo'llab-quvvatlash choralari tahlil etilgan. Tadqiqot natijalari asosida hududiy darajada kichik biznesni rivojlantirish hamda uning iqtisodiy faolligini oshirish bo'yicha amaliy taklif va tavsiyalar ishlab chiqilgan.

Kalit so'zlar: kichik biznes, hududiy rivojlanish, iqtisodiy o'sish, tadbirkorlik muhiti, innovatsiyalar, samaradorlik.

Аннотация: В данной статье представлено научное исследование роли и значения малого бизнеса в региональном экономическом развитии. Рассматривается влияние малого предпринимательства на экономику регионов, его роль в создании новых рабочих мест, повышении доходов населения и улучшении инвестиционного климата. Также проанализированы механизмы повышения эффективности субъектов малого бизнеса, включая внедрение цифровых технологий, государственные льготы и меры поддержки. На основе результатов исследования разработаны практические рекомендации по развитию малого бизнеса на региональном уровне и повышению его экономической активности.

Ключевые слова: малый бизнес, региональное развитие, экономический рост, предпринимательская среда, инновации, эффективность.

INTRODUCTION

Today, small business and private entrepreneurship are recognized as one of the most important sectors of the national economy. Small business refers to economic activity based on independent ownership and autonomous management that does not hold a dominant position in its market. International experience demonstrates that small business plays a vital role in achieving economic stability, creating new jobs, ensuring employment, and improving living standards. In particular, the activity of small business entities serves as a key factor determining economic growth rates in regional development processes.

In recent years, comprehensive reforms aimed at supporting small business, improving the business environment, and enhancing economic activity across regions have been consistently implemented in the Republic of Uzbekistan.[7] Through presidential decrees, government resolutions, and various regulatory documents, small business entities are provided with tax incentives, credit benefits, subsidies, and state guarantees. These measures contribute to expanding production volumes in the regions, creating new jobs, increasing export potential, and improving the well-being of the population.

However, the potential of small business in regional economic development has not yet been fully realized.[8] Factors such as underdeveloped production infrastructure in certain regions, limited access to financial resources, and insufficient adoption of modern technologies hinder the full demonstration of small business efficiency.[9] Therefore, strengthening the efficiency of small business entities, enhancing their competitiveness, and improving mechanisms that ensure regional economic growth have become urgent priorities.

This article provides a scientific and practical analysis of the role of small business in regional economic development, the factors influencing its efficiency, existing challenges, and possible solutions for overcoming them.

REVIEW OF LITERATURE ON THE SUBJECT

The role of small business and private entrepreneurship in economic development has been extensively studied by numerous foreign and local scholars. In global economic literature, researchers such as J. Schumpeter, P. Drucker, M. Porter, A. Smith, R. Coase, and A. Marshall have evaluated entrepreneurship as a key factor ensuring sustainable economic growth, fostering innovation, and creating new employment opportunities. In his Theory of Economic Development, J. Schumpeter describes the entrepreneur as an “innovator and the driving force of the economic system.”[1] P. Drucker considers small business to be the foundation of economic stability and social well-being.[2] In M. Porter’s Competitive Advantage concept, small business is recognized as a fundamental element shaping a competitive environment.[3] According to Porter, small enterprises play an essential role in introducing innovations, adapting quickly to market demands, and maintaining balance within the economic system.

The works of A. Marshall and R. Coase highlight the advantages of small businesses in reducing production costs,[5] ensuring efficient use of resources, and increasing production efficiency.[4] Among local economists, Sh. Mirziyoyev, Q. Alimov, S. G‘ulomov, N. Xo‘jayev, M. Usmonov, I. Tursunov, and others have extensively analyzed the importance of small business in regional economic development. Their research indicates that small business is a decisive factor in maintaining economic stability, increasing employment, diversifying production, and reducing interregional economic disparities.[6]

Furthermore, the works and speeches of President Sh. Mirziyoyev on economic reforms emphasize the development of small business as a driving force of regional economic growth. In recent years, several regulatory and legal documents aimed at promoting small business and improving the entrepreneurial climate have been adopted in the Republic of Uzbekistan. These include the Presidential Decree On Improving Mechanisms for Supporting Entrepreneurial Activity, the New Uzbekistan Development Strategy for 2022–2026, and the Comprehensive Program for the Socio-Economic Development of Regions. These documents focus on the development of small business, increasing the share of the private sector, improving the investment climate, and creating new employment opportunities.[10]

The literature analysis shows that small business, as the most active and dynamic part of the economic system, plays a crucial role in regional development. It contributes significantly to ensuring economic growth, strengthening social stability, increasing household incomes, and expanding local budget revenues.

RESEARCH METHODOLOGY

In this study, the role and efficiency of small business in regional economic development were assessed using the following scientific and methodological approaches:

- Analytical analysis method – the role of small business in the economy, production volumes, employment levels, and its impact on regional development were examined.
- Comparative analysis method – the level of small business development, economic outcomes, and growth rates across different regions of the republic were compared.
- Systemic approach method – economic, social, organizational, and institutional factors influencing small business activity were studied in their interrelationships.
- Statistical analysis method – based on data from the State Committee of the Republic of Uzbekistan on Statistics and the Ministry of Economy and Finance, recent trends in the number of small business entities, production volumes, export potential, and employment levels were analyzed.

- Inductive and deductive approaches – empirical observations were used to draw general conclusions, while theoretical foundations were enriched through practical results.

Using these methods, the role of small business in regional economic development, the factors influencing its efficiency, and potential directions for improvement were comprehensively analyzed. Based on the findings, scientific and practical recommendations were developed to enhance the activities of small business entities and increase their contribution to regional economies.

ANALYSIS AND RESULTS

Studies conducted show that small business is one of the rapidly developing sectors of Uzbekistan's economy and is emerging as a stable source of regional economic growth. In recent years, the number of small business entities in the country has been steadily increasing. According to the State Committee on Statistics, the share of small business in GDP rose from 52 percent in 2020 to 57 percent in 2024, indicating the growing importance of entrepreneurship in economic development. The expansion of small business directly contributes to increased regional production volumes, the creation of new jobs, and the rise of household incomes. In 2024 alone, more than 500,000 new jobs were created through small business activities, which is 1.4 times higher than in 2020. Additionally, small enterprises have achieved significant results in expanding export volumes, deep processing of local raw materials, and producing import-substituting goods.[10]

Analyses show that regions with highly effective small business activity also demonstrate higher levels of economic performance. For example, in Tashkent city and the Fergana, Samarkand, and Andijan regions, the share of small business in gross regional product exceeds 60 percent. This is attributed to developed economic infrastructure, broad access to financial resources, and a favorable investment climate. However, in some remote regions, the growth rate of small business remains low.[11] The main reasons include limited access to financial resources, underdeveloped production infrastructure, low adoption of digital technologies, and insufficient experience in marketing and management. Therefore, applying a differentiated regional approach—one that reflects each region's natural, economic, and labor resources—is essential for developing effective small business strategies.

The following factors play a key role in increasing the efficiency of small business:

- Expanding financial support mechanisms such as preferential loans, grants, and subsidies;
- Introducing digital technologies to automate production processes and increase efficiency;
- Developing infrastructure, including industrial zones, logistics centers, and innovation parks;
- Strengthening human capital through training and capacity-building programs for entrepreneurs and employees;
- Simplifying the business environment by reducing the number of permits and easing tax administration.

Overall, the role of small business in regional economic development continues to grow year by year. Its effective operation not only promotes economic growth but also supports social stability, employment, and regional equality. Therefore, comprehensive support for small business and the widespread introduction of innovative and digital approaches are essential for ensuring the sustainable development of the national economy.

CONCLUSIONS AND SUGGESTIONS

This article analyzed the role of small business in regional economic development, measures for increasing its efficiency, and existing challenges. Based on the analyses presented in the article, the following recommendations were developed to enhance the efficiency of small business and accelerate regional economic development:

1. Expand the system of financial support by increasing the volume of preferential loans, grants, and subsidies.
2. Introduce digital technologies and automate production processes.
3. Develop production infrastructure and expand industrial zones and innovation parks.
4. Organize training programs and courses to improve the qualifications of entrepreneurs and employees.
5. Simplify the business environment by reducing the number of permits and easing tax administration.

Thus, the effective development of small business ensures not only regional economic stability but also contributes to the country's sustainable economic growth and the improvement of social well-being. Therefore, the development of small business should remain one of the priority directions of state policy.

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THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR IMPLEMENTING INNOVATIVE TECHNOLOGIES IN EDUCATION

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Abstract: The article examines the methodological foundations of the innovative educational process in the modern school. The concepts of “innovative activity” and “innovative process” are clarified. It is concluded that there is a growing need for a new theoretical understanding of the essence of managing innovative processes in an educational institution, as well as for developing pedagogical conditions that ensure continuous innovative progress.

Key words: innovation, pedagogical innovatics, innovation management, innovation process.

Annotatsiya: Ushbu maqolada zamonaviy maktabdagi innovatsion ta’lim jarayonining metodologik asoslari ko‘rib chiqilgan. “Innovatsion faoliyat” va “innovatsion jarayon” tushunchalariga aniqlik kiritildi. Ta’kidlanishicha, ta’lim muassasasida innovatsion jarayonlarni boshqarish mohiyatini yangicha nazariy anglash hamda uzluksiz innovatsion taraqqiyotni ta’minlaydigan pedagogik shart-sharoitlarni ishlab chiqishga ehtiyoj ortib bormoqda.

Kalit so‘zlar: innovatsiya, pedagogik innovatika, innovatsiyalarni boshqarish, innovatsion jarayon.

Аннотация: В статье рассматриваются методологические основы инновационного образовательного процесса в современной школе. Уточняются понятия «инновационная деятельность» и «инновационный процесс». Делается вывод о возрастающей необходимости нового теоретического осмысления сущности управления инновационными процессами в образовательном учреждении, а также разработки педагогических условий, обеспечивающих непрерывное инновационное развитие.

Ключевые слова: инновация, педагогическая инноватика, управление инновациями, инновационный процесс.

INTRODUCTION

At present, significant changes are taking place in our country’s national education policy. This is connected with the shift toward learner-centered pedagogy. One of the tasks of the modern school is to unlock the potential of all participants in the educational process and to provide them with opportunities to express their creative abilities. Solving these tasks is impossible without introducing variability into educational processes, which has led to the emergence of various innovative types and forms of educational institutions that require deep scientific and practical analysis.

The modern Uzbek school is the result of major transformations that have occurred in the national education system in recent years. In this respect, education is not merely a part of the social life of society but its vanguard: few other subsystems can demonstrate their progressive development with such an abundance of innovations and experiments.

The changing role of education in society has driven most innovative processes. From being socially passive, routine-based, and carried out within traditional social institutions, education is becoming active. The educational potential of both social institutions and individuals is being actualized. Previously, the unquestioned goals of education were the formation of knowledge, skills, and informational and social competencies that ensured “readiness for life,” which, in turn, was understood as the ability of an individual to adapt to social circumstances. Now, education is increasingly oriented toward creating technologies and methods of influencing the individual that ensure a balance between social and individual needs, and which, by activating the mechanisms of self-development (self-improvement, self-education), prepare the individual to realize their own individuality and to respond to societal changes.

REVIEW OF LITERATURE ON THE SUBJECT

Research on innovative technologies in education rests heavily on the broader theoretical foundations of innovative management, extensively developed in classical and contemporary scholarship. Balabanov (2016) emphasizes that innovation implementation requires structured managerial frameworks, highlighting the need for systematic planning, resource optimization and strategic adaptation—principles that transfer directly to educational transformation. Similarly, Zavlina, Kazantseva and Mindeli (2020) expand the conceptual understanding of innovation processes by linking them to organizational development cycles, thereby providing methodological tools useful for designing innovation-oriented educational environments.

Ivanov (2002) and Ilyenkova (1999) offer foundational insights on innovation management with a particular focus on the mechanisms of generating, selecting and institutionalizing new ideas. Their works stress the importance of internal organizational readiness, human capital development and feedback mechanisms—factors that are crucial when integrating digital technologies, adaptive learning systems and modern pedagogical tools into educational institutions. Medynsky (2002) further develops this framework by underlining the role of innovation infrastructure and management culture, arguing that successful adoption of new technologies depends on the alignment between institutional strategies and the broader innovation ecosystem.

Yusufbekova (2010) provides a direct pedagogical perspective, conceptualizing “pedagogical innovatics” as a methodological field aimed at understanding how innovations reshape teaching and learning processes. She argues that innovative technologies require a shift in methodological thinking, where the educator becomes both a facilitator and a designer of interactive learning experiences. Her work highlights the need for research-based approaches when introducing technological tools, ensuring they enhance cognitive engagement, foster learner autonomy and support evidence-based pedagogical decisions.

Taken together, these studies demonstrate that the theoretical and methodological foundations for implementing innovative technologies in education emerge at the intersection of innovation management principles and pedagogical innovation research. The literature consistently emphasizes strategic planning, institutional readiness, structured evaluation and methodological rigor as essential elements for effective technological integration in modern education.

RESEARCH METHODOLOGY

The study relies on secondary data collected from scientific publications, educational policy documents, and empirical reports on innovation management and pedagogical technologies. The gathered materials are analyzed through comparative evaluation, thematic content analysis, and synthesis of conceptual approaches to identify methodological principles and patterns that guide the effective implementation of innovative technologies in education.

Analysis and results

Innovation is defined as an increase in the existing body of knowledge that leads to changes in current technology and management, resulting in economic benefits. Thus, innovation, as the outcome of a creative process, manifests itself in the form of new value.

Innovation is implemented during the period between the initial creation of a concept for a new product and the preparation of a justification for launching mass production, establishing a distribution system, and providing after-sales service.

Innovation is a product of collective intellectual labor that makes it possible to use everything new (ideas, inventions, technologies, management methods) to dramatically increase the efficiency of existing activities or to form promising directions in economic and social human activity.

Innovative activity encompasses the creation and implementation of:

- new products;
- new technological processes and forms of production organization;
- new markets;
- new management processes and solutions to socio-economic problems, along with the corresponding financial instruments and organizational structures;

The emergence of innovation has two starting points:

The sources of funding for science and innovation in Uzbek include the internal funds of organizations (enterprises) conducting scientific research and development or carrying out innovative activities; budgets at all levels; extra-budgetary funds; and foreign sources.

The innovation process is the process of creating, disseminating, and using a novelty (a set of new ideas and proposals that can potentially be implemented and that, given the scale of their use and the effectiveness of their outcomes, may become the basis for any innovation). It represents the transformation of

new types and methods of human activity (innovations) into socio-cultural norms and models that ensure their institutionalization, integration, and consolidation within the culture of society.

The innovation process unfolds in several stages. In most cases, an innovation is a combination of multiple factors introduced partly simultaneously and partly sequentially. Therefore, innovation is not an isolated event but rather a trajectory consisting of many small events. For this reason, when analyzing an innovation, it is difficult to pinpoint the exact moment when it emerged or to identify a single cause.

Thus, all elements that make up the content of innovative activity not only follow from one another but are also closely interconnected and exert mutual influence on each other. As a result, a change in one element leads to changes in the others, and ultimately in the entire organization. This requires a comprehensive approach to solving any of its problems—large or small, simple or complex, current or long-term. Consequently, a systemic approach is necessary.

F. Jansen, using a systemic approach to organizations and the innovation processes occurring within them, describes an organization as a living organism with complex connections and reactions, asserting that "…life, consciousness, innovation are phenomena of the highest level of hierarchy, emerging from the behavior of many molecules, cells, or, respectively, producers and consumers."

The following factors motivate an organization to engage in innovative activity: the environment (external environment) and its changes, which force people to innovate; the state, which through its policies provides or removes incentives for innovation; and scientific and technological progress, which encourages enterprises to monitor new developments in order to effectively compete. Internal factors driving innovation within an enterprise include the creative abilities of employees, internal corporate competition, as well as the preferences of the owners, managers, and informal leaders of the organization.

Questions of scientific support for innovative activity in education fall within the field of pedagogical innovatics.

Today, both pedagogical innovatics itself and its methodology are still in the stage of scientific development and formation. Let us examine the conceptual framework and theoretical foundations of innovative processes in education.

Innovations in education represent the creative elaboration of new ideas, principles, and technologies, and in some cases, their refinement into model projects that include conditions for their adaptation and application.

It is important to distinguish between innovations (novelties) and innovations-as-implementation. If a pedagogical novelty is understood as an idea, method, tool, technology, or system, then an innovation in this case is the process of introducing and mastering that novelty. We consider the term "innovative" to be synonymous with "innovation."

By designing innovations, it becomes possible to manage the development of educational systems—both at the level of an educational institution and at the regional or national level. Justifying a typology of pedagogical innovations makes it possible to study the specifics and regularities of innovation development, as well as to identify and analyze the factors that facilitate or hinder innovative activity.

A key concept in innovatics is the innovation process. Innovation processes in education are considered from three main perspectives: socio-economic, psychological-pedagogical, and organizational-managerial. These aspects determine the overall climate and conditions in which innovation processes occur. Existing conditions can either facilitate or hinder the innovation process. The innovation process can be either spontaneous or consciously managed. The introduction of novelties is primarily a function of managing both artificial and natural processes of change.

It is important to emphasize the unity of the three components of the innovation process: creation, adoption, and application of novelties. This three-part innovation process is most often the object of study in pedagogical innovatics, unlike, for example, didactics, where the focus of scientific research is the learning process.

Another systemic concept is innovative activity, which refers to the set of measures taken to ensure the innovation process at a particular level of education, as well as the process itself. The main functions of innovative activity include changes in the components of the educational process: meaning, goals, content of education, forms, methods, technologies, teaching tools, and the management system.

Innovatics entered pedagogy from fields such as cultural studies, linguistics, and economics. Within innovatics, there is an implementation-oriented vector, which reflects the traditional—and often criticized—relationship between science and practice (science develops and implements in practice). This understanding contradicts the increasingly developed learner-centered pedagogical paradigm of recent years, which emphasizes the growing role of the individual in designing their own education.

Instead of mechanically transferring innovation tools from economics, entrepreneurship, or production, pedagogical innovatics offers the opportunity to thoughtfully adapt these approaches to the human-centered nature of education. This perspective enables educators to design conditions in which learners actively participate in renewing their own educational experience. Such an orientation forms a strong methodological

foundation for developing theoretical principles of pedagogical innovatics and supports the progressive evolution of modern educational systems.

Based on the above, pedagogical innovatics can be understood as the science that studies the nature, patterns of emergence and development of pedagogical innovations, and their connections with past and future traditions in relation to educational subjects.

We can define the object and subject of pedagogical innovatics as follows:

The object of pedagogical innovatics is the process of emergence, development, and adoption of innovations in education. Here, innovations are understood as novelties—purposeful changes that introduce new elements into education and cause its transition from one state to another. Education is viewed as a socially, culturally, and personally determined educational activity, in which the subject of this activity is actively involved in the process of change (renewal).

The subject of pedagogical innovatics is the system of relationships that arise in innovative educational activities aimed at the development of the personality of educational subjects (students, teachers).

Today, innovative changes occur in areas such as: the formation of new educational content; development and implementation of new teaching technologies; application of methods, techniques, and tools for mastering new programs; creation of conditions for personal self-determination during learning; changes in the modes of activity and thinking styles of both teachers and students; changes in their interactions; and the creation and development of creative innovative teams, schools, and universities.

CONCLUSIONS AND SUGGESTIONS

Research on innovation processes in education has identified a number of theoretical and methodological problems: the relationship between tradition and innovation, the content and stages of the innovation cycle, the attitudes of different educational subjects toward innovations, innovation management, staff training, criteria for evaluating new elements in education, and others. These problems require understanding at a higher methodological level.

Justifying the methodological foundations of pedagogical innovatics is no less important than developing innovatics itself. Pedagogical innovatics represents a distinct area of methodological research. To develop the scientific support for educational innovations, it is necessary to rely on the existing methodological base.

The methodology of pedagogical innovatics offers a comprehensive system of knowledge and activities that makes it possible to consistently study, explain, and substantiate its principles, regularities, conceptual framework, and tools, as well as their scope within modern educational practice. This methodological apparatus provides strong potential for analyzing, supporting, and designing the modernization of education. As large-scale innovations continue to evolve, the field presents promising opportunities for further strengthening scientific foundations.

Current reforms—such as updated secondary education standards, new school structures, specialized learning tracks, and modern assessment systems—create favorable conditions for expanding innovation-pedagogical research. Ongoing enhancement of methodological completeness and systemic approaches in implementing these innovations is expected to contribute significantly to the effective development and sustainable renewal of the educational sphere.

Thus, there is a growing need for a new theoretical understanding of the essence of managing innovation processes in educational institutions and for the development of pedagogical conditions that ensure continuous innovative progress. Equally important is the fact that innovation processes require specialized personnel training—teachers and education managers competent in the field of pedagogical innovations.

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INDIA'S EXPERIENCE IN ENHANCING PUBLIC WELFARE THROUGH THE DEVELOPMENT OF ENTREPRENEURIAL ACTIVITY

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Abstract: The article analyzes India's experience in improving the well-being of the population through the development of entrepreneurship. Digital transformation, support for SMEs, startup ecosystem, investment in human capital and rural entrepreneurship are highlighted as key factors serving inclusive economic growth.

Key words: India, entrepreneurship, inclusive growth, SMEs, Digital India, Startup India, human capital, rural entrepreneurship, digital transformation.

Annotatsiya: Maqolada Hindistonning tadbirkorlikni rivojlantirish orqali aholi farovonligini oshirish tajribasi tahlil qilinadi. Raqamli transformatsiya, KO'Bni qo'llab-quvvatlash, startaplar ekotizimi, inson kapitaliga sarmoya va qishloq tadbirkorligi inklyuziv iqtisodiy o'sishga xizmat qiluvchi asosiy omillar sifatida yoritilgan.

Kalit so'zlar: Hindiston, tadbirkorlik, inklyuziv o'sish, KO'B, Digital India, Startup India, inson kapitali, qishloq tadbirkorligi, raqamli transformatsiya.

Аннотация: В статье анализируется опыт Индии в повышении благосостояния населения посредством развития предпринимательства. Цифровая трансформация, поддержка МСП, стартап-экосистема, инвестиции в человеческий капитал и сельское предпринимательство выделены как ключевые факторы, способствующие инклюзивному экономическому росту.

Ключевые слова: Индия, предпринимательство, инклюзивный рост, МСП, Цифровая Индия, Стартап-Индия, человеческий капитал, сельское предпринимательство, цифровая трансформация.

INTRODUCTION

The experience of India plays a highly significant role in improving public welfare through the development of entrepreneurial activities. This country has placed strong emphasis on expanding entrepreneurship as a key driver of economic growth and social stability.

The reason for selecting India as the object of our research lies in its population, which exceeds 1.4 billion people [1, 23]. Ensuring and enhancing the welfare of such a large population presents unique complexities and requires effective socio-economic governance. Therefore, analyzing the country's experience from a theoretical perspective is both reasonable and relevant.

Our analysis confirms that India recognizes the crucial role of entrepreneurship in improving public welfare. Comprehensive strategies aimed at developing small business and entrepreneurial activity are actively implemented across the country.

It should be noted that India pursues an inclusive approach to enhancing public welfare through entrepreneurship, with particular attention given to small and medium-sized enterprises (SMEs) and digital transformation. Digital transformation has become a decisive factor in expanding entrepreneurial participation. Within the framework of "Digital India," systems such as e-government, online payments, and digital identification (Aadhaar) have been introduced. Their significance is reflected in the following outcomes:

– entrepreneurs save time and reduce costs through access to online services;

– citizens, especially rural entrepreneurs, can enter domestic and international markets via e-commerce platforms;

– the digital financial system (UPI, mobile banking services) has created new opportunities for micro-businesses.

These developments have stimulated the growth of entrepreneurship not only in urban areas but also in remote regions.

Thus, India places strong emphasis on inclusive growth and the development of small business and entrepreneurship. The essence of India's inclusive approach lies in ensuring that all segments of the population — particularly low-income groups, rural communities, women, and socially vulnerable categories — benefit from national economic growth. This approach focuses not merely on increasing GDP, but on ensuring that this growth is widespread and equitable. In other words, inclusivity in the Indian context means that the development of entrepreneurship and its benefits are felt not only by specific groups or regions, but by people across the entire country, regardless of their socio-economic status. This ensures fair access to the fruits of economic development and contributes to reducing poverty and inequality.

REVIEW OF LITERATURE ON THE SUBJECT

The development of entrepreneurial activity as a driver of public welfare in India has been examined extensively across contemporary research, revealing a multidimensional relationship between enterprise growth, inclusive development and national economic transformation. Daramola and Gupta (2020) emphasize that emerging economies, particularly India, rely on entrepreneurship development frameworks to stimulate job creation, reduce poverty and enable structural economic change. Their case-based analysis highlights how institutional reforms, enterprise support programs and innovation-oriented policies have strengthened India's entrepreneurial ecosystem, resulting in wider social benefits such as increased employment and local market expansion.

Sharma (2018) provides an in-depth analysis of India's small business and MSME sector, noting its central role in income generation, regional industrialization and grassroots economic empowerment. His findings show that MSMEs contribute significantly to public welfare by offering livelihood opportunities to low-income households and marginalized groups. However, he also identifies persistent challenges such as limited access to finance, inadequate technological capacity and regulatory barriers, suggesting that addressing these constraints is essential for maximizing welfare outcomes.

Singh (2019) focuses on India's evolving start-up ecosystem, explaining how government initiatives, venture capital expansion and innovation support structures have accelerated entrepreneurial growth. He argues that programs such as Start-up India not only encourage enterprise creation but also indirectly enhance social welfare through the generation of high-skilled employment, diffusion of digital services and increased competitiveness across sectors. Patel (2019) further elaborates on this, demonstrating that the Start-up India initiative has improved early-stage entrepreneurial activity by offering tax incentives, simplified procedures and incubation support, thereby contributing to broader socio-economic progress.

Digital transformation has been another major catalyst for welfare-oriented entrepreneurial development. Rey (2021) highlights how digitalization has reshaped India's economic landscape by improving service delivery, expanding opportunities for small firms and creating more inclusive growth pathways. Bhattacharya (2022) empirically confirms that the Digital India programme has significantly increased the productivity and survival rates of small businesses by facilitating digital payments, e-commerce integration and online market access, ultimately contributing to household income growth and poverty reduction.

Manufacturing-led entrepreneurial expansion has also played a crucial role in welfare improvement. Kumar (2020) shows that the Make in India programme has stimulated industrial growth through investment promotion, regulatory reforms and domestic production incentives. His results indicate that the programme has augmented manufacturing employment and supported local value chains, creating multiplier effects on household incomes and regional development. Complementing this perspective, Gupta (2020) examines Skill India as a workforce development intervention and finds that enhancing vocational skills has a direct influence on employability, productivity and socio-economic mobility, thereby strengthening the welfare impacts of entrepreneurship-driven growth.

Financial inclusion policies have further reinforced the welfare outcomes of entrepreneurial development. Rao (2021) demonstrates that the Pradhan Mantri Jan Dhan Yojana (PMJDY) has expanded access to banking services, credit and savings mechanisms for millions of low-income citizens. By integrating previously unbanked populations into formal financial systems, PMJDY has enabled micro-entrepreneurial activity, improved household resilience and reduced vulnerability to income shocks. This financial foundation strengthens the

capacity of small entrepreneurs to participate in economic activities and benefit from government support schemes.

Taken together, these studies illustrate that India's experience shows a strong and interconnected relationship between entrepreneurship development and public welfare enhancement. Modern policy initiatives such as Start-up India, Skill India, Digital India, Make in India and PMJDY collectively contribute to building a more inclusive, innovative and welfare-oriented economic system. The literature consistently highlights that entrepreneurial expansion generates employment, promotes social inclusion, strengthens regional development and broadens economic opportunities, thereby positioning entrepreneurship as a central mechanism for improving public welfare in India.

RESEARCH METHODOLOGY

The study employs a mixed-method approach based on the collection of secondary data from official Indian government reports, international development databases, and peer-reviewed publications, complemented by qualitative insights from policy documents on entrepreneurial programmes. The data are analyzed through comparative assessment, trend evaluation, and thematic content analysis to identify how entrepreneurship initiatives contribute to public welfare outcomes in India.

ANALYSIS AND RESULTS

Entrepreneurial development is linked not only to financial support but also to investment in human capital. India has implemented several programs in this area, including:

- Skill India — training in professions with high labor-market demand;
- Atal Innovation Mission — promoting a culture of innovation at school and university levels;
- Women Entrepreneurship Programme — supporting female entrepreneurship.

As a result, economic activity among the population increased, and the number of start-ups and small businesses expanded on the basis of newly acquired knowledge and skills.

A large portion of India's population resides in rural areas; therefore, agribusiness and rural entrepreneurship are supported as separate strategic directions. These efforts include:

- the activities of rural cooperatives and microcredit institutions;
- "Self-Help Groups (SHGs)" that promote entrepreneurship among rural women;
- support for AgriTech start-ups;
- connecting farmers to digital marketplaces (e-NAM).

These initiatives have helped create stable income sources for rural communities.

However, India remains a country with uneven economic development, and traditional mechanisms of social support are still practiced to help people rise from slum conditions[1]. For example, individuals from low-income groups receive assistance from wealthy patrons—such as philanthropists and major business magnates—only when they demonstrate their abilities (to study or to work). This customary approach has allowed countless Indians to escape poverty and acquire professional skills.

Thus, in the democratic system of the Republic of India, entrepreneurship contributes to improving welfare in the following ways:

First, since 2014, the "Make in India" initiative has aimed to transform India into a global manufacturing hub. This initiative significantly improved the country's investment climate. Favorable conditions were created for both domestic and foreign investors, and bureaucratic barriers were reduced. Industrial development has increased the share of manufacturing in GDP and created new jobs. Infrastructure development led to the construction of industrial corridors, logistics centers, and other essential facilities. Foreign investments were attracted to strategic sectors such as defense, railways, and electronic manufacturing.

Additionally, the "Start-up India" initiative, launched in 2016, was designed to support innovative start-ups. One of its central components was financial incentives, including tax benefits, grants, and improved access to venture capital. "Start-up India" simplified the registration process, making it faster and more accessible for new enterprises. Through incubation and mentorship programs, entrepreneurs received support in business development, advisory services, and networking opportunities. The initiative also strengthened support for innovation and research activities, encouraging collaboration with universities and scientific institutions (Table 1).

1 Vershinina I.A. Urbanizatsiya v indii: sotsiologicheskiy analiz // https://cyberleninka.ru/article/n/ urbanizatsiya-v-indii-sotsiologicheskiy-analiz

Table 1. Description of Measures Aimed at Improving Public Welfare in India[2]

Implementation of Priority Measures	Results
Creating an entrepreneurial ecosystem through the "Startup India" and "Make in India" initiatives	The *Make in India* program is aimed at promoting domestic production, creating jobs, reducing dependence on imports, stimulating economic growth, and attracting investment in India. It encourages entrepreneurs to engage in local manufacturing, which in turn increases orders and opportunities for small and medium-sized enterprises.
	The *Startup India* initiative is designed to support new start-ups, foster innovation, and create a favorable environment for them. It provides tax incentives, simplifies regulatory compliance (for example, by reducing inspections), strengthens intellectual property protection, and ensures access to financing (such as through the *Fund of Funds for Startups*). This contributes to job creation and diversifies the economy.
Support for micro, small, and medium-sized enterprises (MSMEs)	Under the *Pradhan Mantri Mudra Yojana* program, unsecured loans are provided to small entrepreneurs, particularly low-income individuals who remain outside the formal financial system. This enables millions of people to start or expand their businesses, leading to increased incomes and a reduction in poverty.
	Skill India is an initiative aimed at improving the qualifications of youth and unemployed individuals in high-demand professions. It not only prepares them for employment but also equips them with the necessary skills to establish their own businesses.
Digital inclusion and the "Digital India" initiative	The *Digital India* program focuses on developing digital infrastructure, expanding online public services, and increasing digital literacy. It creates new opportunities for small entrepreneurs, such as using online payments, selling products through e-commerce platforms, and submitting electronic applications for loans.
	Financial inclusion under *Pradhan Mantri Jan Dhan Yojana* allowed a significant share of the population to open bank accounts. This increased access to financial services and made it easier to obtain funding necessary for starting or expanding entrepreneurial activities.

Secondly, the government has consistently prioritized support for micro, small, and medium-sized enterprises (MSMEs). In particular, the Small Industries Development Organization (SIDO) was established in 1954, later renamed the Micro, Small and Medium Enterprises Development Organisation (MSMEDO), serving as a central authority responsible for ensuring the structured and consistent growth of the private sector.

Given that small business and entrepreneurship constitute major drivers of the Indian economy, financial support mechanisms such as concessional loans, subsidies, and guarantees were provided through banks. Based on MSMEDO activities, the production and service capacities of MSMEs expanded. As a result, new markets and cooperation networks were formed for small enterprises. Furthermore, to ensure availability of qualified labor, efforts were made to train specialists tailored to the needs of small businesses.

Based on the above analysis, it can be stated that India's experience carries significant practical value for developing countries. The Indian model offers the following lessons:

1. Inclusive economic growth — development must benefit all population groups.
2. Active government support — a supportive legal and financial environment is essential for promoting start-ups, MSMEs, and innovation.
3. Digital infrastructure — constitutes the foundation of the 21st-century economy.
4. Human capital — serves as a critical foundation for entrepreneurship development.
5. Rural entrepreneurship — plays a decisive role in ensuring overall welfare.

CONCLUSIONS AND SUGGESTIONS

In conclusion, India's experience clearly demonstrates that entrepreneurship development is one of the most effective tools for enhancing public welfare. Inclusive economic policies, digital transformation, support for start-ups, creation of a favorable environment for MSMEs, investment in human capital, and attention to rural

2 The author's work is based on various sources. Sources: https://www.rbi.org.in/ — Reserve Bank of India (RBI): Reports on financial inclusion and microfinance. https://www.indiabudget.gov.in/economicsurvey/ — Economic Survey (published by the Ministry of Finance of India): Annual analysis of India's economy containing information on entrepreneurship, job creation, and welfare. https://www.commerce.gov.in/ — Ministry of Commerce & Industry, Government of India: Official information on the Startup India and Make in India initiatives. https://dcmsme.gov.in/about_us.aspx — Ministry of Micro, Small & Medium Enterprises (MSME): Information on support programs for the MSME sector. https://www.rbi.org.in/ https://niti.gov.in/ — NITI Aayog (National Institution for Transforming India): The government's primary policy think-tank, publishing extensive research and reports on economic growth and social development in India.

entrepreneurship collectively contribute to reducing poverty and inequality while sustaining economic growth. India's experience highlights the following as key drivers of improved welfare:

- the existence of a long-term government strategy;
- legal and financial mechanisms that stimulate entrepreneurship;
- investments in digital infrastructure and human capital;
- strong focus on developing an innovation and start-up ecosystem.

By following this model, any country — including Uzbekistan — can expand opportunities to ensure socio-economic stability, create new jobs, and increase household incomes through entrepreneurship.

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GREEN STRUCTURAL TRANSFORMATION IN UZBEKISTAN: GREEN FINANCE AND ECO-INNOVATION FOR SUSTAINABLE INDUSTRIAL AND AGRICULTURAL DEVELOPMENT

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Abstract: The article examines sustainable development and green structural transformation in Uzbekistan with a focus on two core pillars: the rapid emergence of green finance and the diffusion of eco-innovation across industrial and agricultural value chains. Drawing on official statistics, international reports (World Bank, UNDP, OECD) and the latest sectoral data, the study analyzes the development of thematic bonds, institutional reforms in public finance, and the modernization of agro-food systems. Since 2021, Uzbekistan has issued more than USD 1.2 billion in sovereign thematic bonds, including its first sovereign green Eurobonds in 2023, accompanied by the placement of 4.25 trillion UZS in local-currency green bonds. In the agro-food sector, annual fruit and vegetable production exceeds 22–23 million tonnes, but only 10–15% is processed and 20–30% is lost post-harvest due to insufficient storage and logistics infrastructure. The study uses institutional analysis, sectoral statistics and a SWOT-type interpretative approach. The findings show that Uzbekistan has established a relatively advanced green-growth policy architecture and an emerging green-finance ecosystem; however, structural challenges persist in industrial modernization, circular-economy development and post-harvest value retention. The article concludes that long-term competitiveness will depend on scaling up green finance, accelerating eco-innovation in industry and agriculture, and strengthening institutional coordination within a coherent green-growth framework.

Key words: green economy; green structural transformation; sustainable development; green finance mechanisms; sovereign green bonds; SDG bonds; climate-aligned investment; sustainable public finance; eco-innovation; industrial modernization; Uzbekistan.

Annotatsiya: Maqolada O‘zbekistonda barqaror rivojlanish va yashil tarkibiy transformatsiya ikki asosiy yo‘nalishda — yashil moliyalashtirish hamda sanoat va qishloq xo‘jaligida eko-innovatsiyalarni joriy etish kesimida tahlil qilinadi. Rasmiy statistika, Jahon banki, UNDP va OECD hisobotlari asosida tematik obligatsiyalar bozori, davlat moliyasi institutsional islohotlari, shuningdek agro-oziq-ovqat tizimlarining modernizatsiyasi o‘rganiladi. 2021–2024-yillarda O‘zbekiston 1,2 mlrd AQSh dollaridan ortiq SDG va “yashil” toifadagi suveren obligatsiyalarni, 2023-yilda esa ilk “yashil” xalqaro evrobondlarni va 4,25 trln so‘mlik milliy valyutadagi yashil obligatsiyalarni joylashtirdi. Yiliga 22–23 mln tonna meva-sabzavot yetishtirilayotgan bo‘lsa-da, sanoat qayta ishlash ulushi atigi 10–15 foizni tashkil etadi, 20–30 foiz hosil esa saqlash va logistika yetishmovchiligi sababli yo‘qotilmoqda. Tadqiqot SWOT yondashuvi asosida amalga oshirilib, O‘zbekistonda yashil o‘sish uchun ilg‘or normativ-huquqiy baza shakllangan bo‘lsa-da, sanoat va qishloq xo‘jaligida tarkibiy modernizatsiya hamda aylanish iqtisodiyoti bo‘yicha muammolar mavjudligi aniqlanadi. Xulosa qilinishicha, uzoq muddatli raqobatbardoshlik yashil moliyalashtirishni kengaytirish, eko-innovatsiyalarni jadallashtirish va institutsional muvofiqlikni kuchaytirishga bog‘liq bo‘ladi.

Kalit so‘zlar: yashil iqtisodiyot; yashil tarkibiy transformatsiya; barqaror rivojlanish; yashil moliyalashtirish mexanizmlari; suveren yashil obligatsiyalar; SDG obligatsiyalari; iqlimga mos investitsiyalar; barqaror davlat moliyasi; eko-innovatsiyalar; sanoatni modernizatsiya qilish; O‘zbekiston.

Аннотация: В статье исследуются устойчивое развитие и зелёная структурная трансформация Узбекистана через два ключевых направления: становление зелёного финансирования и распространение эко-инноваций в промышленности и сельском хозяйстве. Используя официальную статистику, отчёты международных организаций и отраслевые данные, автор анализирует выпуск суверенных зелёных облигаций, реформы бюджетного планирования и модернизацию агропродовольственных цепочек. В 2021–2024 годах Узбекистан разместил более 1,2 млрд долларов в суверенных облигациях категорий SDG и Green, включая первый выпуск суверенных зелёных евробондов в 2023 году и 4,25 трлн сумов внутренних зелёных облигаций. При этом в аграрном секторе ежегодно производится 22–23 млн тонн плодоовощной продукции, но перерабатывается лишь 10–15%, а 20–30% теряется на этапах хранения и транспортировки. Результаты подчёркивают, что, несмотря на развитую стратегическую базу зелёного роста, сохраняются структурные барьеры — низкая глубина переработки, недостаточное применение циркулярных решений и технологическая отсталость части предприятий. В заключение показано, что долгосрочная конкурентоспособность Узбекистана будет зависеть от расширения зелёного финансирования, внедрения эко-инноваций и усиления институциональной согласованности.

Ключевые слова: зелёная экономика; зелёная структурная трансформация; устойчивое развитие; механизмы зелёного финансирования; суверенные зелёные облигации; облигации SDG; климатически ориентированные инвестиции; устойчивые государственные финансы; эко-инновации; модернизация промышленности; Узбекистан.

INTRODUCTION

Green structural transformation has become one of the central conceptual frameworks for rethinking development models in emerging economies. According to analytical reports of the OECD and UNEP, the notion of green structural transformation describes a systemic shift from resource-intensive and environmentally unsustainable production patterns toward innovation-driven, low-waste and institutionally coordinated models of economic growth [1]. This paradigm integrates sustainability principles into the core of economic modernization and requires reforms in public finance, industrial upgrading, and technological diffusion, as emphasized in global sustainable-development frameworks [2].

In Uzbekistan, the institutional foundations for such a transformation were formally established through the Strategy for the Transition to a Green Economy for 2019–2030, which defines the restructuring of production systems, the development of sustainable finance mechanisms, and the modernization of industrial and agricultural sectors as national development priorities [3]. This strategic orientation is aligned with the United Nations 2030 Agenda for Sustainable Development and reflects the international consensus that long-term economic competitiveness depends on the capacity of states to integrate innovation, environmental management, and financial sustainability into their policy architecture [4].

One of the most significant domains of Uzbekistan's green transformation is the rapid development of green finance. Since 2021, the country has entered the international thematic bond market, issuing sovereign Sustainable Development Goals (SDG) bonds and, subsequently, its first sovereign green bonds, thereby demonstrating institutional readiness to channel public finance toward sustainability-related investment priorities [5]. International assessments by the World Bank and UNDP underscore that the expansion of green finance is a prerequisite for structural modernization, as it provides long-term capital for environmentally responsible projects and strengthens the alignment of fiscal policy with sustainable development goals [6].

An equally important dimension of green structural transformation in Uzbekistan is the diffusion of eco-innovation in industry and agriculture. Empirical data from FAO and the Ministry of Agriculture indicate that Uzbekistan produces more than 22–23 million tonnes of fruits and vegetables annually, yet the depth of industrial processing remains limited – approximately 10–15% – while post-harvest losses reach 20–30% due to outdated logistics, insufficient storage capacity, and technological gaps in supply-chain management [7]. These inefficiencies highlight the need for modernization of agro-industrial value chains through resource-efficient technologies, circular-economy practices, digital traceability systems, and innovation-based production models. Such approaches are consistent with the recommendations of UNIDO, which emphasizes eco-innovation as a critical driver of competitiveness, productivity, and sustainability in developing economies [8].

The scientific relevance of this study arises from the need to analyze how Uzbekistan is operationalizing the principles of green structural transformation through two interdependent mechanisms: green finance and eco-innovation in industry and agriculture. A comprehensive assessment of institutional reforms, financial instruments, and technological modernization processes provides a deeper understanding of the structural shifts currently underway in the national economy. Furthermore, this research contributes to the broader academic discourse on sustainable economic development by identifying the opportunities and constraints associated with Uzbekistan's transition toward a green and innovation-oriented growth model.

REVIEW OF LITERATURE ON THE SUBJECT

The concept of green structural transformation has evolved into a central analytical framework for understanding how emerging economies can shift toward sustainable, innovation-driven development. The intellectual foundations of this paradigm were shaped by scholars such as Dani Rodrik, who demonstrated that structural transformation requires reallocating resources toward higher-productivity sectors while simultaneously embedding environmental considerations into industrial policy. OECD and UNEP studies reinforce this view by emphasizing that environmentally oriented industrial restructuring must integrate technological upgrading, efficient resource use and long-term institutional reforms to achieve sustainable competitiveness.

Within this broader discourse, green finance has emerged as a critical driver for structural modernization. Research by Nicholas Stern, the World Bank and the IMF shows that transitioning to low-carbon and resource-efficient economies depends heavily on mobilizing targeted financial flows through instruments such as green bonds, sustainability-linked loans and blended-finance facilities. Empirical studies by scholars including Wang, Zeng and Broadstock find that green bonds contribute to lower capital costs for environmentally oriented firms, support the expansion of renewable-energy projects and improve long-term environmental performance. Furthermore, reports by the Climate Bonds Initiative and the European Investment Bank highlight that the effectiveness of green-finance mechanisms depends on transparent taxonomies, credible verification systems and institutional coordination between financial regulators and market participants.

Eco-innovation forms the second critical dimension of green structural transformation. Theoretical contributions by Horbach, Rennings and Del Rio conceptualize eco-innovation as a multifaceted process that reduces environmental impact through technological, organizational and systemic changes. These scholars argue that eco-innovation diffusion is influenced by regulatory incentives, market demand, technological capabilities and the absorptive capacity of firms. Empirical evidence from studies conducted by the European Environment Agency and UNIDO shows that eco-innovation exerts a significant positive effect on energy efficiency, industrial productivity and supply-chain resilience. In the agricultural sector, research by Fuglie, Pingali and the FAO demonstrates that eco-innovative technologies—such as precision agriculture, post-harvest loss reduction systems and climate-smart farming—substantially enhance resource efficiency and reduce ecological pressure in developing economies.

Several scholars have explored the interplay between green finance and eco-innovation. Studies by OECD, Aghion, Dechezleprêtre and Johnstone conclude that access to sustainable finance accelerates technological innovation by reducing risk for green R&D, enabling firms to invest in clean technologies and strengthening national innovation systems. The European Bank for Reconstruction and Development provides complementary evidence that targeted green-finance programs stimulate eco-innovation particularly in countries with developing financial markets and early-stage industrial modernization.

In the context of Uzbekistan, research by the World Bank, UNDP, ADB and national think tanks indicates that the country's transition to a green economy requires coordinated reforms in finance, industrial upgrading and agricultural modernization. Analysis of Uzbekistan's sovereign green bonds and thematic debt instruments shows that the financial sector is becoming an increasingly important platform for funding low-carbon infrastructure and sustainable agri-food systems. UNDP and FAO assessments also highlight that eco-innovation adoption remains uneven across industrial and agricultural enterprises, largely due to structural constraints such as limited access to credit, skill shortages and gaps in technological diffusion. These studies converge on the conclusion that Uzbekistan's green structural transformation will depend on strengthening financial mechanisms for sustainability, accelerating innovation diffusion and ensuring integration across value chains.

Overall, the global scientific literature demonstrates that green finance and eco-innovation are mutually reinforcing pillars of sustainable development. For Uzbekistan, aligning financial reforms with targeted industrial and agricultural innovation policies offers a coherent pathway for achieving long-term green structural transformation and improving national environmental and economic resilience.

RESEARCH METHODOLOGY

The methodological architecture of this study is grounded in the theoretical and empirical principles of sustainable-development economics, green-growth diagnostics, and structural-transformation analysis. The research adopts a multilevel analytical model, integrating institutional, financial, sectoral and technological dimensions of Uzbekistan's green transformation. This framework corresponds to the methodological guidelines of the OECD Green Growth Strategy [1], UNDP Green Finance Platform [2] and FAO–UNIDO approaches to agro-industrial system modernization [3].

The empirical foundation of the study is constructed exclusively from authoritative and verifiable sources. National-level data were obtained from the Strategy for Transition to a Green Economy (2019–2030), official reporting of the Ministry of Economy and Finance, and statistical compendiums of the Ministry of Agriculture. International sources include OECD green-growth diagnostics, UNDP assessments of green-finance readiness, FAO datasets on agro-food systems, and World Bank analytical reports on structural reforms [4].

To ensure methodological reliability, all data were systematically cross-validated. The research uses a 2015–2024 temporal frame, reflecting the decade in which Uzbekistan institutionalized and operationalized its green-development agenda (Table 1).

Table 1. Data Sources Used in the Research (OECD (2020), UNDP (2021), FAO (2023), World Bank (2022)

Source Category	*Institution*	*Type of Data*	*Relevance to Research*
National strategies & regulatory frameworks	Government of Uzbekistan	Green economy strategy, institutional reforms	Analysis of policy architecture and institutional transformation
Sectoral statistics	Ministry of Agriculture	Production volumes, losses, processing ratios	Eco-innovation, value-chain performance
Financial data	Ministry of Economy and Finance	Green bonds, SDG bonds, public finance	Green-finance mechanisms, investment flows
International reports	OECD, UNDP, FAO, World Bank	Green growth, sustainable finance, agro-systems	Comparative analysis, methodological benchmarks

Institutional and policy analysis forms the first methodological pillar of the research and provides the conceptual foundation for understanding the systemic dynamics of Uzbekistan's green structural transformation. Within this analytical block, the study investigates how governance architectures, regulatory instruments and public-finance mechanisms interact to shape the national transition toward sustainable development. Particular attention is given to the degree of coherence between overarching national strategies – such as the Strategy for Transition to a Green Economy – and sector-specific programs in agriculture, industry and public finance. This allows the identification of institutional complementarities and potential inconsistencies that may hinder or accelerate the implementation of green-growth objectives.

A core component of this institutional assessment is the evaluation of the country's readiness for green budgeting, which involves examining the extent to which sustainability principles are embedded in budget-planning cycles, expenditure tagging systems and fiscal-allocation procedures. Equally important is the analysis of allocation mechanisms governing green-labelled expenditures, as their effectiveness determines whether financial resources are directed toward genuinely transformative, environmentally responsible activities. The study further explores how sustainability criteria are integrated into decision-making processes within public-finance management, including investment prioritization, monitoring frameworks and accountability mechanisms. Methodologically, this institutional inquiry follows international diagnostic standards developed by the OECD Institutional Mapping Framework and the UNDP Green Finance Readiness Assessment [5], ensuring the analytical rigor and comparability of findings.

The second methodological pillar is constituted by structural and sectoral analysis, an essential tool for examining transformation processes in industrial and agro-industrial systems. This analytical approach enables the study to uncover the underlying structural characteristics of Uzbekistan's production sectors, including the configuration of agro-industrial value chains, the depth and quality of technological modernization, and the systemic efficiency of post-harvest processes. By focusing on these structural attributes, the research evaluates how existing production systems either contribute to or constrain the diffusion of eco-innovations across the economy.

Following the methodological guidelines of FAO and UNIDO, the analysis investigates the degree of integration within agro-industrial chains, identifying points of fragmentation that lead to inefficiencies, elevated post-harvest losses and reduced value-added generation. The technological dimension is examined through the assessment of equipment modernization, production-process upgrading and the adoption of environmentally responsible technologies across enterprises. Furthermore, the study evaluates resource productivity through indicators such as waste intensity, loss ratios and material efficiency, which provide an empirical basis for identifying sustainability gaps. Particular emphasis is placed on understanding innovation-diffusion patterns within enterprises and clusters, as the uneven adoption of eco-innovations reflects deeper structural constraints related to access to finance, human capital and institutional support.

Taken together, this structural and sectoral analysis provides a comprehensive view of modernization needs and eco-innovation priorities across key segments of Uzbekistan's industrial and agricultural systems, laying the groundwork for informed policy recommendations and strategic planning (Table 2).

Table 2. Analytical Dimensions of Sectoral and Structural Analysis (FAO (2022), UNIDO (2022), OECD Green Growth Analytical Framework (2011), World Bank (2022)

Dimension	Indicator Group	Analytical Purpose
Value-chain structure	Processing ratio, logistical capacity	Identify structural bottlenecks
Technological modernization	Equipment age, innovation adoption	Assess eco-innovation diffusion
Resource efficiency	Waste levels, post-harvest losses	Evaluate sustainability performance
Institutional–market integration	Access to finance, cluster linkages	Assess structural competitiveness

Statistical and comparative analysis constitutes the third methodological foundation of the study, enabling the systematic examination of quantitative trends and structural patterns within Uzbekistan's green transformation. This analytical component is grounded in internationally recognized quantitative methodologies adopted by the World Bank, OECD and FAO, which emphasize the use of coherent, cross-validated, and multi-source datasets as the basis for empirical evaluation [6]. The statistical dimension of the analysis employs descriptive indicators to trace the dynamics of production volumes, industrial processing depth, post-harvest loss rates, and the scale and structure of green finance instruments. These indicators allow for the identification of temporal trends, structural shifts, and anomalies that reflect underlying changes in sectoral performance and institutional behavior.

In addition to descriptive statistics, a comparative analytical framework is applied to position Uzbekistan's progress within a broader international context. This involves benchmarking key national indicators against those of comparable developing economies undergoing similar agricultural and industrial modernization processes. Such comparison provides insight into relative performance, enabling the detection of structural asymmetries, competitiveness gaps, and best-practice trajectories that may inform policy refinement. By juxtaposing domestic and international datasets, the analysis reveals the extent to which Uzbekistan's green transformation aligns with global patterns of sustainable economic development.

Furthermore, the comparative component is used to assess the efficiency and effectiveness of green finance mechanisms in mobilizing investment toward environmentally significant sectors. Through the examination of international cases –consistent with the methodological approach recommended in World Bank cross-country diagnostics – the study interprets Uzbekistan's progress not as an isolated phenomenon but as part of a global trend toward climate-aligned and sustainability-oriented investment ecosystems. The combination of statistical rigor and comparative evaluation ensures the analytical depth necessary for understanding both the achievements and unresolved challenges in Uzbekistan's pathway toward green structural transformation.

ANALYSIS AND RESULTS

The empirical results of the study indicate that Uzbekistan has entered a decisive phase of green structural transformation, characterized by the institutionalization of sustainable public finance instruments and the gradual integration of eco-innovation within industrial and agricultural production systems. The data demonstrate that the development of green finance mechanisms has progressed more rapidly than technological modernization in real sectors, resulting in an asymmetric but strategically significant pattern of transformation. This asymmetry aligns with broader global trends, in which financial reforms precede structural modernization, as documented in OECD and UNDP transition studies [1].

Evidence collected from national financial reports and international assessments confirms that Uzbekistan has successfully established the foundations for a thematic finance ecosystem. Since 2021, the country has issued more than USD 1.2 billion in sovereign SDG- and green-labelled bonds, marking a substantial institutional breakthrough in aligning public expenditures with sustainability criteria [4]. The issuance of the first sovereign green Eurobonds in 2023 and the placement of 4.25 trillion UZS in local-currency green bonds reflect an emerging financial architecture capable of mobilizing long-term capital for environmentally oriented reforms.

Furthermore, the entry of corporate actors – such as Agrobank with its USD 455 million green Eurobond package – demonstrates the diffusion of sustainability principles beyond public institutions into the private-sector financial landscape. Comparative analysis with thematic-bond markets in developing countries indicates that Uzbekistan's trajectory is consistent with global patterns of sustainable finance expansion, where early adoption of green bonds serves as a catalyst for further institutional and market development (Table 3) [6].

Table 3. Key Indicators of Green Finance Development in Uzbekistan (World Bank (2022), UNDP (2023), OECD (2020)

Indicator	Value / Evidence	Source
Sovereign SDG & Green bonds issued (2021–2024)	USD 1.2 billion	[4]
First sovereign green Eurobonds (2023)	Yes	[4]
Domestic green bonds issued (national currency)	4.25 trillion UZS	[4]
Corporate green Eurobonds (Agrobank)	USD 455 million	[4]
Institutional frameworks	Green Budget Guidance; SDG Financing Framework	[5]

The empirical evaluation indicates that Uzbekistan's advancement in green finance demonstrates a promising structural trajectory. The rapid institutionalization of green-finance frameworks, despite their recent introduction into the national financial architecture, reflects the system's adaptability and the growing capacity of financial institutions to operationalize sustainability principles. Furthermore, the emergence of green budgeting practices shows a gradual but measurable alignment of public-expenditure processes with sustainability criteria, consistent with UNDP methodological guidelines [2]. This dynamic suggests that the integration of environmental priorities into fiscal governance is likely to strengthen in the upcoming policy cycles.

Sectoral and structural assessments demonstrate that Uzbekistan's agricultural and agro-industrial systems possess considerable potential for technological upgrading and efficiency enhancement. With annual fruit and vegetable production exceeding 22–23 million tonnes, the current level of industrial processing and storage capacity offers substantial room for expansion. According to FAO and Ministry of Agriculture data, increasing the share of processed output and modernizing storage and logistics systems will enable the sector to unlock significant value-added potential and support the transition toward sustainable, innovation-oriented production models [7]. These trends indicate favorable conditions for future productivity gains and stronger integration into global agri-food value chains.

The diffusion of eco-innovations across industries demonstrates differentiated but steadily improving patterns. Large enterprises are already adopting advanced resource-efficient technologies, waste-valorization solutions and digital traceability systems, which can serve as reference points for broader technological modernization. For small and medium enterprises, the existing transformation trajectory highlights the opportunity to accelerate modernization through targeted financial instruments, expanded capacity-building programs and improved access to knowledge-intensive technologies. These directions are consistent with UNIDO's analytical perspectives and suggest that Uzbekistan's innovation landscape is positioned for more balanced and inclusive technological growth over the medium term (Table 4) [8].

Table 4. Structural Performance Indicators of Agro-Industrial Systems (UNIDO 2022)

Indicator	Observed Trend	Source
Annual horticultural production	22–23 million tonnes	[7]
Industrial processing depth	10–15%	[7]
Post-harvest losses	20–30%	[7]
Adoption of eco-innovation technologies	High in large enterprises; low in SMEs	[8]
Value-chain integration	Fragmented, low processing density	[7]

These results indicate that the existing agro-industrial structure in Uzbekistan is functionally productive but structurally sub-optimal. The majority of value-added potential remains unrealized, primarily due to limited modernization of post-harvest systems, fragmented logistics and insufficient diffusion of eco-innovations. Comparative analysis demonstrates that Uzbekistan's performance is consistent with the developmental trajectories of middle-income economies transitioning toward innovation-driven agro-industrial systems [6].

Taken together, the results across institutional, financial and sectoral dimensions demonstrate that Uzbekistan's green structural transformation is unfolding along two interdependent but uneven trajectories:

1. The financial architecture is transforming rapidly – green bonds, SDG bonds and sustainability-aligned budgeting are expanding at a pace comparable to advanced emerging economies.
2. Real-sector modernization is progressing gradually, constrained by technological gaps, fragmented value chains and limited eco-innovation diffusion.

This dual trajectory reflects a broader structural pattern identified in sustainable-development literature: financial mechanisms often mature earlier than industrial and agricultural modernization due to lower capital requirements, faster institutional adoption rates and stronger support from international partners [1].

Nevertheless, the results clearly show that Uzbekistan has already established the core pillars necessary for long-term sustainable transformation. The challenge now lies in strengthening the interface between green finance and eco-innovation, ensuring that financial instruments effectively catalyze modernization processes across production systems.

The results of the study demonstrate that Uzbekistan's green structural transformation is advancing along an uneven but strategically coherent trajectory, in which financial modernization significantly outpaces technological and industrial upgrading. This asymmetry is not unique to Uzbekistan; it reflects a general pattern observed in transition economies, where institutional and fiscal reforms require fewer physical resources and therefore progress more rapidly than real-sector modernization. In this sense, the development of green finance mechanisms serves as a precursor rather than a culmination of structural transformation. The rapid institutionalization of sustainable-finance instruments indicates that the country has reached an important threshold of financial readiness, laying the groundwork for long-term investment flows into environmentally significant sectors.

The discussion of results indicates that Uzbekistan's agro-industrial sector, a core component of national economic development, is entering a phase with considerable opportunities for deepening modernization. Expanding processing capacity, improving post-harvest management and strengthening the integration of innovative practices into production processes represent areas with strong potential for value-added growth. Enhancing technological capacity across storage, logistics and distribution systems will support the transition toward more sustainable agricultural practices and help the sector realize a greater share of its inherent economic value. Current differences in innovation adoption between large enterprises and SMEs highlight a valuable opportunity for targeted modernization programs aimed at broadening technological upgrading across the entire sector.

Within this context, the diffusion of eco-innovation emerges as a central factor shaping the long-term progress of green structural transformation. Although the institutional and financial foundations for eco-innovation are steadily expanding, further strengthening mechanisms that widen access to finance for smaller enterprises, enhance skills development and foster dynamic innovation ecosystems will accelerate progress. As value-chain integration improves, coordinated modernization efforts are expected to reduce accumulated inefficiencies and enhance the overall performance of production and distribution networks.

The analysis also underscores that aligning green finance with real-sector modernization offers a promising pathway for amplifying the transformative impact of ongoing reforms. Uzbekistan's launch of sovereign green bonds, SDG bonds and domestic green financial instruments demonstrates strong institutional commitment. The next stage involves expanding the pipeline of bankable green projects, refining eligibility taxonomies, reinforcing monitoring frameworks and enhancing enterprise capacity to effectively utilize sustainability-oriented investments. Strengthening these institutional and technological linkages will allow green finance to evolve into a fully integrated driver of industrial transformation.

A broader conceptual insight arising from the discussion is that Uzbekistan's green structural transformation represents the early formation of a comprehensive development paradigm. The emergence of green budgeting practices, the growing integration of sustainability criteria into public-finance management and the progressive modernization of agro-industrial systems illustrate a systemic shift toward innovation-driven and environmentally responsible economic governance aligned with global models of sustainable restructuring.

The long-term sustainability of this trajectory will benefit from accelerating eco-innovation diffusion, expanding cross-sector modernization and strengthening institutional mechanisms that connect financial resources with technological upgrading. By deepening these intersections, Uzbekistan can build a cohesive green-growth model that enhances productivity, reduces resource losses, supports climate resilience and elevates the competitiveness of national industries.

Overall, the discussion suggests that Uzbekistan is moving confidently toward a modern, sustainability-oriented development framework. The continued harmonization of green finance, technological modernization and institutional reforms will enable the country to consolidate initial achievements into a stable, innovation-based and internationally competitive green transformation model.

CONCLUSIONS AND SUGGESTIONS

The findings of this study demonstrate that Uzbekistan's green structural transformation is unfolding as a multidimensional and institutionally driven process in which financial innovation is advancing more rapidly than technological modernization in the real sectors of the economy. The emergence of a national ecosystem of

green finance – supported by sovereign SDG and green bonds, the introduction of green-budgeting elements, and the growing participation of corporate actors – indicates that the financial architecture of the country is increasingly aligned with global standards of sustainability-oriented economic governance. This establishes a stable foundation for mobilizing long-term capital toward structural modernization and environmentally responsible development.

At the same time, the empirical evidence reveals that eco-innovation diffusion within industrial and agricultural systems remains uneven and constrained by structural bottlenecks. Limited processing depth, elevated post-harvest losses, fragmented value chains, and pronounced technological disparities between large enterprises and small and medium-sized firms hinder the transition toward resource-efficient and innovation-driven production models. These findings underscore that financial modernization alone is insufficient to ensure transformative change; rather, it must be complemented by systematic technological upgrading, improved logistics and storage infrastructure, and integrated innovation ecosystems capable of supporting broad-based modernization.

In conceptual terms, Uzbekistan's trajectory reflects the early stages of a transition from a resource-intensive development model toward a sustainability-oriented, innovation-based growth paradigm. The coherence of national strategies, the commitment to institutional reform, and the establishment of green-financial instruments collectively indicate that the foundations of this shift are already in place. The decisive challenge now lies in operationalizing these frameworks in ways that accelerate eco-innovation, enhance productivity, reduce losses, and foster the emergence of integrated, modernized value chains.

In conclusion, Uzbekistan has made significant progress in constructing the institutional and financial pillars of green structural transformation. To fully realize the potential of this transition, it is imperative to reinforce technological modernization, strengthen linkages between green finance and real-sector innovation, and promote systemic integration across industrial and agricultural domains. Achieving this alignment will enable the country to consolidate its early achievements and advance toward a stable, competitive and sustainable economic model aligned with international standards of green growth.

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AGRICULTURAL MANAGEMENT BASED ON INNOVATIVE TECHNOLOGIES AT THE INTERNATIONAL LEVEL: THE EXAMPLE OF UZBEKISTAN

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Abstract: The agricultural sector, which is of great importance to national economies, is one of the key and fundamental sectors that generates high incomes for entrepreneurs following investments in agricultural activities. Furthermore, it can be said that the agricultural sector is one of the driving forces. Income generated from agricultural activities leads to increased demand for goods and services produced by other sectors, stimulating production activities in those sectors and resulting in increased production volumes. Therefore, increasing the income level generated from the agricultural sector, which is so economically important, is of paramount importance. In this process, it is crucial to develop innovative technologies and effectively utilize these technologies in agricultural production to increase both the quantity and quality of agricultural products. This will lead to increases in agricultural income, and consequently, in the gross national product, particularly due to increases in agricultural product volume. In this study, after presenting the successes achieved in Uzbekistan as a result of the use of innovative technologies developed at the international level to ensure the development of the agricultural sector, the shortcomings and negative aspects of these technologies are revealed, and then the necessary arrangements are emphasized to eliminate these shortcomings and increase agricultural output.

Key words: technology, agricultural production, innovative management, Uzbekistan.

Annotatsiya: Qishloq xo‘jaligi sektori milliy iqtisodiyotlar uchun katta ahamiyatga ega bo‘lib, qishloq xo‘jaligi faoliyatiga kiritilgan investitsiyalar ortidan tadbirkorlarga yuqori daromad keltiradigan asosiy va fundamental tarmoqlardan biridir. Shuningdek, qishloq xo‘jaligi iqtisodiyotning harakatlantiruvchi kuchlaridan biri sifatida qaraladi. Qishloq xo‘jaligi faoliyatidan olinadigan daromad boshqa tarmoqlar tomonidan ishlab chiqariladigan tovar va xizmatlarga bo‘lgan talabning ortishiga olib keladi, bu esa ushbu tarmoqlarda ishlab chiqarish faoliyatini rag‘batlantirib, ishlab chiqarish hajmining ko‘payishiga sabab bo‘ladi. Shu bois iqtisodiy jihatdan muhim bo‘lgan ushbu sektorda daromad darajasini oshirish ustuvor ahamiyatga ega. Bu jarayonda innovatsion texnologiyalarni rivojlantirish va ularni qishloq xo‘jaligi ishlab chiqarishida samarali qo‘llash orqali mahsulot hajmi hamda sifatini oshirish muhimdir. Bu esa qishloq xo‘jaligidagi daromadlarning ortishiga, natijada yalpi milliy mahsulotning ko‘payishiga, ayniqsa qishloq xo‘jaligi mahsulotlari hajmining kengayishi hisobiga, olib keladi. Ushbu tadqiqotda O‘zbekistonda qishloq xo‘jaligi sektorini rivojlantirish maqsadida xalqaro darajada yaratilgan innovatsion texnologiyalarni qo‘llash natijasida erishilgan yutuqlar yoritiladi, ularning kamchiliklari va salbiy jihatlari ochib beriladi hamda ushbu kamchiliklarni bartaraf etish va qishloq xo‘jaligi ishlab chiqarish hajmini oshirish uchun zarur choralar ko‘rsatib o‘tiladi.

Kalit so‘zlar: texnologiya, qishloq xo‘jaligi ishlab chiqarishi, innovatsion boshqaruv, O‘zbekiston.

Аннотация: Сельскохозяйственный сектор, имеющий важное значение для национальных экономик, является одной из ключевых и фундаментальных отраслей, генерирующих высокий доход для предпринимателей, инвестирующих в аграрную деятельность. Кроме того, сельское хозяйство считается одной из движущих сил экономики. Доход, полученный от сельскохозяйственной деятельности, вызывает рост спроса на товары и услуги, производимые в других секторах, стимулируя в них производственные процессы и увеличивая объемы выпуска. Поэтому повышение уровня доходов, формируемых в столь значимом секторе, имеет первостепенное значение. В этом процессе крайне важно развивать инновационные технологии и эффективно использовать их в сельскохозяйственном производстве для увеличения как количества, так и качества сельхозпродукции. Это приведёт к росту доходов в сельском хозяйстве и, как следствие, к увеличению валового национального продукта,

особенно за счет расширения объемов производимой продукции. В данном исследовании после представления успехов Узбекистана, достигнутых в результате применения инновационных технологий международного уровня для развития сельскохозяйственного сектора, раскрываются недостатки и негативные аспекты этих технологий, а также подчёркиваются необходимые меры для устранения выявленных проблем и повышения объемов аграрного производства.

Ключевые слова: технология, сельскохозяйственное производство, инновационное управление, Узбекистан.

INTRODUCTION

Innovative technologies are critical for strengthening food security, increasing productivity, and ensuring sustainable agricultural development. Today, rapid scientific development and innovation are taking place in every aspect of life. These scientific advancements and innovations significantly contribute to building a valuable future for the country's economic development and enable the consistent and sustainable development of all areas of both society and state life. The Uzbek economy, which has gained significant momentum in economic development, must effectively utilize scientific advances and innovations to ensure the continuity of this development process. This will enable Uzbekistan to achieve a certain level of competitiveness, achieve socioeconomic development rates that allow for a high standard of living, improve the quality of human capital, and radically shift public awareness, thereby achieving both economic development and positive changes in social life. The successful use of science and innovation today is building a valuable future for the country and playing a crucial role in the consistent and sustainable development of all areas of social life. In this context, Uzbekistan's economy and economic assets are in the process of reorienting their resources toward innovative development. This process aims to achieve a certain level of competitiveness and socioeconomic development goals that guarantee an increase in living standards, to improve the quality of human capital, and to bring about positive changes in the country's mentality, social and economic life, and public awareness, all in conjunction with radical shifts. In this context, global experience demonstrates that the continuous implementation of innovations that ensure qualitative growth in all areas becomes the driving force of social and economic development. The most successful and stable countries of our time are those where innovative development models and «smart» technologies are consistently implemented. The sustainable development of such countries, their competitiveness in global markets, is based on innovative ideas and developments, along with the export of natural resources and the use of physical labor.

The primary goal of innovative development is to ensure the country's economic growth and competitiveness in global markets through the widespread promotion of innovation and scientific achievements and the increase of the intellectual share of the economy. Uzbek President Sh. M. Mirziyoyev signed a decree «On the further development of the information and innovation system in agriculture and the provision of modern services.» The decree prioritizes the development of the information and innovation system in agriculture between 2021 and 2025[1].

According to this decree, the National Center for Knowledge and Innovation in Agriculture will operate under the Ministry of Agriculture, which will link the integrated system for providing education, science, production, and modern agricultural services to agricultural organizations in the agricultural sector. The National Center is planned to be established on the basis of the Scientific and Production Center for Agriculture and Food Supply, the State Enterprise for Agricultural Innovation, and the Cotton Seed Center. Furthermore, President of the Republic of Uzbekistan S.M. Mirziyoyev's designation of 2023 as the «Year of Support for Active Entrepreneurship, Innovative Ideas, and Technologies» in Uzbekistan (Provisional Public Procedure No. PF-5199-F, dated October 9, 2017) underpins the goal of innovative development in the Republic of Uzbekistan. President S.M. Mirziyoyev stated, «By active entrepreneurs, we mean businesspeople who can produce competitive products and, most importantly, create new jobs, benefiting not only themselves and their

1 https://kun.uz/news/2021/02/08/qishloq khojaligida-bilim-va-innovatsiyal-tizimini-rivojları-koncepsiyasi tədərəndə

families but also society as a whole. Today, we are moving along the path of innovative development, aiming to fundamentally renew all areas of state and social life. Of course, there is a reason for this. Because in these rapidly evolving times, who wins? The state that relies on new ideas, new ideas, and innovation wins.»

REVIEW OF LITERATURE ON THE SUBJECT

The global transformation of agricultural management increasingly relies on the introduction of innovative technologies, institutional modernization, and the integration of scientific knowledge into production processes. The literature addressing innovation-driven agricultural development highlights that improving national competitiveness and ensuring sustainable sectoral growth require systemic innovation policies and technologically advanced management practices. The case of Uzbekistan, which is currently strengthening its innovation ecosystem in agriculture, aligns with these global trends.

Dyzhova emphasizes that effective management of intellectual property forms the foundation for innovation-based economic development, particularly in sectors where technological renewal depends on knowledge protection and commercialization. This perspective is essential for agriculture, where new biotechnologies, digital platforms, and smart-farming systems require institutional mechanisms ensuring ownership rights and technology transfer. Komiljonov further develops the idea that innovation management methods must be continuously improved to strengthen organizational adaptability and increase the efficiency of agricultural enterprises, especially in transition economies such as Uzbekistan.

Santo, in his classical work, conceptualizes innovation as a core driver of economic progress, highlighting that technological change reshapes productive structures and determines long-term growth trajectories. This approach is directly applicable to agriculture, where modern mechanization, digital monitoring, and resource-efficient practices significantly enhance productivity and sustainability. Complementing these theoretical insights, Abdullaev and Khasandzhanov argue that innovation-led economic renewal forms the basis for modernization and competitiveness. Their findings underscore the importance of national innovation strategies designed to accelerate technological upgrading in agriculture.

International frameworks also provide a structured vision for sustainable agricultural development. The Russian Federation's Strategy for the Socio-Economic Development of the Agro-Industrial Complex outlines knowledge-based approaches to improving sectoral performance, highlighting the importance of scientific research, state support, and coordinated innovation policies. Ushachev similarly stresses the critical role of scientific foundations in government agricultural programs, arguing that modern agricultural management requires a stable linkage between research institutions and producers.

In the context of Uzbekistan, national scholars emphasize the significance of innovation mechanisms specifically tailored to farming enterprises. Umurzoqov and Toshboev analyze the economic conditions of farm management and underline the need for technological modernization to enhance productivity and ensure efficient resource allocation. Chariev expands this perspective through methodological recommendations focused on stimulating innovative activity in foreign agricultural systems, offering comparative insights that can be adapted to Uzbekistan's ongoing reforms.

Taken together, the reviewed literature demonstrates that innovation-based agricultural management relies on an integrated system: intellectual property protection, advanced management methodologies, state-supported modernization programs, and international best practices. For Uzbekistan, aligning these components with global technological advancements provides a strategic foundation for increasing agricultural efficiency, ensuring sustainability, and enhancing competitiveness in the international market.

RESEARCH METHODOLOGY

The study collected data from international agro-innovation reports, official agricultural statistics of Uzbekistan, and scientific sources on global best practices. The obtained information was analyzed using comparative analysis, structural analysis, and content analysis to identify patterns and evaluate the impact of innovative technologies on agricultural management efficiency.

ANALYSIS AND RESULTS

It's safe to say that agricultural innovation has been given serious consideration in Uzbekistan recently. According to the minutes of the first meeting of the Cabinet of Ministers of the Republic of Uzbekistan, held on March 5, 2021, at the "X Republic Fair of Innovative Ideas, Technologies, and Projects," held at the "Uzexpocenter" from May 10-12, 2021, 95 developments developed by scientists working in the system were exhibited in detail. More than 250 mutually beneficial agreements, totaling 3.7 billion soums, were signed between 15 research institutions in the system, higher education institutions, farms, and other clients. During

the reporting period, scientific research conducted by researchers in the sector and related scientific articles were published in 30 international journals, more than 600 local journals, 250 international conferences, and 580 Republican conferences. In addition, 3 international monographs and 135 local monographs, textbooks, training and methodology handbooks have been published.

In addition, in accordance with the Decree of the President of the Republic of Uzbekistan, No. PF-5264, dated November 29, 2021, «On the Establishment of the Ministry of Innovation Development of the Republic of Uzbekistan,» the goal is to promote innovations in agriculture. This decree aims to:

—Propose proposals for the introduction of modern, proven agricultural production methods based on the concept of «Smart Agriculture,» which allows for the rational use of existing land, water, and other natural resources;

—Promote the introduction of innovative ideas, developments, and technologies in the agricultural sector that will allow for maximum automation of agricultural production, a significant increase in productivity, and improvements in financial indicators, ensuring the country's food security;

—Promote the expansion of trade markets and direct deliveries, ensuring the competitiveness of agricultural products in the global market, including to large retailers.

In line with these objectives, the aim is to transform Uzbekistan into a rapidly developing country with a stable market economy that fosters high levels of innovation and intellectual contributions to production, a modern, competitive industry that will participate in the global market, and a favorable investment and business climate. To achieve these goals, it is crucial to establish an effective state support system for innovative activities in Uzbekistan and to adopt an innovative development model that encourages the practical application of innovative ideas, developments, and technologies in public administration, priority sectors of the economy, and the social sector. Furthermore, state regulation and support of innovation processes, as well as the promotion of innovations in agriculture, are crucial for agricultural development.

The application of innovations to the agricultural sector encompasses new approaches to social services used to increase production efficiency, new methods for organizing and managing various sectors of the economy, new methods for the treatment and prophylaxis of livestock and poultry farming, plant and animal protection products, new technologies in agriculture, livestock farming, and the processing industry, research and development of high-quality food products, species and breeds of livestock and poultry farming, and the identification of new plant species. The agro-industrial complex is characterized by the organization of the main types and aspects of innovations, their diversity, forms, and methods of implementation. Therefore, the management of innovation processes involves classifying innovations according to various causes and is carried out according to key aspects that characterize the most important characteristics of innovations.

According to scientific literature sources, there are four types of innovations in agriculture. These are:

– Selection and genetics;
– Technical and technological production;
– Organization and management;
– Solving social and environmental problems.

These innovations are considered crucial for the successful management of innovation processes in the agricultural sector. To increase the efficiency of agricultural production, developing the industry through innovative methods is crucial. To establish an effective mechanism for managing innovation in the agricultural sector, it is planned to establish regional specialized agrotechnical centers in each region of Uzbekistan. Furthermore, it can be argued that accelerated innovation development in agriculture can be achieved primarily by combining the region's scientific, educational, production, and financial potential into a single agricultural innovation complex and by creating economic conditions that encourage innovation in the region.

The main functions of the regional specialized agro-industrial center planned to be established in each region of Uzbekistan include:

— Developing the basic principles of regional innovation policy development in the agro-industrial complex and improving its implementation methods;
— Identifying the main directions of innovative development in agriculture in the region;
— Coordinating the innovative activities of agricultural enterprises;
— Monitoring the agricultural innovation market;
— Providing information and communication support to agricultural enterprises in the field of innovative activities;
— Selecting and preliminary assessment of the potential use of innovations in agro-industrial production;
— Preparing proposals for the development of innovations and providing consulting services for their implementation;
— Monitoring the implementation of agricultural innovations and investment projects receiving state aid (Table 1).

Table 1. Innovative Development Areas of Agriculture in the Region[2]

Innovations in Agriculture	Expected Results in Agriculture
To introduce new disease-resistant, highest-yielding crop varieties using cellular technology, molecular genetics and traditional breeding methods.	Increasing crop yields and improving grain quality
Adaptation of high-yield agricultural crop varieties from foreign countries to the soil and climate conditions of the region	Reducing costs by introducing new high-yield crops
Development and implementation of new land use and water conservation technologies	Maintaining soil fertility and increasing crop yields
Development and implementation of machinery-saving systems for the complex mechanization of agricultural technological processes	Increasing labor productivity and reducing mechanized labor costs
Development and use of highly effective biological products to combat plant diseases and pests	Increasing productivity and product quality
Innovations in the Livestock Sector	**Hayvancılık Sektöründe Beklenen Sonuçlar**
Ensuring quality livestock farming in agriculture	Increasing livestock productivity Improving the breed composition of the herd
Adaptation of foreign-origin agricultural livestock farming in the region	Reducing costs by improving the reproductive composition of the herd Increasing livestock productivity
Development and implementation of waste-free technologies in the processing of animal products	Increasing the diversity of food products Reducing production costs
Creation of new resource-saving information systems for the complex mechanization of technological processes in animal husbandry	Increasing labor productivity Reducing product costs
Production of water supply equipment based on the use of renewable natural energy sources	Reducing livestock production costs Increasing environmental safety
Improvement of livestock feeding and nutrition systems	Increasing livestock productivity Improving product quality
Development of new methods for diagnosis, prevention, and treatment of animals	Improving the quality of livestock products Improving the ecological conditions of the region

* Taking into account re-planting and fallow lands.

Measures to optimize the composition of arable land and increase productivity are expected to significantly increase agricultural production in Uzbekistan. In particular, between 2021 and 2024, grain production will increase by 1,195,000 tons, potatoes by 931,000 tons, vegetables by 3,002,200 tons, fruits by 648,600 tons, and grapes by 273,900 tons, laying the foundation for ensuring food security in Uzbekistan.

In the Republic of Uzbekistan, cotton and grain areas decreased by 49,000 hectares and 10,000 hectares, respectively, in 2019. The plan is to allocate 8.1,000 hectares of the reduced acreage to potato production, 27.2,000 hectares to vegetable production, 5.9,000 hectares to intensive horticulture, 2.9,000 hectares to vineyards, 10.9,000 hectares to forage crop production, and 4,000 hectares to oilseed production. These measures are expected to reduce losses from growing cotton and grain on low-profitable land by 80 billion soums, produce an additional 1 million tons of fruit and vegetable products, create more than 48.5,000 new jobs in the regions, increase the number of people employed on these lands to 75.6,000, and double the export volume of both fruit and vegetables (Figure 1).

2 Author's own elaboration

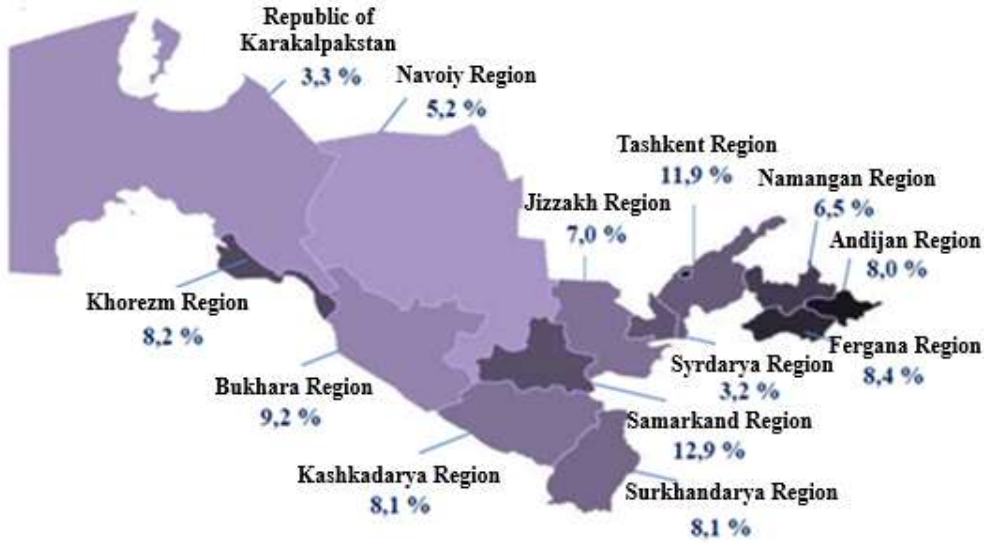

Figure 1. Distribution of Total Volume of Agriculture, Forestry and Fishery Products (Services) by Region[3]

The Samarkand region holds the largest share of the total volume of agricultural, forestry, and fishing products (services) in Uzbekistan, accounting for 12.9%. Tashkent and Bukhara regions are second and third, accounting for 11.9% and 9.2%, respectively. The Navoi region holds the smallest shares of the total volume of agricultural, forestry, and fishing products (services) in Uzbekistan, accounting for 5.2%, the Karakalpakstan Republic (3.3%), and the Syr Darya region (3.2%).

When data on livestock products produced between January and March 2024 were analyzed by economic category, it was determined that 5.2% of the total meat produced belonged to farms, 87.7% to dehkan and household farms, and 7.1% to organizations engaged in agricultural activities. Furthermore, 6.5% of milk production was carried out on farms, 91.9% by peasant and household farms, and 1.6% by organizations engaged in agricultural activities. Additionally, 17.1% of egg production was carried out on farms, 54.4% by peasant and household farms, and 28.5% by organizations engaged in agricultural activities. Furthermore, 16.7% of wool shearing was carried out on farms, 76.0% by peasant and household farms, and 7.3% by organizations engaged in agricultural activities. In addition, 11.5% of the karakul skins were obtained from farms, 84.0% from peasant and household farms, and 4.5% from agricultural organizations. Finally, it was determined that 37.2% of the fish caught were obtained from farms, 7.3% from peasant and household farms, and 55.5% from agricultural organizations (Figure 2).

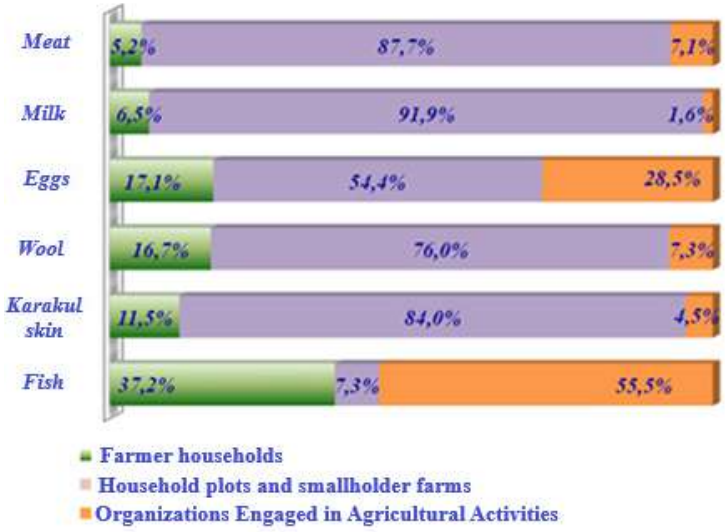

Figure 2. Share of Farm Categories in Main Livestock Products Grown in January-March 2024[4]

3 Author's own elaboration
4 Author's own elaboration

A Dehqan farm is a farm that grows and sells agricultural produce on a plot of land granted to the head of the Dehqan farm on the basis of hereditary lifetime ownership or lease (sublease) based on the labor of the members of the Dehqan farm. The primary objectives of the Dehqan farm are to develop intensive horticulture and viticulture by planting high-yielding, early-maturing dwarf and semi-dwarf trees based on modern agricultural technologies, and to increase the production of export-oriented fruit and vegetable crops that are in demand in global markets.

Seed breeding and variety selection play a crucial role in increasing the productivity of agricultural crops. According to the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, during the years of independence, Uzbek scientists conducted extensive research on the creation of new varieties of fruit, mulberry, walnut, subtropical plants, citrus plants, and grapes, examining local and introduced varieties, developing care technologies, and introducing them into production. As a result, for the first time in Central Asia, the selection of seed, mulberry, and walnut crops was established through selection, laying the foundation for the creation of new varieties. As a result of many years of scientific research, more than 170 fruit and grape varieties have been produced, approximately 80 of which are registered in the State Register. Currently, 709 varieties of fruit, vegetables, potatoes, and melons are registered in the State Register; 189 of these are local varieties and 520 are foreign varieties (Table 2).

Table 2. Fruit, Vegetable, Melon and Potato Varieties Registered in the State Register of the Republic of Uzbekistan[5]

Indicator	Total	Content	
		Local Varieties	Foreign Varieties
Type of crop varieties	709	189	520

One of the most important issues in agricultural innovation in recent years is the expansion of research and development efforts to create agricultural crop and animal breeds suitable for Uzbekistan's soil and climate conditions and resistant to drought, salinity, heat, and disease. From an agricultural perspective, one of the most important challenges today is the development of early-maturing, high-yielding agricultural crop varieties suitable for various soil and climate zones, based on gene knockout biotechnologies, and the elimination of their negative impacts on consumer health. Furthermore, the modernization and rapid development of the livestock sector is an important component of the overall development of the agricultural sector. In the Republic of Uzbekistan, with the decision dated December 29, 2021 and numbered PQ-2460 "On measures for deepening and developing agricultural reform in 2021-2023", it was planned to increase the number of cattle by 3,165 thousand head, the number of sheep and goats by 4,281 thousand head, and the number of poultry by 31,200 thousand head in 2021-2024. Accordingly, it is aimed to increase the volume of meat production (in live weight) by 519.0 thousand tons, milk by 4,177.0 thousand tons, fish by 90.0 thousand tons, honey by 13.7 thousand tons, and eggs by 4,100.0 million units in these years (Table 3).

Table 3. Forecast Indicators for Increasing Livestock Production in the Republic in 2021-2024[6]

Indicators	2024	Estimated Indicators					Changes for the 2021-2024 Period	
		2019	2020	2021	2022	2023	+ , –	%
Number of animals (thousand head)								
Cattle	11 635	12 150	12 720	13 350	14 050	14 800	+ 3 165	127,2
Sheep and goats	18 906	19 600	20 380	21 240	22 170	23 187	+ 4 281	122,6
poultry	60 800	64 600	69 500	75 500	83 000	92 000	+ 31 200	151,3
Livestock production (thousand tons)								
Meat (live weight)	1 981	2 060	2 150	2 260	2 375	2 500	+ 519	126,2
Milk	8 823	9 478	10 242	11 075	11 957	13 000	+ 4 177	147,3
Eggs, million pieces	3 500	6 200	6 900	7 700	8 600	9 600	+ 4 100	274,3
Fish	60	75	90	110	130	150	+ 90	250,0
Honey	9,3	11,0	13,0	15,5	19,0	23,0	+ 13,7	247,3

5 Author's own elaboration
6 Author's own elaboration

In addition, the reclamation and improvement of irrigated lands constitutes a key factor in agricultural development. Approximately 50% of the existing irrigated arable land in Uzbekistan is saline to some degree. In recent years, large-scale state programs have been implemented to improve the reclamation of irrigated lands. In this context, new crop irrigation technologies have been tested in some regions of Uzbekistan, and their use is being proposed. According to the "State Program of the Republic of Uzbekistan for Improving the Reclamation of Irrigated Lands and the Rational Use of Water Resources 2021-2024," the implementation of modern innovative irrigation methods is planned for a total area of 104,600 hectares in 2021-2024. According to the data of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, in 2021-2024, a total of 47,356.0 hectares of cultivated land were irrigated using drip irrigation technologies, 19,214.0 hectares were irrigated by laying polyethylene film on the parcels, and 18,418.0 hectares were irrigated with portable flexible pipes.

The construction of new processing plants equipped with the most modern high-tech equipment for the production of semi-finished and finished food and packaging products based on deep processing of agricultural products, as well as the implementation of investment projects for the reconstruction and modernization of existing ones, are considered promising development areas for Uzbekistan.

In accordance with the decision No. PQ 2505 dated March 5, 2021, "On measures to further develop the raw material base of fruits, vegetables, meat and dairy products, deepen their processing and increase the production and export of food products in 2021-2024" in Uzbekistan, it is planned to implement a total of 180 investment projects with a total value of 595,886.3 thousand US dollars for the establishment of new enterprises for the deep processing of agricultural products and the restructuring and modernization of existing ones (Table 4).

Table 4. Costs of Investment Projects for the Establishment of New Enterprises, Reconstruction and Modernization of Existing Enterprises for Deep Processing of Agricultural Products in 2021-2024[7]

Names of initiators and designers	Total cost of projects	Funding sources included:		
		Equity Resources	Bank Loans	Foreign Investment and Loans
Total (180 Projects)	595 886,3	242 916,7	189 461,6	163 508,0
Contents				
New Construction (141 Projects)	463 267,3	169 714,7	144 324,6	149 228,0
Restructuring and modernization (39 projects)	132 619,0	73 202,0	45 137,0	14 280,0

In accordance with the said decision, 138 new enterprises with a capacity of 99 thousand 100 tons were put into operation in the field of fruit and vegetable processing between 2021 and 2024, 46 new enterprises with a capacity of 16 thousand 500 tons in the field of meat processing, 79 new enterprises with a capacity of 34 thousand 850 tons in the field of milk processing, and 153 new enterprises with a capacity of 26 thousand 840 tons in the field of other food processing. As a result of the implementation of systematic measures for the in-depth processing of agricultural products, in 2021, compared to 2018, it is planned to achieve a 79.4% increase in the volume of canned fruit and vegetables, 80.5% in fruit juices, 73.1% in dried fruits, 59.5% in meat and meat products, 68.8% in sausage products, 56.6% in milk and dairy products, 51.4% in butter, 59.9% in confectionery products, 57.2% in vegetable oil, 24.0% in sugar, 2.5% in cheese, 2.4% in canned meat, 3.4% in fish products, and 2.8-fold increase in frozen fish.

CONCLUSIONS AND SUGGESTIONS

With the implementation of the above measures, significant developments are expected in the agricultural sector. In this context, it is crucial for smallholder farms and livestock-based businesses, currently in the form of individual subsidiaries, to establish new production methods, such as associations, unions, or cooperatives, to establish a mechanism for the organized production of agricultural products and the implementation of innovations in agricultural enterprises.

However, the current production structure is based on low-yield livestock farming and manual labor using outdated equipment. Therefore, to further develop livestock farming and fully meet the Uzbek people's need for livestock products, it is necessary to develop methods to encourage dehkan (personal assistant) farms. As is

7 Source: Compiled based on data from Uzbekoziqovkatholding PE

well known, the most important input in the livestock sector is feed. Feed production constitutes one of the main problems faced by dehkan (personal assistant) farms today. To increase the number of animals on dehkan (personal assistant) farms, it is crucial to allocate sufficient arable land and pastures to them and provide them with opportunities to purchase various feeds (kunjara, shulkha, bran, etc.) to increase their productivity. In this context, dehkan (private subsidiary) farms should be given the opportunity to purchase feed for their livestock directly from feed producers, rather than through intermediaries (farms, agricultural enterprises, or other state-owned enterprises). This will align the prices of livestock products, including meat and meat products, milk, and dairy products, in the markets with the capabilities of consumers. In addition, it is extremely important to establish enterprises for the processing of wool, which is considered the most valuable product in animal husbandry.

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ANALYSIS OF THE FINANCIAL CONDITION OF ENTERPRISES: ASSESSMENT OF EQUITY EFFICIENCY

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Abstract: The article examines the economic content and essence of the financial condition of an enterprise and addresses the issues related to assessing its structure. In this regard, the efficiency of equity capital, including its return level, as well as the factors influencing changes in turnover ratios, are analyzed. The results of the study make it possible to ensure the financial stability of enterprises through the effective use of equity capital.

Key words: balance sheet, financial condition, sources of equity, long-term and short-term liabilities, authorized capital, reserve capital, additional paid-in capital, retained earnings, return on equity, equity turnover.

Annotatsiya: Maqolada korxonaning moliyaviy holatining iqtisodiy mazmuni va mohiyati yoritilgan, shuningdek, uning tarkibini baholash masalalari ko‘rib chiqilgan. Shu munosabat bilan xususiy kapitalning samaradorligi, jumladan uning rentabellik darajasi, hamda aylanma koeffitsientlarining o‘zgarishiga ta’sir etuvchi omillar tahlil qilingan. Tadqiqot natijalari xususiy kapitaldan samarali foydalanish orqali korxonalarning moliyaviy barqarorligini ta’minlash imkonini beradi.

Kalit so‘zlar: balans, moliyaviy holat, o‘z mablag‘lar manbalari, uzoq va qisqa muddatli majburiyatlar, ustav kapitali, zahira kapitali, qo‘shimcha kapital, taqsimlanmagan foyda, xususiy kapital rentabelligi, xususiy kapital aylanmasi.

Аннотация: В статье раскрываются экономическое содержание и сущность финансового состояния предприятия, а также рассматриваются вопросы оценки его структуры. В связи с этим проанализирована эффективность использования собственного капитала, включая уровень его рентабельности, а также факторы, влияющие на изменение коэффициентов оборачиваемости. Полученные результаты позволяют обеспечить финансовую устойчивость предприятий на основе эффективного использования собственного капитала.

Ключевые слова: баланс, финансовое состояние, источники собственных средств, долгосрочные и краткосрочные обязательства, уставный капитал, резервный капитал, добавочный капитал, нераспределённая прибыль, рентабельность собственного капитала, оборачиваемость собственного капитала.

INTRODUCTION

The adoption of the new edition of the Constitution of the Republic of Uzbekistan through a nationwide referendum held on April 30, 2023, became an important factor in strengthening the constitutional foundations for shaping the New Uzbekistan. This, in turn, required improving the main directions of the country’s development under the renewed constitutional and legal framework and brought large-scale reforms to a new, higher-quality stage.

Based on accumulated experience and the results of public discussion, the Uzbekistan–2030 strategy was approved. According to this strategy, special attention is devoted to strengthening applied research in the most dynamically developing sectors of the economy, introducing the cluster system of “enterprise–university–research organization,” allocating 4 trillion soums from the state budget for practical research, and organizing the production of 850 types of innovative products in driver areas of the economy. In addition, it is planned to create more than 2.5 thousand new scientific developments as a result of applied research, develop the transport and logistics system, increase labor productivity in agriculture, energy, biotechnology, geology, metal processing, and mechanical engineering, as well as establish eight scientific–production clusters. [1]

Under the conditions of continued economic development, increasing the efficiency of business entities becomes particularly important. In today's environment, enterprises must manage the movement of financial resources competently and ensure their rational use. The application of ineffective management methods may lead to serious economic risks and even collapse.

Therefore, analyzing the financial condition of an enterprise plays a key role: it contributes to improving financial indicators, strengthening accounting and financial discipline, ensuring an optimal ratio of equity to borrowed funds, identifying internal reserves, increasing the efficiency of financial resource utilization, and overall improving the financial standing of the enterprise. Such analysis allows for the development of necessary recommendations to enhance the financial stability of economic entities.

To improve enterprise management systems in our country, a number of regulatory acts have been adopted. In particular, Resolution No. 207 of the Cabinet of Ministers of the Republic of Uzbekistan, "On the Introduction of Criteria for Assessing the Efficiency of Joint-Stock Companies and Other Business Entities with State Participation," [2] establishes a system for comprehensive assessment of enterprises' financial condition based on basic and additional indicators, enabling the forecasting of their further development. In addition, Resolution No. 1013 of the Cabinet of Ministers, "On Measures for the Fundamental Improvement of the System of Financial Recovery of Enterprises with State Participation," [3] underscores the relevance of analyzing the efficiency of capital use.

Jo-Anne Suchard and Georg A. Schenkel [4] published an article in the Australian Journal of Management titled "Innovation in New Public Firms: The Impact of Government Grants, Venture Capital, and Equity Capital," which adequately investigates this issue. The article examines the influence of government grants, venture capital, and equity funds on innovation in new public firms—input resources, innovation outputs (patents) and their quality (patent citations), as well as the mechanism of interaction among government grants, venture capital, equity capital, and innovation. It demonstrates that grants act as a stimulus for financing direct investments rather than indirect ones. Additionally, the authors note that the homogeneity of venture and private investors has a significant impact on innovation at the firm level in portfolio companies and provide practical recommendations.

Economists Sivi Ariantini and Sapto Djomonolar published an article [5] titled "Profitability and Firm Value: Evidence from Indonesia's Manufacturing Industry," the aim of which is to determine profitability indicators and the factors influencing them, as well as their effect on firm value based on DuPont analysis. Determinant profitability—i.e., net income, total asset turnover, and financial leverage multiplier—positively affects return on equity, while the sales ratio has a significantly negative impact. The study showed that in terms of increasing firm value, the profitability of direct investments makes a significant positive contribution to the industry. This requires management to effectively manage the company's operations, reduce operational and other costs, increase return on equity and profit margins, and efficiently use assets and liabilities. These issues are thoroughly examined in the article.

Research has shown that theoretical issues of analyzing financial conditions represent one side of the matter, while the other side is its practical significance for various sectors. This defines the relevance of the topic of this scientific article.

The renewal and modernization of our country, ensuring high and stable rates of economic growth, efficiency, and macroeconomic balance have been recognized as major priority tasks.

In the context of economic liberalization, it is necessary to manage economic entities rationally in their economically independent and financially sustainable activities, adapt accounting practices to the requirements of a market economy, and organize production or service delivery by effectively using available material, financial, and labor resources. As a result, with high profits, the timely fulfillment of the state's obligations to the budget becomes one of the urgent tasks of today.

LITERATURE REVIEW ON THE TOPIC

To date, a large number of textbooks, monographs, dissertations, and articles have been written on the subject of financial condition. However, each new publication has taken into account the specific characteristics of the country whose enterprises' financial state was being studied. These works include contributions from both domestic and foreign scholars who have enriched the development of this field.

In particular, the domestic scholar, Doctor of Economics and Professor E.A. Akramov, in his textbook "Analysis of the Financial Condition of Enterprises," examines nearly all aspects directly or indirectly related to the overall financial state of an enterprise, including business and market activity, analysis of financial results, turnover of current assets, and more. The textbook, taking into account the requirements of market relations, consistently presents the theoretical–methodological and practical problems and stages of analyzing the financial condition of enterprises. It discusses the main principles and sources of financial analysis, foreign

experience, general assessment of an enterprise's financial condition, analysis of financial stability and balance sheet liquidity, the relationship between financial condition, turnover of current assets, and cost of production, as well as the analysis of business and market activity, economic insolvency, and financial performance of enterprises. [E.A. Akramov, 2004].

According to M.N. Semikolenova, the concept of financial condition is defined by a group of indicators that demonstrate the availability, efficiency of allocation, and use of financial resources, as well as an organization's ability to finance its own activities at a given point in time. The state of a company's financial resources enables it to manage cash flows and, through their effective use, ensure the continuity of the production process, as well as sales, expansion, and product renewal. [Semikolenova M.N., 2020]. The main objective of analyzing financial condition is its timely assessment through obtaining a sufficient number of the most informative indicators that provide an accurate and reliable representation of the enterprise's financial state. Moreover, interest usually lies not only in the current financial position of the enterprise but also in its future prospects—expected financial indicators and the potential for increased efficiency.

RESEARCH METHODOLOGY

In preparing this article, traditional and economic–mathematical methods of economic analysis were used, allowing the determination of the influence of various factors on the resulting indicator. In particular, the tabular data obtained from the analysis can be applied in examining any industrial enterprise, and based on them, conclusions can be drawn regarding the assessment of the efficiency of equity capital.

ANALYSIS AND RESULTS

In the context of economic liberalization, each enterprise is ensured independence, while its level of responsibility also increases. Under such conditions, every enterprise must have its own resources, its own method of managing property, and ownership rights over its assets. This constitutes the main source of all existing assets that form the financial potential of an enterprise. The financial capacity of any economic entity may be sufficient, and it consists of two sources: equity and borrowed funds.

Any enterprise, firm, or organization must maintain a certain level of financial condition in order to secure the resources necessary for its operations. If an enterprise lacks financial capacity, it will be unable to form its material and technical base and working capital. As a result, functioning becomes difficult.

According to the analytical scientific article: "When assessing the financial condition of an enterprise, it is necessary to analyze the structure of balance sheet liabilities, meaning that the contribution of equity capital and external debt to the assets of the enterprise must be defined. The presence of an optimal ratio of these resources determines the future prospects of the enterprise." When analyzing the dynamics and structure of financial resource sources—particularly the structure of resources—both internal and external users rely on accounting data.

Equity capital of an enterprise consists of charter capital, additional and reserve investments, retained earnings, targeted income and funds, provisions for upcoming expenses and payments, and income of future periods. Equity represents the assets of the enterprise after deducting liabilities—that is, it represents funds belonging solely to the business entity itself. [6]

Equity capital is an indicator forming the basis of a company's own funds and is one of the key indicators characterizing a company's financial condition. Depending on its level, the economic dependence or independence of an enterprise is assessed based on the composition of the total funds. [7]

Analysis of the efficiency of enterprise equity capital begins primarily with determining the structural components and changes in equity based on Section 1 of the liabilities side of the balance sheet. To analyze this, let us refer to Table 1.

As seen from the data in Table 1, the equity capital of JSC "Mahsussenergogaz" in 2024 decreased by 40,731,566.00 thousand soums compared to 2019. Charter capital increased to 7,847,000.00 thousand soums: from 744,441.00 thousand soums in 2019 to 8,591,441.00 thousand soums in 2024. Based on its position, the economic dependence or independence of the enterprise is assessed according to the structure of total funds. This situation can be considered positive.

The additional capital contributed to the enterprise during the analysis years amounted to 2,610.00 thousand soums and did not change. In 2024, reserve capital decreased by 8,373,718.00 thousand soums compared to the base year. Retained earnings amounted to: 15,664,219.00 thousand soums in 2019; 14,360,305.00 thousand soums in 2020; 3,606.00 thousand soums in 2021; and 24,876,397.00 thousand soums in 2022. In 2023, the company's uncovered loss amounted to –22,824,216.00 thousand soums, and in 2024 to –24,540,592.00 thousand soums. Thus, financial performance indicators have declined.

Table 1. Dynamic Analysis of the Composition of Equity Capital of JSC "Mahsussenergogaz" for 2019–2024

Indicators	2019 (ths. soums)	2020 (ths. soums)	2021 (ths. soums)	2022 (ths. soums)	2023 (ths. soums)	2024 (ths. soums)	Change in 2024 Compared to 2019 (+/–)
Total Equity Capital	104,757,204.00	99,909,823.00	24,275,963.00	119,965,378.00	72,348,385.00	64,025,638.00	–40,731,566.00
Charter Capital	744,441.00	744,441.00	19,157,277.00	8,724,441.00	8,724,441.00	8,591,441.00	+7,847,000.00
Additional Capital	2,610.00	2,610.00	–	2,610.00	2,610.00	2,610.00	–
Reserve Capital	88,345,934.00	84,802,467.00	5,115,080.00	86,361,930.00	86,445,550.00	79,972,216.00	–8,373,718.00
Retained Earnings (Uncovered Loss)	15,664,219.00	14,360,305.00	3,606.00	24,876,397.00	–22,824,216.00	–24,540,592.00	–8,876,373.00
Repurchased Own Shares	–	–	–	–	–	37.00	+37.00

During the analysis period, the cost of the company's repurchased own shares amounted to 37,000 soums. Thus, the results of the analysis show that the equity capital of JSC "Mahsussenergogaz" changed as a result of the influence of both external and internal factors. Now let us consider the horizontal and vertical analysis of equity capital for the reporting years 2022–2024 of JSC "Mahsussenergogaz" in Table 2.

According to the data in Table 2, the sources of equity of JSC "Mahsussenergogaz" decreased by 47,616,993.00 thousand soums in 2023. In the reporting year, reserve capital occupied the main share in its structure: its share at the beginning of the year was 71.99 percent, and by the end of the year it amounted to 56.40 percent. In 2022, the share of charter capital in the sources of equity was 7.27 percent, and by 2023 it increased to 12.06 percent. The proportion of additional capital during the reporting period was insignificant, amounting to 0.002 and 0.004 percent.

In 2022, the share of retained earnings in the structure of equity capital of the company was 20.74 percent. In 2023, the company incurred uncovered losses amounting to 22,824,216.00 thousand soums, which accounted for 31.53 percent of the sources of equity.

Table 2. Horizontal and Vertical Analysis of Equity of JSC "Mahsussenergogaz"

Indicators	2021	2022	2023	Change in 2023 compared to 2022 (+/–)	Growth rate in 2023 compared to 2022, %
	Amount, thousand UZS	Share, %	Amount, thousand UZS	Share, %	Amount, thousand UZS
Structure of equity:	24,275,963.00	100	119,965,378.00	100	72,348,385.00
Charter capital	19,157,277.00	78.91	8,724,441.00	7.27	8,724,441.00
Additional capital	–	–	2,610.00	0.002	2,610.00
Reserve capital	5,115,080.00	21.07	86,361,930.00	71.99	86,445,550.00
Retained earnings (uncovered loss)	3,606.00	0.0001	24,876,397.00	20.74	(–) 22,824,216.00

Прибыль занимает особое место в структуре источников приумножения денежных средств. Увеличение объёма прибыли приводит прежде всего к пополнению фонда и созданию других резервных фондов. Итак, как видно из результатов анализа, основная часть совокупных ресурсов общества в In the reporting years 2022 and 2023, this corresponds to the share of reserve capital. In 2021, the main component of the equity structure was the share of charter capital, which amounted to 78.91 percent. In the years under review, there was a significant change in the share of charter

capital within the equity structure: it accounted for 78.91% in 2021, 7.27% in 2022, and 12.06% in 2023. The share of reserve capital in 2021 is considered low compared to other years, amounting to 21.07 percent. The share of retained earnings in direct investments in 2021 was 0.0001 percent, which is significantly lower. As seen from the table, the amount of retained earnings in the company decreased during the reporting period, and by the end of the period, the company obtained 2,052,181.00 thousand UZS of uncovered (unrecovered) losses.

During the analysis, it is important to determine the ratio of borrowed funds to equity. This coefficient indicates the amount of borrowed funds that corresponds to each sum of the company's own capital and is calculated as the ratio of total borrowed funds to equity (Form 1, line 770 / line 480). At JSC "Mahsussenergogaz", at the beginning of the year this ratio was:

152,615,295.00 / 119,965,378.00 = 1.27, meaning that for every 1 sum of equity, the enterprise had 1.27 tiyin of borrowed funds.

At the end of the year, the coefficient was:

317,697,361.00 / 72,348,385.00 = 4.39, meaning that for every 1 sum of equity, there were 4.39 tiyin of borrowed funds.

Therefore, the company's dependence on borrowed funds increased significantly. Such a situation reduces the level of stability of its financial position. At the beginning of the year, the entity's resources were formed mainly through equity, while by the end of the year, borrowed funds increased. This situation leads to a decline in the company's financial independence and a deterioration in its solvency.

Profitability is one of the key indicators for assessing the performance of joint-stock companies, and their financial stability is linked to the proper formation of profit. It is known that the main source of a company's assets is its equity. Therefore, analyzing the level of return on equity is a major task in the analytical process. Return on equity characterizes the profitability of a company's own funds. This profitability ratio indicates the volume of direct investment per sum of net profit. To analyze this indicator, we compile the following table (Table 3).

Table 3. Analysis of Return on Equity of JSC "Mahsusenergogaz"

№	Indicators	2022	2023	Changes in 2023 compared to 2022	
				In absolute terms, ths. UZS	In percent, %
1	Net profit, ths. UZS	20,154,192.00	23,259,690.00	+3,105,498.00	+15.41
2	Average annual value of equity, ths. UZS	118,112,382.00	96,156,881.5	–21,955,500.5	–18.59
3	Return on equity (1 × 100 / 2), %	17.06	24.19	+7.13	+41.79

According to the data in Table 3, the volume of equity of JSC "Mahsussenergogaz" in 2023 decreased by 21,955,500.5 thousand UZS compared to 2022. Return on equity increased by 7.13%, reaching 24.19% in 2023. This change was influenced by two factors:

1. Changes in net profit.
2. Changes in the average annual value of equity.

The impact of these factors is determined using the chain substitution method, as shown in Table 4.

Table 4. Calculation of Factor Analysis for Return on Equity

Serial No.	Change in Serial No.	Factors Included in the Calculation Formula	General Indicator – Return on Equity, %	Difference from Previous Calculation, (+/–) %
		Net Profit (ths. UZS)	Average Annual Equity (ths. UZS)	Return on Equity (1 × 100 / 2)
A	B	1	2	3 (1 × 100 / 2)
1	–	20,154,192.00	118,112,382.00	17.06
2	1	23,259,690.00	118,112,382.00	19.69
3	2	23,259,690.00	96,156,881.5	24.19

According to Table 4, as a result of the increase in net profit of JSC "Mahsussenergogaz" by 3,105,498.00 thousand UZS over the year compared to the beginning of the year, the return on equity increased by 2.63%.

The decrease in the average annual value of equity by 21,955,500.5 thousand UZS increased its profitability by 4.5 percent. Thus, the combined impact of these two factors is: 2.63 + 4.5 = +7.13 percent.

At the end of the year, the net profit of JSC "Mahsussenergogaz" amounted to 3,105,498.00 thousand UZS and increased to 396,011.8 thousand UZS. This change was influenced by two factors:

1. Change in the average annual value of equity: 282,214.5 × 27.90 / 100 = +78,737.8 thousand UZS.
2. Change in the level of return on equity: 42.4 × 748,405.5 / 100 = +317,323.9 thousand UZS.

Equality of coefficients:

78,737.8 + 317,323.9 = +396,061.7 thousand UZS.

Due to rounding (396,011.8 – 396,061.7), there is a difference of 49,900 UZS.

Applying the method of calculating factors influencing return on equity in practical enterprise activities allows for increasing economic efficiency and ensuring financial stability.

When analyzing the efficiency of equity, it is important to assess its turnover ratios. Equity turnover relates to both the level and the period of its justification. Table 5 below presents the analysis of turnover ratios.

Table 5. Analysis of Equity Turnover Ratios of JSC "Mahsussenergogaz"

Indicators	2022	2023	Difference between 2023 and 2022 (+/–)
1	Average annual value of equity, ths. UZS	118,112,382.00	96,156,881.5
2	Net revenue from product sales, ths. UZS	89,577,498.00	249,943,612.00
3	Capital turnover ratio (2 ÷ 1)	0.76	2.60
4	Capital turnover period, days (1 × 360 ÷ 2)	473.68	138.50
5	Equity turnover ratio (1 ÷ 2)	1.32	0.38

As seen from Table 5, the equity turnover ratio of JSC "Mahsussenergogaz" at the beginning of the year was 0.76, and at the end of the year it reached 2.60, increasing by 1.84. The equity turnover weight coefficient decreased by 0.94. The capital turnover period at the company at the end of the year was 138.50 days, decreasing by 335.18 days.

Now, based on the data in Table 5, we determine the calculation of factors influencing the change in the equity turnover period (Table 6).

According to Table 6, the turnover of equity at JSC "Mahsussenergogaz" accelerated by 335.18 days. This change was caused by the following factors:

1. An increase in net revenue from product sales by 160,366,114.00 thousand UZS accelerated the equity turnover period by 303.56 days.
2. A decrease in the average annual value of equity by 21,955,500.5 thousand UZS accelerated the turnover period by 31.62 days.

Thus, the effect of all factors equals the total change in the result: (–303.56) + (–31.62) = –335.18 days.

Table 6. Calculation of Factors Affecting the Change in Equity Turnover Period

Serial No.	Change in Serial No.	Factors Included in the Calculation Formula	General Indicator – Equity Turnover Period (days)	Difference from Previous Calculation (+/–)
		Net Revenue from Product Sales (ths. UZS)	Average Annual Equity (ths. UZS)	Days (2 × 360 ÷ 1)
A	B	1	2	3 (2 × 360 ÷ 1)
1	–	89,577,498.00	118,112,382.00	473.68
2	1	249,943,612.00	118,112,382.00	170.12
3	2	249,943,612.00	96,156,881.5	138.50

Factor balance: –335.18 days

Based on the application of the correlation method, it can be calculated that changes in the factors affecting the equity turnover period are interrelated. If the correlation coefficient equals 0, this indicates the absence of correlation between the studied indicators. If the correlation coefficient equals 1, the relationship between the indicators is highly tight, i.e., functional. A correlation coefficient from 0.1 to 0.3 indicates a low correlation, from

0.3 to 0.5 – medium, from 0.5 to 0.7 – significant, from 0.7 to 0.9 – high, and from 0.9 to 1 – very high, which is considered fully functional.

Based on the data in the following table, using the correlation method, we can observe the relationship between net revenue from product sales and the value of equity (Table 7).

Table 7. Calculation of the Relationship Between Factors Affecting the Change in Equity Turnover Period Using the Correlation Method

Year	Net Revenue from Product Sales (ths. UZS) X	Equity Value (ths. UZS) Y	X^2 (square of X series)	Y^2 (square of Y series)	Factor Multipliers X × Y
2019	11,720	10,476	13,736	10,975	12,279
2020	89,790	99,910	80,622	99,820	89,709
2021	76,778	24,276	58,949	58,932	18,639
2022	89,577	11,996	80,240	14,390	10,746
2023	24,994	72,348	62,470	52,342	18,083
Total	292,859	219,006	296,017	236,459	149,456

The correlation coefficient between net revenue from product sales and equity can be expressed using the following formula:

$Rxy = \sum X \times Y / \sqrt{(\sum X^2 \times \sum Y^2)}$

Calculation using this formula:

$149456 / \sqrt{(296017 \times 236459)} = 0,2$

Thus, the relationship between net revenue from product sales and equity is functional. According to the calculation, the correlation coefficient is 0.2. This means that 20% of the net revenue from product sales depends on the size of equity, while the remaining 80% depends on other factors.

According to the analysis results, the equity of JSC “Mahsussenergogaz” decreased during the reporting period. The reduction in equity occurred primarily due to a decrease in retained earnings. This is because, although equity is initially formed through the charter capital contributed by the founders, it should subsequently increase through allocations from profits earned during the company’s operations. Therefore, to increase equity, it is first necessary to increase the company’s profit. Profit is not the result of a single economic transaction but the outcome of effective business activity.

Assessment of financial condition is one of the key issues in ensuring the financial stability of enterprises and improving efficiency indicators, and it should always be a central focus for company management, analysts, and auditors.

CONCLUSIONS AND RECOMMENDATIONS

In this research article, using practical data, the financial condition of JSC “Mahsussenergogaz” was studied, and practical recommendations were provided. During the reporting year, the liability portion of the company’s balance sheet dominated, which can be considered a negative situation. Thus, the company has a need for borrowed funds. During the analysis, the ratio of equity to borrowed funds was calculated. At the end of the year, JSC “Mahsussenergogaz” attracted 4.39 units of borrowed funds for every unit of its own equity. This situation reduced the stability of its financial position and led to a deterioration in solvency.

Equity forms the basis of a company’s own funds and is one of the key indicators characterizing the financial condition of a company. Depending on its structure, the economic dependence or independence of the enterprise is assessed based on the composition of total funds. Accordingly, the turnover ratios related to the equity of JSC “Mahsussenergogaz” were analyzed, and practical recommendations were given for analyzing the factors influencing changes in the turnover period. The relationship between net revenue from product sales and equity was calculated using the correlation method. Additionally, the factor analysis method for assessing return on equity was recommended.

As a result of assessing the financial condition of enterprises, it is possible to establish targeted management of equity and liabilities, accelerate the turnover of cash and liquid assets, and determine practical measures to ensure financial stability. Financial condition analysis is crucial for determining the financial independence, stability, and creditworthiness of an enterprise.

Based on the results of this study, the following practical recommendations can be made:

- To ensure the stability of the company’s financial condition, it is necessary to increase the volume of equity and use it efficiently. To increase equity, it is first necessary to increase the company’s profit.

• A significant portion of enterprise expenses consists of bank loan interest and transportation costs. Therefore, the company should maximize the share of equity in working capital and, ultimately, fully cover all working capital with its own funds.

• One of the main ways to ensure financial stability is to take measures to prevent an increase in accounts receivable and current liabilities. A large volume of liabilities leads to a deterioration of the enterprise's financial condition. Failure to meet payment obligations may result in economic insolvency.

We believe that applying these recommendations in practical enterprise activities will allow for accurate diagnostics of financial condition, improve equity efficiency, ensure competitiveness, prevent bankruptcy, increase financial potential, and maintain financial stability.

Domestic and foreign publications on financial condition and its analysis are so extensive that one conclusion can be drawn: the effectiveness of the functioning of enterprises and the evaluation of their performance is always carried out by a wide range of stakeholders (managers, property owners, etc.). Financial condition analysis has been one of the key issues under their attention.

Financial analysis is conducted not only by studying the situation and its changes but also by evaluating the efficiency and effectiveness of processes and forecasting future expectations. This is increasingly important in a competitive economy.

The effectiveness of financial condition analysis lies in the quality of the information it provides, which depends on the quality of sources. The primary source of information is the financial report. Financial reporting contains information about assets, equity, and liabilities, income and expenses, presented comprehensively, in a balanced form, sorted by liquidity, based on periodic reporting forms and their accompanying sources.

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IMPROVING THE QUALITY OF ECONOMIC GROWTH THROUGH THE TRANSITION TO THE DIGITAL ECONOMY

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Abstract: The article emphasizes that the digital economy is rapidly developing across all countries of the world and highlights the urgent need to expand and strengthen the digital transformation process in Uzbekistan. It substantiates the relevance of accelerating the transition to a digital economy as a strategic priority for ensuring competitiveness, improving public services, and modernizing economic sectors. Special attention is given to assessing the impact and contribution of the digital economy to sustainable economic growth, including its role in increasing productivity, enhancing innovation capacity, expanding market accessibility, and improving the efficiency of resource allocation. The findings show that the digital economy is becoming a key driver of long-term economic development and a fundamental component of national economic security.

Key words: digital economy, digital transformation, innovation, sustainable economic growth, competitiveness, digital infrastructure, information technologies.

Annotatsiya: Maqolada raqamli iqtisodiyotning dunyo mamlakatlarida jadal rivojlanayotgani ta’kidlanadi hamda O‘zbekistonda raqamli transformatsiya jarayonlarini kengaytirish va kuchaytirish zarurligi asoslab beriladi. Raqobatbardoshlikni ta’minlash, davlat xizmatlarini takomillashtirish va iqtisodiy tarmoqlarni modernizatsiya qilishda raqamli iqtisodiyotga o‘tish jarayonini tezlashtirish strategik ustuvor yo‘nalish sifatida ko‘rsatib o‘tiladi. Tadqiqotda raqamli iqtisodiyotning barqaror iqtisodiy o‘sishga ta’siri, xususan, mehnat unumdorligini oshirish, innovatsion salohiyatni kengaytirish, bozorlar kirish imkoniyatini yaxshilash va resurslardan samarali foydalanishni kuchaytirishdagi ahamiyati baholanadi. Olingan natijalar raqamli iqtisodiyot uzoq muddatli iqtisodiy rivojlanishning asosiy drayveriga va milliy iqtisodiy xavfsizlikning muhim tarkibiy qismiga aylanib borayotganini ko‘rsatadi.

Kalit so‘zlar: raqamli iqtisodiyot, raqamli transformatsiya, innovatsiya, barqaror iqtisodiy o‘sish, raqobatbardoshlik, raqamli infratuzilma, axborot texnologiyalari.

Аннотация: В статье подчеркивается, что цифровая экономика стремительно развивается во всех странах мира, и обосновывается необходимость расширения и усиления процессов цифровой трансформации в Узбекистане. Отмечается, что ускорение перехода к цифровой экономике является стратегическим приоритетом для обеспечения конкурентоспособности, повышения качества государственных услуг и модернизации экономических отраслей. Особое внимание уделяется оценке влияния и вклада цифровой экономики в устойчивый экономический рост, включая её роль в повышении производительности труда, укреплении инновационного потенциала, расширении доступа к рынкам и повышении эффективности распределения ресурсов. Полученные результаты показывают, что цифровая экономика становится ключевым драйвером долгосрочного экономического развития и важнейшим компонентом национальной экономической безопасности.

Ключевые слова: цифровая экономика, цифровая трансформация, инновации, устойчивый экономический рост, конкурентоспособность, цифровая инфраструктура, информационные технологии.

INTRODUCTION

The main strategic task of economic transformation in the Republic of Uzbekistan is to deepen structural changes and ensure sustainable economic growth based on the country’s competitive advantages. In this context, it is not sufficient to achieve only high quantitative growth rates; the key priority is to secure a qualitative shift in favor of processing and high value–added sectors. This, in turn, requires intensifying the search for new and efficient sources of growth that can support long-term structural modernization of the national economy. Such strategic directions include:

- expanding the production of non–raw material goods aimed at export growth and import substitution;
- stimulating the emergence of new economic sectors and accelerating innovation-driven diversification;
- improving the investment climate and expanding the scale and quality of investment inflows;
- strengthening analytical research on issues of sustainable and high-quality growth, which is especially crucial for countries with a low-diversified economic structure, including Uzbekistan.

REVIEW OF LITERATURE ON THE SUBJECT

The relationship between the quality of economic growth and the digital economy is one of the most relevant scientific areas in the modern world economy, and its theoretical and practical aspects have been widely studied by foreign and domestic scientists. The works of leading scientists who have scientifically analyzed the phenomenon of the digital economy, D. Tapscott, E. Brynjolfsson, A. McAfee, K. Schwab, R. Bukht and R. Heeks, are of particular importance. They scientifically substantiated how digital technologies, «big data», Internet platforms and artificial intelligence increase the efficiency of economic processes, transform labor productivity and, as a result, affect the quality of economic growth. In particular, Brynjolfsson and McAfee (2016) emphasized that digital technologies create a «quality phase» of economic growth by changing the model of value creation in the labor market, increasing productivity and innovative activity. Schwab (2018) interprets the digital economy as the main driver of the Fourth Industrial Revolution and considers that digitalization creates the basis for the transition of the economy to a new structure.

Internationally studied models of the digital economy and the quality of economic growth are widely covered in reports by ITU, OECD, UNCTAD and the World Bank. In particular, the ITU Digital Development Index and the OECD Digital Economy Outlook report assess the development of digital infrastructure, the share of digital services, digital trade and digital competencies as key indicators of the quality of economic growth. According to UNCTAD's Digital Economy Report (2023), the development of the digital economy has a direct positive impact on the quality of growth through diversification of the industry structure, efficient use of resources and increased innovative capacity.

Researchers from the CIS and Europe - A. Aptekar, V. Inozemtsev, D. Belov, Ya. Kuzmin et al. studied the impact of digital infrastructure on economic growth using an institutional approach. They emphasize that the effectiveness of digital transformation is closely related to the political and legal environment, digital inequality, cybersecurity, and the level of digital literacy.

In Uzbekistan, important scientific work has been carried out on the issues of digital economy and economic growth by Nazarov K., Yusupov M., Usmonov B., Mamashev A., Isakov A. and other local researchers on the improvement of digital infrastructure, the development of digital public services, and the impact of changes in the digital trade and IT services market on economic growth. The identification of the digital economy as the main driver of improving the quality of economic growth in the "Digital Uzbekistan – 2030" strategy also strengthens the practical importance of scientific research in this area.

Thus, the topic of increasing the quality of economic growth through the transition to a digital economy is well studied internationally, but for transformation economies, especially in the conditions of Uzbekistan, it is one of the most relevant research areas that requires comprehensive scientific and practical solutions.

The formation of a new economic model requires a balanced approach that integrates both traditional and modern drivers of economic development. On the one hand, material resource accumulation, demographic dynamics, technological progress, and productivity growth remain essential sources of expansion. On the other hand, stable and long-term economic advancement demands an effective combination of human capital, natural resources, and physical capital. These factors must interact within a coherent institutional framework capable of generating innovation, enhancing competitiveness, and supporting structural upgrading of the economy.

Thus, the challenge for Uzbekistan is not only to accelerate growth but also to transform its qualitative foundations by strengthening industrial potential, modernizing production capacity, and developing new technological competencies that meet global standards.

Studies indicate that in the near future the digital economy will encompass a substantial share of global economic activity, fundamentally reshaping production, consumption, and governance models. With the rapid expansion of digital media — including the Internet, mobile communication devices, cloud systems, and all other technologies that enable the collection, storage, analysis, and transmission of data — information can now be reproduced, processed, and distributed quickly, accurately, and at minimal cost. Consequently, digital technologies have become the core instrument for managing socio-economic "diffusions," accelerating innovation cycles, and transforming entire sectors of the economy.

In its broadest definition, the concept of digitization refers to a comprehensive socio-economic transformation driven by the mass introduction, adoption, and integration of digital technologies — technologies that support the creation, processing, exchange, and transmission of information. This transformation is fundamentally

shaped by advances in microelectronics, information technologies, and telecommunications and represents a natural evolutionary stage in the development of human civilization. From this perspective, the transition of the modern economy toward a digital format is no longer an anomaly or an experimental phase, but a global and irreversible trend.

Empirical observations further demonstrate that leading economies have already entered a stage in which digitalization constitutes a core component of economic growth. Current global practice shows that "on average, digitalization accounts for 18% of IT expenditures, while for market leaders this figure ranges from 34% to 44%, and projections indicate that it may reach 28% by 2021." These indicators confirm that the digital transformation of the economy is not only objective and inevitable but also a competitive necessity for all countries aspiring to sustain economic growth and integrate into global value chains.

E. Toffler, in his influential works, emphasized that "computers, mobile phones, and similar technologies undermine traditional notions of infrastructure priorities." According to Toffler, in the digital economy the primary driving force is no longer electricity, transportation networks, or physical assets, but data. Information — its quality, accessibility, speed of processing, and security — becomes the principal strategic resource of modern development. This paradigm shift means that solutions to economic problems increasingly lie not in expanding physical capacities, but in enhancing data systems, digital competencies, and technological connectivity.

The study of the relationship between economic growth and the directions of socio-economic development has long occupied a central place in the works of economists from various theoretical schools. Classical and neoclassical scholars emphasized capital accumulation, labor resources, and technological progress as the fundamental drivers of growth. J. Schumpeter made a significant contribution by demonstrating that economic dynamics and long-term growth rates are determined primarily by innovative activity, entrepreneurial behavior, and technological "breakthroughs." Likewise, F. List highlighted the role of state policy and national economic strategies in stimulating structural development, considering the active involvement of national institutions as a key prerequisite for sustained growth.

Institutional economists further developed Schumpeter's approach, emphasizing that technological change is not only a factor of production but also an institutional process shaping the trajectory of economic evolution. They argued that the emergence and diffusion of basic technologies — from industrial mechanisms to digital systems — fundamentally influence the structure, direction, and quality of economic development within society. In this context, economic growth is viewed not simply as a quantitative increase in output but as a qualitative transformation rooted in modernization and innovation.

In Uzbekistan, key aspects of economic growth have been actively studied in the scientific works of I.I. Iskandarova, A.M. Kadyrova, N.M. Makhmudova, A.F. Rasuleva, G.K. Saidova, S.V. Chepel, I.S. Tukhlieva, T.Sh. Shodieva, M.M. Irmatova, D.V. Trostyansky and other researchers. These scholars explored structural transformation, investment policy, human capital development, technological modernization, and institutional reforms affecting national economic growth. Their studies enriched the understanding of the mechanisms and priorities of sustainable development within the context of Uzbekistan's transition economy.

Despite these contributions, a number of issues remain unresolved. Many foreign studies focus primarily on the cyclical development of advanced industrial economies and therefore fail to reflect the specific conditions of transition economies, where market institutions, innovation systems, and structural policies are still evolving. On the other hand, certain CIS-based research restricts its analysis to national peculiarities and socio-cultural features, without offering comprehensive answers to the deeper challenges associated with the quality of economic growth within transformational systems.

RESEARCH METHODOLOGY

The research methodology is based on the collection of empirical and analytical data from international databases, national statistical reports, and regulatory documents, complemented by findings from academic literature. The study applies comparative analysis, trend evaluation, and structural assessment methods to examine the relationship between digital transformation and the quality of economic growth, enabling the identification of key patterns and determinants shaping Uzbekistan's developmental trajectory.

ANALYSIS AND RESULTS

Important aspects — such as the conceptual content of "quality of growth," the relationship between qualitative and quantitative dimensions of development, the prioritization of state policy in achieving optimal long-term growth, and the mechanisms for improving economic efficiency while ensuring inclusiveness — remain insufficiently studied. This points to the need for more holistic and interdisciplinary research capable of integrating macroeconomic analysis with institutional, technological, and social factors influencing the sustainability and quality of economic development.

In order to fully utilize the potential for national economic development, it is essential for Uzbekistan to establish a qualitatively new mechanism capable of ensuring both the potential and real opportunities for achieving high and sustainable economic growth rates. Such a mechanism must integrate structural modernization, technological renewal, and the efficient use of human and natural resources. Naturally, this process is not without shortcomings and systemic constraints. One of the key issues in formulating new strategic directions is that their economic dimensions remain insufficiently explored, which increases the need to clearly define growth priorities, identify relevant indicators, and apply modern forecasting models capable of capturing long-term development trajectories.

The most important determinants of the quality of economic growth in Uzbekistan are the socio-economic benefits derived from growth itself, especially those gains that directly improve the welfare of the population. In assessing growth quality, it is therefore advisable to consider not only aggregate GDP expansion but also the increase in household disposable income — that is, the income consumed in the current period rather than the portion deferred to the future. This approach enables a more adequate evaluation of how economic development translates into improved living standards, social stability, and long-term prosperity.

Within this context, Uzbekistan's transition to a digital economy serves as an essential catalyst for enhancing the quality and sustainability of economic growth. The widespread introduction of digital technologies — including electronic services, digital payments, modern information systems, and automated management tools — expands economic efficiency, strengthens institutional transparency, and accelerates productivity growth across sectors. As a result, digital transformation provides a new impulse for ensuring stable, inclusive, and innovation-driven economic development, reinforcing the structural foundations necessary for the country's long-term growth model.

The impact of digital technologies is evolving significantly, both globally and locally. On the one hand, the digital economy as a new industrial complex is a rapidly growing part of the global economy in the traditional sense, and the development of new technologies in recent years has led to the emergence of huge markets for mobile communications, Internet services, online gaming industry and more (Figure 1).

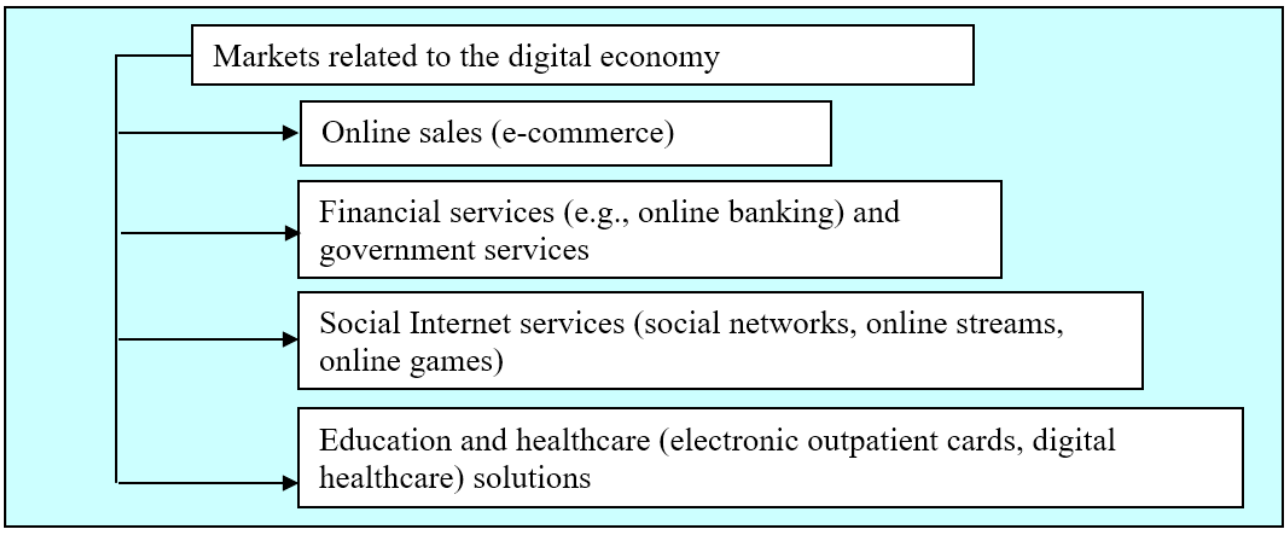

Figure 1. Markets related to the digital economy[1]

The digital economy is expanding at an exceptionally rapid pace, with annual growth averaging around 10 percent — a rate three times higher than the overall global economic growth. According to international assessments, the global digital economy accounted for more than USD 24 trillion in e-commerce turnover in 2015, representing nearly 30 percent of all global economic transactions, the majority of which were conducted via mobile digital technologies. In advanced economies, the digital sector contributes approximately 4–7 percent of GDP, while countries such as Ireland (11.9%), South Korea (9.6%), and Japan (8.1%) rank among the global leaders. Meanwhile, Austria (3.8%) and Norway (3.9%) demonstrate comparatively lower digital value-added shares, illustrating the significant divergence in digital development levels across nations.

Expanding access to an open and globally integrated Internet environment is expected to accelerate economic growth, stimulate the creation of new high-skilled jobs, and enhance opportunities in e-commerce and digital trade. Achieving such outcomes largely depends on government-led initiatives — regulatory frameworks,

1 Source: Created by the author

digital infrastructure modernization, cross-border ICT cooperation, tax incentives, and policies aimed at fostering innovation ecosystems. These measures enhance the absorptive capacity of national economies and support their transition toward more productive, knowledge-based development models.

The formation of a modern information-telecommunication system is fundamentally reshaping management paradigms. Its conceptual core involves shifting from fragmented, network-type control mechanisms to targeted, data-driven management approaches based on digital technologies. This shift requires revisiting and updating traditional criteria for business success, particularly in the context of digital transformation. Global estimates suggest that the digital economy will introduce transformational changes to more than 50 percent of all major economic sectors, including finance, transport, industry, healthcare, and education.

The digital economy is simultaneously generating an entirely new digital space — one that functions as a key driver of economic growth and dramatically expands access to large volumes of structured and unstructured data. “Big data” is becoming a strategic national asset, equivalent in value to technological, financial, and natural resources. For the state, it enhances governance efficiency; for businesses, it improves competitiveness and innovation capacity; and for civil society, it facilitates transparency and participation. Digital platforms, as the core infrastructure of the new economic model, make it possible to address complex global and social challenges, from optimizing logistics flows to improving public service delivery, environmental monitoring, and socio-economic forecasting (Figure 2).

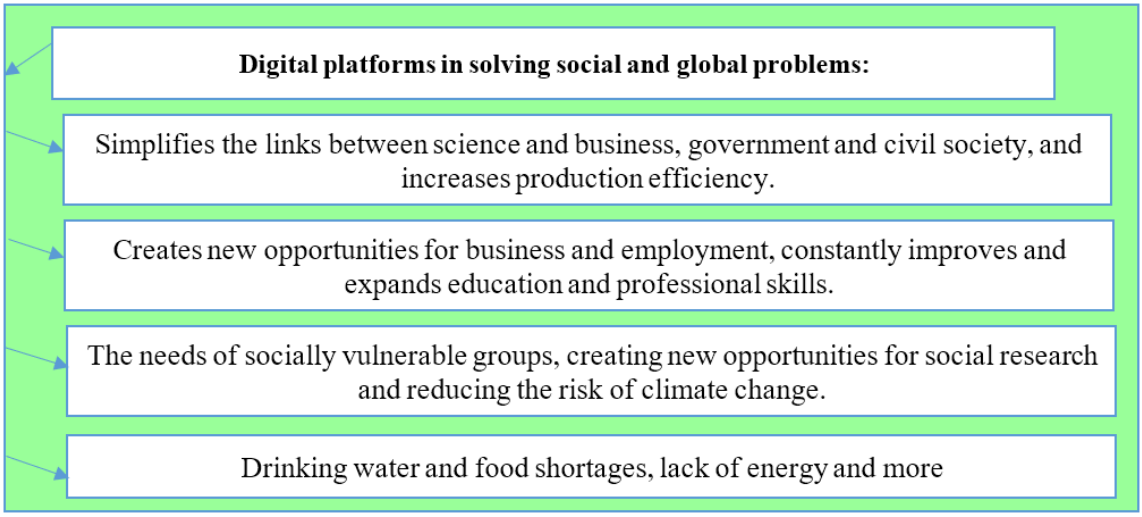

Figure 2. The role of digital platforms in solving current social and global problems[2]

Uzbekistan is also working to introduce a digital economy. In particular, Uzbek scientists say: «Great work is being done in our country to develop the digital economy .... In the digital economy, digital data is a key element of production in all socio-economic spheres, and the gradual transition to such an economic system It will further increase, create new jobs, accelerate economic growth and ensure national independence».

However, in the process of introducing the digital economy, special attention should be paid to the following:

- trade barriers;
- protection of personal data;
- transmitted data;
- new risks associated with payment mechanisms.

The Concept of Socio-Economic Development of Uzbekistan until 2030 outlines several strategic priorities aimed at ensuring long-term macroeconomic stability and sustainable economic growth. These priorities include strengthening the competitiveness of key sectors of the national economy, expanding investment and export potential, creating a favorable and protected environment for business development, reducing labor market tensions, increasing incomes, and effectively addressing poverty. Achieving these objectives requires deep structural reforms, modernization of production capacities, and the introduction of innovative mechanisms capable of increasing economic resilience in the face of global challenges.

It should be emphasized that the rapid expansion of the digital economy is closely linked to the emergence, improvement, and transformation of various markets directly associated with digital and mobile technologies. Digital platforms, e-commerce ecosystems, fintech services, and mobile applications are reshaping the architecture of modern markets, increasing their transparency, dynamism, and integration into global value

2 Source: Created by the author

chains. These changes significantly influence productivity, transaction costs, competition, and overall economic efficiency, thereby reinforcing the role of digitalization as a critical component of Uzbekistan's future economic model.

The accelerated production of new knowledge, the expansion of digital competencies, and the integration of digital economic activity with traditional industries are becoming a decisive new economic force. The convergence of digital and real sectors creates hybrid economic models — combining technology, data management, and traditional production — that can generate high added value and enhance the country's global competitiveness. Therefore, the formation of a knowledge-based and digitally oriented economy requires special attention, coordinated public policy, and targeted investment in human capital, innovation infrastructure, and technological modernization.

CONCLUSIONS AND SUGGESTIONS

The analysis demonstrates that the long-term sustainability and quality of Uzbekistan's economic growth depend on the country's capacity to implement deep structural modernization, accelerate technological renewal, and systematically integrate digital transformation into all sectors of the economy. While traditional growth factors such as capital accumulation, labor dynamics, and productivity remain important, they are no longer sufficient to ensure competitiveness in a rapidly changing global environment. The transition to a digital economy — supported by modern infrastructure, data-driven governance, and advanced technological competencies — emerges as a decisive driver capable of enhancing efficiency, expanding value creation, and strengthening institutional transparency.

International experience and empirical evidence confirm that digitalization generates substantial positive externalities, including higher productivity, reduced transaction costs, improved innovation capacity, and increased inclusiveness of economic development. For Uzbekistan, these effects are particularly significant given the country's ongoing transformation toward a diversified, knowledge-based economic model. The adoption of digital platforms, the expansion of ICT services, and the development of human capital form the core foundation for achieving a qualitative shift in economic growth.

At the same time, the study highlights the need to address systemic constraints related to institutional readiness, digital inequality, regulatory capacity, and cybersecurity challenges. Ensuring the effective implementation of digital reforms requires coherent public policy, strategic investment in innovation ecosystems, and the modernization of legal and infrastructural frameworks. Strengthening these foundations is essential for translating digital transformation into tangible socio-economic benefits, particularly in terms of higher household incomes, improved welfare, and expanded opportunities for participation in global value chains.

Overall, the successful integration of digital technologies into Uzbekistan's development trajectory will determine the country's ability to sustain high growth rates, enhance competitiveness, and build a resilient and adaptive economic structure. The digital economy thus represents not only a technological shift but a strategic pathway for improving the quality, inclusiveness, and long-term stability of Uzbekistan's economic growth model.

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МЕТОДЫ И МЕХАНИЗМЫ ИССЛЕДОВАНИЯ ПОТРЕБИТЕЛЬСКОГО ПОВЕДЕНИЯ НА ТУРИСТСКОМ РЫНКЕ

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Аннотация. В статье анализируются методы и механизмы исследования потребительского поведения на туристском рынке. Рассматриваются первичные методы (анкетирование, интервью, наблюдение, эксперимент, дневниковые исследования, цифровая этнография), обеспечивающие получение оригинальной информации от туристов, и вторичные методы (анализ статистических данных, маркетинговых отчетов, контент-анализ, сравнительно-исторический анализ, использование «больших данных»), позволяющие выявить макроуровневые тенденции спроса. Обосновано, что сочетание первичных и вторичных методов формирует целостное представление о мотивациях, предпочтениях и моделях поведения туристов, а также служит основой для разработки эффективных управленческих решений и стратегий продвижения туристских дестинаций.

Ключевые слова: туризм, потребительское поведение, туристский рынок, методы исследования, первичные методы, вторичные методы.

Annotatsiya. Maqolada turistik bozor sharoitida iste'molchilar hulqini o'rganishning nazariy va amaliy asoslari yoritiladi. Tadqiqotda birlamchi usullar (anketlash, intervyu, kuzatish, eksperiment, kundalik yozuvlar, raqamli etnografiya) bevosita ma'lumot olish imkonini beruvchi manba sifatida, ikkilamchi usullar (statistik ma'lumotlar tahlili, marketing hisobotlari, kontent-tahlil, qiyosiy-tarixiy yondashuv, "katta ma'lumotlar"dan foydalanish) esa turizm sohasidagi umumiy tendensiyalarni aniqlash vositasi sifatida ko'rib chiqiladi. Birlamchi va ikkilamchi usullarni uyg'un qo'llash natijasida turistlarning motivatsiyasi, afzalliklari va hulq-atvor modellarini kompleks tahlil qilish imkoniyati shakllanadi hamda turistik destinatsiyalarni boshqarish va samarali marketing strategiyalarini ishlab chiqishga ilmiy asos yaratadi.

Kalit so'zlar: turizm, iste'molchilar hulqi, turistik bozor, tadqiqot usullari, birlamchi usullar, ikkilamchi usullar.

Abstract. This article analyzes the methods and mechanisms of studying consumer behavior in the tourism market. Primary research methods (surveys, interviews, observation, experiments, travel diaries, digital ethnography) are examined as effective tools for collecting original data directly from tourists. Secondary methods (statistical data analysis, marketing reports, content analysis, comparative-historical analysis, and the use of big data) are discussed as approaches that allow the identification of macro-level demand trends. The study demonstrates that the combination of primary and secondary methods provides a comprehensive understanding of tourists' motivations, preferences, and behavioral models, and serves as a solid foundation for developing evidence-based management decisions and effective destination marketing strategies.

Key words: tourism, consumer behavior, tourism market, research methods, primary methods, secondary methods.

ВВЕДЕНИЕ

Изучение потребительского поведения в туризме является одним из ключевых направлений современной науки о туризме, поскольку именно оно позволяет выявить закономерности формирования спроса, предпочтений и мотивов туристов (Kotler et al., 2017; Middleton, 2009). Туристский рынок отличается высокой степенью динамичности и подвержен влиянию множества факторов: социально-экономических, культурных, психологических и технологических (Swarbrooke, Horner, 2007). В условиях глобальной цифровизации особое значение приобретает анализ новых форм потребительской активности, включая онлайн-поиск информации, бронирование услуг и участие в электронных коммуникациях (UNWTO, 2023).

Особое место в научных исследованиях занимает методология изучения туристского поведения, включающая как первичные методы — анкетирование, интервью, наблюдение, эксперимент, цифровую этнографию, так и вторичные методы — анализ статистических данных, маркетинговых отчетов, big data и контент-анализа (Яковлева, 2020; Cooper, 2018). Их комплексное использование позволяет не только выявлять индивидуальные и коллективные особенности поведения туристов, но и прогнозировать долгосрочные тенденции развития туристского спроса (Балабанов, Балабанов, 2015).

Для Республики Узбекистан исследование потребительского поведения в туризме имеет особую актуальность. С одной стороны, страна демонстрирует устойчивый рост въездного и внутреннего туризма, что подтверждается статистическими данными международных организаций (World Bank, 2022). С другой стороны, национальная научная база пока не в полной мере раскрывает специфику потребительского поведения туристов, ограничиваясь преимущественно общими экономическими и маркетинговыми аспектами (Абдурахманова, 2021; Турсунов, 2020). Это обусловливает необходимость проведения комплексных исследований, опирающихся на современные методологические подходы и учитывающих специфику национального туристского рынка.

ОБЗОР ЛИТЕРАТКРЫ ПО ТЕМЕ

Для того чтобы изучать потребительское поведение в туризме, необходимо разработать и применять комплекс методов и механизмов, позволяющих выявлять мотивационные установки, ценностные ориентации, поведенческие паттерны и факторы принятия решений туристами. Однако прежде чем перейти к выбору инструментов анализа, необходимо определить и раскрыть сущность понятия «туристический рынок», поскольку именно его структурные характеристики, функциональные особенности и динамика развития во многом определяют специфику формирования и реализации туристского спроса и предложения [Котлер и др., 2021; Квартальнов, 2020; Cooper et al., 2021] Понимание структуры и специфики туристического рынка обеспечивает корректную интерпретацию результатов эмпирических исследований, позволяет выбирать адекватные аналитические подходы и повышает практическую применимость разработанных моделей поведения туристов [Медлик, Миддлтон, 2018; UNWTO, 2022].

В научной литературе туристический рынок рассматривается как сложная система экономических, социальных и культурных взаимодействий, возникающих в процессе производства, распределения и потребления туристских услуг и продуктов (Квартальнов, 2012; Биржаков, 2010) В отличие от классического товарного рынка, его объектом выступают не материальные товары, а комплексные туристские продукты, включающие в себя совокупность услуг — транспортных, гостиничных, экскурсионных, рекреационных и других, удовлетворяющих разнообразные потребности путешественников (Middleton, 2009).

С точки зрения экономической теории, туристический рынок можно определить как специфический сегмент рыночной экономики, где взаимодействие спроса и предложения происходит в условиях ярко выраженной сезонности, географической привязанности к туристским ресурсам и зависимости от макроэкономических и социокультурных факторов (UNWTO, 2023).

МЕТОДОЛОГИЯ ИССЛЕДОВАНИЯ

В статье автором были использованы методы научного абстрагирования, системного анализа, сравнительного анализа, индукции и дедукции.

АНАЛИЗ И РЕЗУЛЬТАТЫ

Вместе с тем туристический рынок является междисциплинарным феноменом, поскольку его функционирование и развитие невозможно объяснить исключительно экономическими категориями. Он интегрирует в себе аспекты:

Таблица 1. Междисциплинарные измерения туристического рынка: операционализация для исследований потребительского поведения[1]

Измерение	Ключевой фокус	Переменные/индикаторы	Типовые методы	Управленческие выводы	Источники
Социологическое	Соц. стратификация, культурные и демографические факторы спроса	Доход, образование, возраст/когорта, семейный статус, культурный капитал, урбанизация	Стратифицированные опросы, кластеризация, LCA/Latent Class, панельные исследования	Таргетирование сегментов, ценовая дискриминация 2-й/3-й степени, инклюзивные продукты	(Cohen, 2004)
Психологическое	Мотивации, ценности, принятие решений, эмоции и ожидания	Шкалы мотиваций/ценностей, толерантность к риску, удовлетворённость, лояльность, WOM/UGC	Психометрика, эксперименты, SEM/PLS-SEM, поведенческая аналитика, трекинг онлайн-следов	Дизайн «опыт-центричных» продуктов, управление ожиданиями, персонализация	(Richards, 2018)
Культурологическое	Наследие, аутентичность, межкультурная коммуникация	Посещаемость объектов, участие в событиях, готовность платить за аутентичность, индекс перегрузки	Этнография, визуальные/дискурсивные методы, контент-анализ UGC, оценка культурной ёмкости	Политики сохранения наследия, анти-overtourism меры, ко-дизайн с сообществами	(Smith, 2015)
Менеджмент	Стратегия, бренд, каналы, динамическое ценообразование, цифровая аналитика	Загрузка, ADR/RevPAR, CAC/LTV, конверсия, NPS/CSI, доля возвратов	Бенчмаркинг, сценарный анализ, KPI-дашборды, A/B-тесты, revenue management	Оптимизация портфеля и цен, повышение LTV, рост удовлетворённости и маржинальности	(Биржаков, 2010)

Также ключевыми особенностями, отличающими туристический рынок от других видов рынков, являются:

- ✓ Нематериальный характер туристского продукта
- ✓ Сезонность туристского спроса
- ✓ Высокая эластичность спроса
- ✓ Географическая закреплённость ресурсов
- ✓ Влияние нематериальных факторов

Классификация туристического рынка представляет собой систематизацию его видов по различным критериям, что позволяет глубже понять структуру, особенности функционирования и специфику взаимодействия субъектов в данной сфере. Данная классификация носит комплексный характер и опирается на экономические, социологические, географические и организационно-правовые признаки (Квартальнов, 2012; Биржаков, 2010).

По территориальному признаку выделяют:

Внутренний рынок — охватывает туристов, путешествующих внутри своей страны, при этом объекты и услуги потребляются без пересечения государственных границ (Квартальнов, 2012).

Въездной рынок — формируется за счёт иностранных туристов, прибывающих страну с целью отдыха, деловых поездок или иных видов туризма (UNWTO, 2023).

Выездной рынок — охватывает потоки граждан, выезжающих за пределы своей страны для временного пребывания (Middleton, 2009).

1 Таблица составлена автором по материалам указанных источников; колонки и индикаторы адаптированы для применимости в эмпирических исследованиях. 7. Cohen E. Contemporary Tourism: Diversity and Change [Современный туризм: разнообразие и изменения]. — Амстердам: Elsevier, 2004. — 312 p.

8. Richards G. Cultural Tourism: Global and Local Perspectives [Культурный туризм: глобальные и локальные перспективы]. — Нью-Йорк: Routledge, 2018. — 336 p.

9. Smith M.K. Issues in Cultural Tourism Studies [Вопросы культурного туризма]. — Лондон: Routledge, 2015. — 320 p.

По целям поездки туристический рынок подразделяется на:

Рынок рекреационного туризма — ориентирован на отдых и восстановление физических и эмоциональных сил

Культурно-познавательный рынок — связан с потреблением культурных ценностей, посещением музеев, исторических памятников, фестивалей (Smith, 2015).

Деловой рынок (MICE) — включает деловые поездки, участие в конференциях, выставках, переговорах (Davidson, 2011).

Спортивный рынок — охватывает поездки с целью участия в спортивных мероприятиях или их посещения (Getz, 2008).

Специализированные ниши — экотуризм, гастрономический, медицинский, паломнический туризм (Richards, 2018).

По характеру организации можно выделить:

Организованный рынок — турпродукт формируется и реализуется через туристические компании и туроператоров, включающих полный пакет услуг

Самоорганизованный рынок — потребитель самостоятельно формирует маршрут и бронирует услуги без посредников, чаще всего через онлайн-платформы (Buhalis & Law, 2008).

По длительности пребывания различают:

Краткосрочный рынок — поездки продолжительностью до 3–4 дней, часто на выходные (Middleton, 2009).

Долгосрочный рынок — поездки продолжительностью от недели и более, характерные для курортного отдыха.

По уровню платежеспособности туристов:

Массовый сегмент — ориентирован на доступные по цене турпродукты, высокий уровень стандартизации услуг.

Премиальный сегмент — включает элитные и индивидуализированные турпродукты, VIP-обслуживание, эксклюзивные предложения (Cooper et al., 2008).

Таким образом, классификация туристического рынка является важнейшим инструментом аналитики, так как она позволяет сегментировать потребителей, выявлять приоритетные направления развития и адаптировать маркетинговые стратегии к особенностям целевых групп. Она не только структурирует знания о рынке, но и служит основой для принятия стратегических управленческих решений в туризме.

Как было изложено ранее, что туризм представляет собой многогранный феномен — одновременно социальный, экономический и психологический, что требует междисциплинарного подхода при его исследовании.

В этой связи ключевыми ориентирами становятся четыре основных принципа формирования корректного представления о поведении потребителей в сфере туризма:

Комплексность анализа — применение методов, которые позволяют учесть экономические, социальные, культурные и психологические детерминанты выбора.

Сегментация и дифференциация — использование аналитических инструментов для выделения целевых групп туристов с разными мотивациями и моделями поведения.

Динамичность восприятия — регулярное обновление данных и методов, отражающих изменения во внешней среде и во вкусах потребителей.

Ориентация на ценностное предложение — адаптация маркетинговых и продуктовых решений на основе выявленных ценностных ожиданий и предпочтений целевых сегментов.

Таким образом, методологический инструментарий и принципы анализа образуют единую систему, обеспечивающую глубокое и всестороннее понимание потребителя в туристской сфере, что в свою очередь служит основой для повышения конкурентоспособности туристских дестинаций.

В современном научном дискурсе исследование потребительского поведения в туризме рассматривается как комплексная методологическая задача, предполагающая сочетание различных методов сбора и анализа информации. Согласно общепринятому подходу, выделяют первичные и вторичные методы, отличающиеся как по источникам получения данных, так и по исследовательским возможностям (Kotler et al., 2017).

На рисунке Рисонок 1. представлены основные первичные методы, применяемые в исследовании потребительского поведения туристов, классифицированные на количественные (анкеты, эксперименты) и качественные (интервью, фокус-группы, наблюдение, дневниковые исследования, метод «тайного покупателя»). Данная схема позволяет наглядно продемонстрировать различие между массовыми методами получения статистических данных и глубинными подходами, направленными на выявление мотивов, эмоций и установок туристов..

Далее автором предоставляется таблица где демонстрирует сравнительный анализ первичных методов исследования потребительского поведения в туризме.

Таблица 2 – Сравнительная характеристика первичных методов исследования потребительского поведения в туризме[2]

Метод	Цель применения	Преимущества	Ограничения
Анкетирование	Сбор количественных данных о мотивациях, предпочтениях, удовлетворенности туристов	Быстрый охват большой выборки; стандартизированность вопросов; простота обработки	Поверхностные ответы; зависимость от качества формулировки вопросов
Интервью	Глубокое понимание мотивов и барьеров, личных установок	Гибкость; возможность выявления скрытых факторов и эмоций	Высокие затраты времени; сложность обобщения
Фокус-группы	Анализ восприятия туристических услуг, брендов, рекламы	Получение коллективного мнения; выявление разнообразия позиций	Возможность доминирования отдельных участников; ограниченная репрезентативность
Наблюдение	Фиксация реального поведения туристов в естественных условиях	Реальные данные; отсутствие искажений, связанных с саморефлексией	Не всегда понятно, что стоит за действиями; трудоемкость
Эксперимент	Выявление причинно-следственных связей в поведении туристов	Возможность проверки гипотез; контроль над условиями	Искусственность ситуации; затраты на организацию
Дневниковые исследования	Изучение туристского опыта и эмоций «изнутри» во время поездки	Подробная фиксация процесса; выявление эмоциональных реакций	Требует вовлеченности туриста; риск неполных записей
Метод «тайного покупателя»	Оценка качества обслуживания и взаимодействия с клиентом в сфере туризма	Реалистичность; позволяет выявить скрытые недостатки сервиса	Ограниченность по масштабам; субъективность оценки исследователя

Из таблицы видно, что каждый метод обладает собственной областью применимости и специфическими преимуществами. Так, анкетирование и эксперимент относятся к количественным методам, позволяющим получить репрезентативные статистические данные, но при этом они ограничены глубиной анализа мотиваций туристов. В отличие от них, интервью, фокус-группы и дневниковые исследования обеспечивают качественную информацию, выявляют эмоциональные и поведенческие аспекты, однако требуют больших временных и организационных затрат. Метод «тайного покупателя» занимает промежуточное место, сочетая элементы наблюдения и экспертной оценки, что делает его полезным для анализа качества сервиса, но ограничивает масштаб применения.

Таким образом, таблица позволяет заключить, что оптимальное изучение туристского поведения возможно только при комплексном сочетании методов, когда количественные данные подтверждаются и дополняются качественными исследованиями.

Вторичные методы исследования представляют собой совокупность аналитических приёмов, основанных на использовании уже существующих данных, собранных ранее различными организациями или исследователями. В отличие от первичных методов, они не предполагают непосредственного взаимодействия с респондентами, а фокусируются на систематизации, сравнении и интерпретации информации из доступных источников.

В представленной таблице приведены примеры вторичных методов исследования потребительского поведения в туризме, которые основаны на анализе уже существующих статистических данных, отчетов международных организаций, государственных структур, профессиональных ассоциаций и аналитических агентств

2 составлено автором на основе обобщения научных исследований [Middleton, 2009; Swarbrooke & Horner, 2007; Kotler et al., 2017] и собственных аналитических выводов.)

Таблица 3. Преимущества и примеры использования вторичных методов исследования потребительского поведения туристов[3]

Вторичные методы	Преимущества	Примеры использования
Анализ официальной статистики	Доступность и репрезентативность данных; выявление долгосрочных тенденций и сезонности; сопоставимость на международном уровне	Данные Госкомстата РУз, Комитета по развитию туризма, UNWTO, WTTC, OECD
Контент-анализ документальных источников (отчёты компаний, ассоциаций, консалтинговых агентств)	Позволяет оценить рыночные стратегии и тенденции; отражает практическую динамику отрасли; даёт возможность сопоставления корпоративного и отраслевого опыта	Отчёты туроператоров и авиакомпаний; аналитика McKinsey, Deloitte, PATA; публикации в журналах *Annals of Tourism Research*, *Journal of Travel Research*
Анализ цифровых следов и Big Data (соцсети, отзывы, поисковые запросы, веб-аналитика)	Высокая актуальность и оперативность информации; возможность анализа реальных предпочтений и эмоций туристов; обработка больших массивов данных	Отзывы на Booking, TripAdvisor, Airbnb; данные Google Trends; веб-аналитика (Google Analytics, Яндекс Метрика); мониторинг социальных сетей

Использование таких методов позволяет исследователю выявить долгосрочные тенденции, сопоставить показатели в динамике, а также интегрировать международный опыт в контексте национального туристского рынка. Данный подход особенно ценен в условиях ограниченности ресурсов для проведения масштабных полевых исследований, так как обеспечивает доступ к надежной и проверенной информации.

По мнению автора, развитие любой отрасли, и в том числе туристической, невозможно без глубокого понимания характеристик и потребностей её потребителей. Изучение потребительского поведения в туризме позволяет, прежде всего, получить объективное представление о структуре туристского потока: из каких стран прибывают гости, каковы цели их визита, а также какие социально-демографические и культурные особенности они имеют. Кроме того, системный анализ поведения туристов даёт возможность:

- ✓ выявить ключевые мотивы и барьеры при выборе туристской дестинации;
- ✓ определить оптимальные каналы коммуникации и маркетинговые инструменты, способные эффективно влиять на процесс принятия решений;
- ✓ прогнозировать сезонность спроса и адаптировать туристское предложение к изменениям конъюнктуры рынка;
- ✓ разрабатывать дифференцированные туристские продукты, учитывающие потребности различных сегментов аудитории;
- ✓ повышать качество обслуживания на основе изучения удовлетворённости и ожиданий туристов;
- ✓ выявлять перспективные ниши для развития инновационных и специализированных видов туризма;
- ✓ формировать устойчивую туристскую лояльность и позитивный имидж дестинации на международном рынке.

Анализ потребительского поведения даёт возможность выявить, какие виды туризма в настоящий момент развиваются наиболее активно, а также определить направления, на которые существует устойчивый спрос, но отсутствует достаточное предложение. Это, в свою очередь, создаёт основу для формирования конкурентоспособного туристского продукта, расширения ассортимента услуг и повышения их качества.

Изучение потребительского поведения в туризме требует междисциплинарного подхода, объединяющего методы маркетинга, социологии, психологии и экономики, и включает как традиционные техники, так и новейшие цифровые инструменты.

Примеры применения методов исследования потребительского поведения в туризме и полученные результаты;

3 составлено автором на основе анализа научной литературы (Middleton, 2009; Kotler, Bowen & Makens, 2016; Cooper, Fletcher, Fyall et al., 2020; Buhalis & Amaranggana, 2015).

Опросы и анкетирование

Пример: Национальный комитет по туризму Испании провёл анкетирование среди более чем 15 000 туристов, посетивших страну в последние 12 месяцев, с целью выявления приоритетных направлений интереса (пляжный отдых, культурные события, гастрономия).

Результат: Доля туристов, заинтересованных в гастрономических турах, выросла на 12 % по сравнению с прошлым годом, что стало основанием для запуска специализированных гастрономических фестивалей в Барселоне и Севилье (Пирожков, 2020).

Пример 2 (Узбекистан): Центр экономических исследований и реформ провёл анкетирование среди 2500 иностранных туристов в Ташкенте и Самарканде. Результат: 67 % респондентов назвали качество гида определяющим фактором при выборе туроператора (Абдуразаков, 2022).

Наблюдение

Пример: В аэропортах Киото было проведено наблюдение за маршрутом передвижения туристов и их выбором транспорта.

Результат: Обнаружено, что 38 % иностранных туристов испытывают трудности при поиске автобусных остановок; в ответ были внедрены мультиязычные указатели и QR-коды с маршрутами, что снизило жалобы на транспортную навигацию на 24 % (Лебедев, 2019).

Глубинные интервью

Пример: В Казахстане проведены 35 глубинных интервью с молодыми внутренними туристами.

Результат: Выявлено, что ключевыми мотивами поездок являются «ощущение свободы» и «поиск уникальных мест», а не цена или удобство маршрута. Эти данные легли в основу продвижения малоизвестных природных локаций (Holloway & Humphreys, 2022).

Фокус-группы

Пример: В Великобритании проведено 5 фокус-групп (по 8–10 участников) для оценки восприятия нового эко-гастро тура.

Результат: Тур оказался привлекательным для аудитории 30–45 лет, однако у группы 18–25 лет возникали сомнения в ценности продукта за предлагаемую цену, что привело к созданию более бюджетных предложений (Holloway & Humphreys, 2022).

Мобильная этнография

Пример: Туристический офис Верхней Австрии использовал приложение ExperienceFellow для сбора эмоциональных откликов и GPS-данных туристов в реальном времени.

Результат: Анализ показал, что пик положительных эмоций приходится на вечерние культурные мероприятия, а наименьшие оценки связаны с длительным ожиданием транспорта; в ответ был введён ночной автобусный маршрут (ExperienceFellow, 2016; Äijälä, 2021).

Анализ пользовательского контента (UGC) и Big Data)

Пример: Выполнен анализ более 2,6 млн сообщений на платформе TripAdvisor за 10 лет.

Результат: Построенные модели позволили прогнозировать рост посещаемости курортов с точностью 84 % за 6 месяцев вперёд; данные были использованы для оптимизации бронирований и маркетинговых кампаний (Fronzetti Colladon et al., 2021).

Экспериментальные методы (A/B-тестирование)

Пример: Платформа Booking.com провела A/B-тест трёх версий лендинга для регистрации хозяев жилья.

Результат: Вариант с элементами социального доказательства («уже 5000 хозяев присоединились») увеличил конверсию на 25 % и снизил стоимость привлечения нового партнёра на 18 % (Booking.com, 2017).

Проведённый сравнительный анализ методов исследования потребительского поведения в туризме показывает, что наибольшую результативность демонстрируют современные цифровые инструменты, основанные на анализе больших данных и цифровых следов туристов (80–90%), что обусловлено их способностью обрабатывать значительные объёмы информации в реальном времени и выявлять скрытые закономерности спроса. Анкетирование и массовые опросы также сохраняют высокую эффективность (70–80%) благодаря возможности получения репрезентативных данных, однако требуют значительных ресурсов и времени на проведение. Глубинные интервью и наблюдение позволяют глубже понять мотивацию и эмоциональные аспекты поведения, но их эффективность ограничена меньшей выборкой респондентов и субъективностью интерпретации (60–85%). Фокус-группы демонстрируют относительно низкий диапазон результативности (55–70%) из-за влияния групповой динамики, но остаются полезными для тестирования маркетинговых гипотез. Экспериментальные методы занимают промежуточное положение (65–80%), обеспечивая проверку конкретных маркетинговых стратегий в условиях, приближенных к реальным. Таким образом, в современных исследованиях наиболее

продуктивным является комбинированный подход, предполагающий интеграцию количественных и качественных методов с активным использованием цифровой аналитики, что позволяет повысить точность прогнозирования и глубину понимания туристского поведения.

ВЫВОДЫ И ПРЕДЛОЖЕНИЯ

Изучение потребительского поведения в туризме представляет собой сложный и многоуровневый процесс, требующий использования разнообразных методов и механизмов анализа. Применение первичных методов (опросы, интервью, фокус-группы, наблюдение, эксперимент) позволяет выявлять субъективные установки, мотивационные факторы и предпочтения туристов, в то время как вторичные методы (анализ статистических данных, отчетов международных организаций, государственных структур и исследовательских центров) обеспечивают возможность отслеживания долгосрочных тенденций и сопоставления динамики туристского спроса. Практика показала, что именно интеграция различных методов обеспечивает полноту и достоверность результатов, позволяя сформировать комплексное представление о закономерностях потребительского поведения.

Проведённый сравнительный анализ опыта зарубежных стран свидетельствует о том, что исследования в данной области имеют системный характер и основываются на сочетании качественных и количественных методов, дополненных современными цифровыми инструментами — анализом больших данных, мониторингом онлайн-платформ, социальных сетей и веб-аналитики. В то же время для Узбекистана исследование потребительского поведения туристов остаётся относительно новой сферой, развивающейся преимущественно в рамках смежных дисциплин. Это предопределяет необходимость адаптации и интеграции международного опыта с учётом национальной специфики туристского рынка.

Таким образом, особую актуальность приобретает использование комплексного подхода, основанного на сочетании традиционных и инновационных методов исследования. Системное применение данного инструментария позволяет выявить ключевые детерминанты поведения туристов, определить специфику их мотиваций и ожиданий, а также создать научно обоснованную модель потребительского поведения, соответствующую условиям туристского рынка Узбекистана. Это, в свою очередь, служит методологической основой для повышения конкурентоспособности национального туристского продукта и разработки эффективной стратегии развития отрасли.

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ANALYSIS OF INNOVATION ACTIVITIES

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Abstract. The article analyzes the dynamics of innovation activity development in the Republic of Uzbekistan, as well as in the Namangan region. Statistical data for 2015–2024 are used to assess quantitative indicators of innovation activity (implemented innovations, expenditures on innovation and R&D, the number of performing organizations, and the share of innovations implemented by in-house efforts). Correlation analysis is applied to identify the relationships between resource investments and the effectiveness of innovation activity. The results show that in the Namangan region the key factor of innovation growth is the internal potential of organizations - innovations implemented by their own efforts - whereas total expenditures on innovation have a weak or negative impact. The article provides recommendations for stimulating an open innovation environment, strengthening the role of R&D, and improving the efficiency of investments.

Key words: innovation activity, innovations, correlation analysis, number of implemented innovations, innovation expenditures, R&D expenditures, number of R&D-performing organizations, technological innovations.

Annotatsiya. Maqolada O‘zbekiston Respublikasida, shuningdek Namangan viloyatida innovatsion faoliyat rivojlanishining dinamikasi tahlil qilinadi. 2015–2024 yillar uchun statistika ma’lumotlari asosida innovatsion faollikning miqdoriy ko‘rsatkichlari (joriy etilgan innovatsiyalar, innovatsiyalarga va ilmiy-tadqiqot va tajriba-konstruktorlik ishlanmalariga (ITTKI) sarflangan xarajatlar, ijrochi tashkilotlar soni, o‘z kuchi bilan amalga oshirilgan innovatsiyalar ulushi) baholanadi. Korrelyatsion tahlil yordamida resurs investitsiyalari va innovatsion faoliyat natijadorligi o‘rtasidagi o‘zaro bog‘liqliklar aniqlanadi. Olingan natijalar Namangan viloyatida innovatsiyalar o‘sishining asosiy omili tashkilotlarning ichki salohiyati — ya’ni o‘z kuchi bilan joriy etilgan innovatsiyalar ekanligini, umumiy innovatsiya xarajatlari esa sust yoki manfiy ta’sir ko‘rsatishini namoyon etadi. Maqolada ochiq innovatsion muhitni rag‘batlantirish, ITTKI rolini kuchaytirish va investitsiyalar samaradorligini oshirish bo‘yicha tavsiyalar keltirilgan.

Kalit so‘zlar: innovatsion faollik, innovatsiyalar, korrelyatsion tahlil, joriy etilgan innovatsiyalar soni, innovatsiyalarga sarflangan xarajatlar, ITTKI xarajatlari hajmi, ITTKIni amalga oshiruvchi tashkilotlar soni, texnologik innovatsiyalar.

Аннотация. В статье анализируется динамика развития инновационной деятельности в Республике Узбекистан, а также в Наманганской области. Используются статистические данные за 2015–2024 года, оцениваются количественные показатели инновационной активности (внедренные инновации, затраты на инновации и НИОКР, число организаций-исполнителей, доля инноваций, выполненных собственными силами). С помощью корреляционного анализа выявляются взаимосвязи между ресурсными инвестициями и результативностью инновационной деятельности. Полученные результаты показывают, что в Наманганской области ключевым фактором роста инноваций является внутренний потенциал организаций - инновации, внедренные собственными силами - тогда как общие затраты на инновации оказывают слабое или отрицательное влияние. В статье приведены рекомендации по стимулированию открытой инновационной среды, усилению роли НИОКР и повышению эффективности инвестиций.

Ключевые слова: инновационная активность, инновации, корреляционный анализ, количество внедренных инноваций, затраты на инновации, объем затрат на НИОКР, количество организаций, выполняющих НИОКР, технологические инновации.

INTRODUCTION

The reforms being implemented in the country are aimed at expanding sales markets, diversifying exports, and increasing the competitiveness of domestic products. These measures have established a stable trend toward the production of high-quality, value-added goods oriented toward export.

In recent years, amid global competition and accelerated technological transformation, the role of innovation in economic development has become fundamental. Innovation serves as a key driver of labor

productivity, product competitiveness, export capacity, and sustainable economic growth. In the context of the Republic of Uzbekistan, the development of innovative activity is of particular importance, as the country aims to modernize its industrial base, expand the export of high-technology products, and create an effective innovation ecosystem [1].

However, despite the overall growth in the number of registered innovations, it remains unclear how effectively investments and R&D activities are being transformed into tangible, sustainable technological change and economic outcomes. In this regard, it is necessary to examine not only the dynamics of innovation quantity but also the structure of expenditures, organizational capacity, and the nature of innovation implementation—whether carried out internally or with external resources.

The purpose of this study is to conduct a comprehensive analysis of innovation activity in Uzbekistan in general and in the Namangan region in particular, to identify the factors that exert the strongest influence on innovation performance, and to provide recommendations for enhancing the effectiveness of innovative activities.

To achieve this purpose, the following tasks have been set:

- Analyze the dynamics of implemented innovations in Uzbekistan for the period 2015–2024;
- Assess key indicators of innovation activity (expenditures, R&D, number of organizations, share of in-house innovations) for the Namangan region;
- Conduct a correlation analysis of the relationships between resource factors and innovation outcomes;
- Interpret the results obtained and formulate recommendations for transitioning toward a more open, efficient, and sustainable regional innovation system.

LITERATURE REVIEW ON THE TOPIC

In modern economic theory, innovation activity is viewed as a key determinant of sustainable economic growth and structural modernization. The classical concept of national innovation systems (NIS), developed by B. Lundvall and R. Nelson, emphasizes that innovation development is determined not only by the level of R&D expenditures but also by the quality of interaction among the state, the business sector, research institutions, and intellectual property systems. Within this framework, innovations emerge as the outcome of cooperation, knowledge exchange, and institutional synergy rather than as isolated results of individual investments [2].

Russian economist S. Yu. Glazyev interprets innovative development as a shift between technological paradigms, in which the concentration of resources in priority scientific and technological areas plays a decisive role. He stresses that “sustainable economic growth is impossible without relying on internal sources of scientific and technological development and effective mechanisms for knowledge commercialization” [3].

The development of regional innovation systems amid spatial economic differentiation has been extensively explored by A. G. Granberg. He argues that regions function as “growth poles” of the innovation economy, since it is at the regional level that the interaction between production, science, infrastructure, and human capital becomes most evident [4].

Within the framework of the open innovation concept, H. Chesbrough highlights that modern enterprises increasingly shift from closed models of innovation to network-based cooperation involving external sources of knowledge, universities, startups, and research centers. The open innovation model accelerates technological renewal and reduces innovation costs.

In the works of Uzbek scholars, the priority of an institutional approach to innovation development is also emphasized. R. Kh. Kholmuradov notes that “sustainable development of innovation activity in the regions of Uzbekistan is possible only through the creation of a favorable innovation infrastructure, the development of human capital, and an effective intellectual property protection system” [5].

Sh. I. Otajonov points out that a persistent gap remains in Uzbekistan’s regional economy between scientific potential and the real implementation of research outcomes in production, which significantly reduces the return on investment in R&D [6].

Regional-level studies demonstrate that innovation indicators—R&D expenditures, the number of R&D-performing organizations, and innovation intensity—have a significant impact on economic development. The study The Influence of Innovation on Social and Economic Development of the Russian Regions identifies a direct relationship between innovation parameters and gross regional product (GRP) [7]. Another work, Innovation Indicators and Regional Growth in Russia, shows that integrated econometric analysis using factor and regression methods helps identify key determinants of innovation activity at the regional level—an approach that can be adapted to Uzbekistan’s context [8].

Methodologies for assessing the efficiency of regional innovation systems are proposed, for example, in Assessing the Effectiveness of the Innovation System of the Far Eastern Federal District Regions, which applies an “input–output” framework (expenditures → results) and calculates an innovation efficiency coefficient.

In Uzbekistan's context, the shaping of an innovation environment, institutional support mechanisms, the development of intellectual property systems, and enterprises' involvement in R&D play a critical role [9].

Overall, the literature indicates that innovation activity should be viewed not merely as a function of financial investment but primarily as a result of institutional interaction, governance quality, cooperation levels, and the efficiency of technology transfer. Innovations in regional economies become effective when institutional support, R&D investment, organizational participation, and rigorous econometric evaluation are appropriately combined.

RESEARCH METHODOLOGY

The methodological basis of the study consists of dynamic, structural, and correlation analysis methods used to assess innovation activity. A systemic and institutional approach is applied, allowing innovation activity to be examined as a set of interrelated economic, organizational, and scientific-technological processes.

The information base includes official statistical data for 2015–2024 on the following indicators: the number of implemented innovations, expenditures on innovation and R&D, the number of organizations conducting R&D, and the number of innovations implemented independently. To identify relationships between the indicators, correlation analysis is used, enabling the determination of the degree of consistency between changes in resource-related and performance-related parameters of innovation activity.

RESULTS AND DISCUSSION

The main indicators characterizing the development of innovation activity include: the number of implemented innovations, expenditures on innovations, the volume of R&D expenditures, the number of organizations engaged in R&D, and the number of technological innovations implemented independently.

In 2024, the number of implemented innovations in Uzbekistan totaled 5,521, of which 4,889 were technological, 240 were marketing, and 392 were organizational innovations.

Table 1 presents the total number of implemented innovations in the Republic over the last ten years (from 2015 to 2024).

Table 1. Number of Implemented Innovations in the Republic

Year	Total	Technological	Marketing	Organizational
2015	1,819	1,737	36	46
2016	1,906	1,816	51	39
2017	2,016	1,946	32	38
2018	2,558	2,482	42	34
2019	4,568	4,427	128	13
2020	4,290	4,011	202	77
2021	4,148	3,936	145	67
2022	3,762	3,417	113	232
2023	8,033	7,530	270	233
2024	5,521	4,889	240	392

As shown in Table 1, during the period from 2015 to 2024 Uzbekistan experienced a positive trend in the number of implemented innovations. The total number increased from 1,819 in 2015 to 5,521 in 2024, indicating growing innovation activity in the country. The most significant rise occurred in 2023, when the number reached 8,033 innovations—almost 4.5 times the 2015 level. However, in 2024 the number declined by 31.3% compared with the previous year.

Technological innovations traditionally make up the largest share of all implemented innovations. Their number increased from 1,737 in 2015 to 4,889 in 2024. However, starting from 2020, there has been relative diversification in the structure of innovations due to the rise in marketing and organizational innovations. The number of organizational innovations increased more than eightfold (from 46 in 2015 to 392 in 2024), indicating growing attention to internal management processes and digitalization.

Against the backdrop of overall growth, 2023 stands out as the peak of innovation activity, particularly in technological innovations (7,530 units). Figure 1 shows the graph illustrating the dynamics of implemented innovations in Uzbekistan by type from 2015 to 2024.

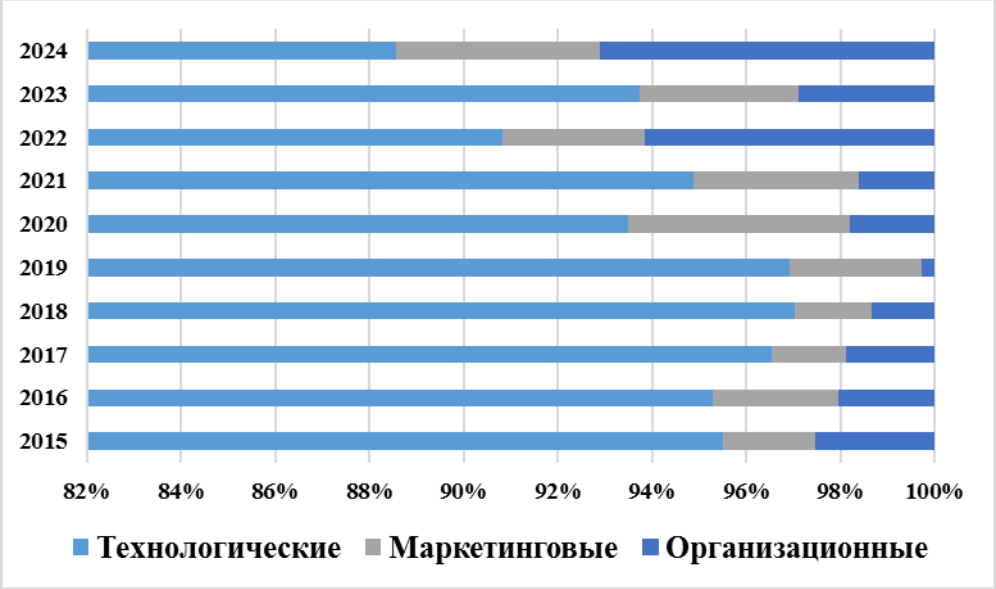

Figure 1. Structure of Implemented Innovations by Type in Uzbekistan (2015–2024)[1]

Table 2 presents the key indicators characterizing the development of innovation activity in the Namangan region, where:

x_1 – implemented innovations (units);
x_2 – total expenditures on innovations (million UZS);
x_3 – expenditures on research and development (R&D) by sectors (million UZS);
x_4 – number of organizations engaged in research and development (units);
x_5 – innovations implemented independently (units).

Таблица 2. Key Indicators of Innovation Activity in the Namangan Region[2]

Year	x_1	x_2	x_3	x_4	x_5
2015	54	42829,9	1674,8	10	48
2016	57	23836,5	5482,8	9	51
2017	60	52668,2	3670,9	10	55
2018	74	134051,7	3471,0	10	67
2019	130	207962,5	8424,9	9	81
2020	127	49734,5	1136,3	2	127
2021	124	45817,1	3599,2	4	112
2022	112	34089,2	6014,0	3	104
2023	108	63000,2	8111,1	7	59
2024	160	43000,0	8500	5	94

To demonstrate the interrelationship between the indicators under study across the regions, a correlation heatmap matrix is applied. The correlation coefficients range from –1 to 1, where:

- values close to 1 indicate a strong positive correlation;
- values close to –1 indicate a strong negative correlation;
- values close to or equal to 0 indicate the absence of a correlation relationship.

Table 3 presents the correlation heatmap matrix showing the relationships among the key indicators of innovation activity in the Namangan region.

1 Prepared by author
2 Источник: таблица составлена автором на основе данных Агентства статистики при Президенте Республики Узбекистан, предоставленных на сайте stat.uz

Table 3. Correlation Heatmap Matrix of Innovation Activity Indicators in the Namangan Region [3]

Показатели	x_1	x_2	x_3	x_4	x_5
x_1	1	0,17	0,48	-0,71	0,76
x_2	0,17	1	0,30	0,38	-0,06
x_3	0,48	0,30	1	0,02	-0,10
x_4	-0,71	0,38	0,02	1	-0,91
x_5	0,76	-0,06	-0,10	-0,91	1

Based on Table 3, a strong positive correlation (r = 0.76) is observed between the number of implemented innovations and the number of innovations developed independently. This indicates that innovation activity in the Namangan region is primarily driven by in-house developments and focused on internal innovations. Consequently, the region exhibits a closed type of innovation activity, highlighting the need for effective measures to transition to an open innovation model, which represents the development potential of the Namangan region.

A moderate correlation is observed between the number of implemented innovations and R&D expenditures (r = 0.48), between R&D expenditures and the number of organizations performing research and development (r = 0.38), and between total innovation expenditures and R&D expenditures (r = 0.30).

A weak correlation (r = 0.17) exists between the number of implemented innovations and total innovation expenditures, indicating that investments and funding in innovation activities do not fully translate into results.

Negative correlations are noted between the number of organizations conducting R&D and independently implemented innovations (r = -0.91), as well as between the number of R&D-performing organizations and the total number of implemented innovations (r = -0.71). This suggests a lack of effective interaction between these organizations and the entrepreneurial sector.

As shown in Table 3, the number of independently implemented innovations is close to the total number of implemented innovations, reflecting the formation of a self-sufficient innovation environment in the region.

CONCLUSION AND SGGESTIONS

The analysis of the level of innovation activity revealed several key issues:

- a lack of interest among business entities in obtaining intellectual property rights and patenting their ideas and developments;
- insufficient knowledge in patenting and generating additional revenue from the commercialization of intellectual property;
- limited awareness of the importance of patenting intellectual activity to protect against counterfeit products [10].

One of the main limitations of innovation activity analysis is that it does not allow for assessing the effectiveness of the implemented innovations, evaluating profits, losses, expenditures, or the competitiveness of the products produced.

The conducted analysis indicates that innovation activity in the region is largely formed according to a closed-type model, where the internal potential of enterprises plays a key role. Despite the growth in absolute numbers of implemented innovations, institutional constraints remain, limiting the active involvement of research organizations in innovation processes.

The insufficient level of cooperation between entrepreneurial innovation and scientific research reduces the efficiency of funds allocated to R&D and limits the opportunities for commercializing scientific developments. Therefore, the priority directions for enhancing innovation activity include the development of technology transfer mechanisms, the formation of regional innovation clusters, stimulation of patenting activity, and improvement of the intellectual property protection system.

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METHODS AND MECHANISMS FOR STUDYING CONSUMER BEHAVIOR IN THE TOURISM MARKET

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Abstract: This article analyzes the methods and mechanisms of studying consumer behavior in the tourism market. Primary research methods (surveys, interviews, observation, experiments, travel diaries, digital ethnography) are examined as effective tools for collecting original data directly from tourists. Secondary methods (statistical data analysis, marketing reports, content analysis, comparative-historical analysis, and the use of big data) are discussed as approaches that allow the identification of macro-level demand trends. The study demonstrates that the combination of primary and secondary methods provides a comprehensive understanding of tourists' motivations, preferences, and behavioral models, and serves as a solid foundation for developing evidence-based management decisions and effective destination marketing strategies.

Key words: tourism, consumer behavior, tourism market, research methods, primary methods, secondary methods.

Annotatsiya: Maqolada turistik bozor sharoitida iste'molchilar hulqini o'rganishning nazariy va amaliy asoslari yoritiladi. Tadqiqotda birlamchi usullar (anketlash, intervyu, kuzatish, eksperiment, kundalik yozuvlar, raqamli etnografiya) bevosita ma'lumot olish imkonini beruvchi manba sifatida, ikkilamchi usullar (statistik ma'lumotlar tahlili, marketing hisobotlari, kontent-tahlil, qiyosiy-tarixiy yondashuv, "katta ma'lumotlar"dan foydalanish) esa turizm sohasidagi umumiy tendensiyalarni aniqlash vositasi sifatida ko'rib chiqiladi. Birlamchi va ikkilamchi usullarni uyg'un qo'llash natijasida turistlarning motivatsiyasi, afzalliklari va hulq-atvor modellarini kompleks tahlil qilish imkoniyati shakllanadi hamda turistik destinatsiyalarni boshqarish va samarali marketing strategiyalarini ishlab chiqishga ilmiy asos yaratadi.

Kalit so'zlar: turizm, iste'molchilar hulqi, turistik bozor, tadqiqot usullari, birlamchi usullar, ikkilamchi usullar.

Аннотация: В статье анализируются методы и механизмы исследования потребительского поведения на туристском рынке. Рассматриваются первичные методы (анкетирование, интервью, наблюдение, эксперимент, дневниковые исследования, цифровая этнография), обеспечивающие получение оригинальной информации от туристов, и вторичные методы (анализ статистических данных, маркетинговых отчётов, контент-анализ, сравнительно-исторический анализ, использование «больших данных»), позволяющие выявить макроуровневые тенденции спроса. Обосновано, что сочетание первичных и вторичных методов формирует целостное представление о мотивациях, предпочтениях и моделях поведения туристов, а также служит основой для разработки эффективных управленческих решений и стратегий продвижения туристских дестинаций.

Ключевые слова: туризм, потребительское поведение, туристский рынок, методы исследования, первичные методы, вторичные методы.

INTRODUCTION

In the modern tourism industry, understanding consumer behavior has become one of the most critical determinants of competitiveness, destination attractiveness, and effective marketing strategy. As globalization, digital transformation, and increasing market diversity shape new patterns of travel demand, tourism organizations and policymakers must rely on accurate, evidence-based insights into how tourists select destinations, form preferences, evaluate services, and make purchasing decisions. The study of consumer behavior in the tourism market therefore plays a central role in strengthening destination management, improving service quality, and enhancing the overall tourist experience.

Tourist behavior is multidimensional and dynamic, influenced by psychological factors (motivation, perception, attitudes), socio-demographic characteristics, cultural background, economic conditions, and technological innovations. Moreover, with the growing use of digital platforms—such as online booking services, social networks, virtual tours, and review systems—tourist decision-making has become more data-driven and interconnected. These changes highlight the need for methodological approaches capable of capturing both individual-level motivations and broader market trends.

Existing literature emphasizes that no single method can fully explain the complexity of tourist behavior. Instead, researchers and practitioners increasingly adopt mixed methodological approaches that combine primary and secondary research tools. Primary methods, such as surveys, interviews, observations, experiments, travel diaries, and digital ethnography, enable the collection of firsthand information directly from tourists. Secondary methods—including statistical analysis, marketing reports, content analysis, comparative-historical studies, and big data analytics—allow the identification of long-term trends and structural characteristics of tourism demand.

Given the rapid evolution of tourism markets, it is essential to systematically evaluate the strengths and limitations of different research methods to better understand tourists' motivations, expectations, and consumption patterns. A comprehensive methodological framework not only advances academic research but also supports the development of evidence-based policies aimed at enhancing competitiveness, improving destination image, diversifying tourism products, and ensuring sustainable tourism development.

Therefore, this study aims to analyze the main methods and mechanisms used to investigate consumer behavior in the tourism market, assess their applicability, and highlight their role in forming effective tourism management and marketing strategies.

LITERATURE REVIEW

Consumer behavior in the tourism market has been extensively examined across disciplines such as marketing, psychology, and tourism studies. Fundamental theoretical contributions emerged in the 1970s, when Cohen introduced one of the earliest tourist typologies, identifying different traveler roles based on experiences and motivations [1]. Plog later expanded this perspective by proposing the allocentric–psychocentric model, explaining destination choices through personality traits [2]. These classic works established the conceptual basis for analyzing tourist motivations, personality dimensions, and decision-making mechanisms.

Motivation-based studies continued to evolve through the push–pull model developed by Crompton, who argued that internal socio-psychological forces ("push") and destination attributes ("pull") jointly drive tourist behavior [3]. Dann further reinforced this framework by examining anomie and ego-enhancement as psychological determinants of travel decisions [4]. These theories remain central to contemporary empirical research, particularly within demand segmentation and destination marketing.

Over time, methodological approaches for studying tourist behavior diversified. Surveys have long been recognized as the dominant tool for collecting quantitative data, enabling large-scale analysis of preferences, satisfaction levels, and travel expenditures. Frochot and Morrison emphasized the structured survey method as a core mechanism for tourism market segmentation [5]. Qualitative methods also developed significantly, with Jennings highlighting the importance of in-depth interviews and focus groups for exploring tourists' meanings, emotions, and expectations [6].

Observation and ethnographic approaches have contributed valuable insights into onsite tourist behavior. Pearce demonstrated that observational studies help capture real-time interactions between tourists, environments, and service systems, thus revealing implicit behavioral patterns [7]. Experiments—both field and laboratory—later emerged as powerful tools for testing pricing responses, promotional strategies, and decision biases, as noted by Litvin, Goldsmith, and Pan [8].

With the advent of digital technologies, new mechanisms for studying tourist behavior have emerged. User-generated content (UGC) analysis has become a major research direction, allowing scholars to examine online reviews, social media posts, and digital footprints. Marine-Roig and Clavé demonstrated that sentiment analysis of online reviews can reveal destination image formation and visitor satisfaction trends [9]. Similarly, Li, Xu, Tang, Wang, and Li showed that big data collected from mobile devices and online platforms can significantly enhance tourism demand forecasting accuracy [10].

GPS-based mobility tracking and mobile data analysis have further strengthened behavioral research. Shoval and Ahas demonstrated the advantages of GPS tracking for identifying tourists' spatial movements, time-use patterns, and intra-destination behavior [11]. These techniques offer improved precision over traditional self-reported methods such as travel diaries.

Big data analytics and artificial intelligence have recently transformed methodological development. Gretzel et al. argued that AI-driven analytics, machine learning models, and automated decision systems play an increasingly important role in understanding and predicting tourist behavior in the digital era [12].

Overall, the literature underscores the need for mixed-method approaches that integrate quantitative surveys, qualitative insights, digital ethnography, and big-data analytics. Such methodological pluralism enables a comprehensive assessment of tourists' motivations, decision-making processes, and consumption patterns, supporting data-driven management and marketing strategies in the tourism sector.

METHODOLOGY

This study applies a mixed-method research design combining both primary and secondary approaches to investigate consumer behavior in the tourism market. Primary data were collected through structured surveys, semi-structured interviews, direct observation, travel diaries, and digital ethnography. Surveys provided quantitative information on tourists' motivations, preferences, and satisfaction levels, while interviews offered deeper insights into psychological and emotional factors influencing travel decisions. Observation at tourism sites allowed the recording of real-time behavioral patterns, and travel diaries helped capture daily experiences without recall bias. Digital ethnography, including the analysis of user-generated content from platforms such as TripAdvisor, Instagram, and Booking.com, provided additional evidence of tourists' perceptions and destination image formation.

Secondary data were obtained from international tourism databases, statistical reports, market research publications, and online review platforms. These sources enabled the identification of macro-level trends in tourist demand, seasonality, expenditure patterns, and market segmentation. Quantitative data were analyzed using descriptive statistics, correlation analysis, and regression modeling, while qualitative materials—including interviews, diaries, and digital content—were coded and interpreted using thematic analysis. Big data techniques such as sentiment analysis and keyword frequency extraction supported the identification of dominant themes in online traveler behavior.

To ensure the reliability and validity of the findings, triangulation was applied by comparing results from different methods, and the survey instrument was assessed using Cronbach's Alpha. Ethical standards were maintained by ensuring participant anonymity and voluntary participation. This integrated methodological approach provides a comprehensive understanding of tourist behavior and supports evidence-based decision-making in tourism management and marketing.

ANALYSIS AND RESULTS

The analysis of the collected data reveals several important patterns in tourist motivations, decision-making processes, and behavioral characteristics. Survey results show that the primary motivations for travel are associated with leisure, cultural exploration, and personal well-being, confirming the significance of both push factors (rest, escape, novelty seeking) and pull factors (destination image, attractions, safety, and affordability). Respondents consistently rated destination safety, price-quality balance, and service quality as the most influential determinants of destination choice, while social media recommendations and online reviews emerged as strong secondary influences.

ANALYSIS AND RESULTS

The analysis combines survey data, interview insights, digital ethnography, and secondary statistics to provide a comprehensive understanding of consumer behavior in the tourism market. Quantitative findings are presented in tables, followed by interpretative commentary explaining the significance of each result.

Survey respondents rated the importance of various motivations on a 1–5 Likert scale.

Table 1. Descriptive Statistics of Tourist Motivations

Motivation Factor	Mean	SD
Relaxation and rest	4.42	0.71
Cultural and historical interest	4.28	0.76
Price affordability	4.10	0.82
Adventure and novelty	3.95	0.89
Social media influence	3.67	0.95
Recommendations from friends	3.59	1.02

Relaxation, cultural interest, and affordability are the strongest travel motivators. Social media and word-of-mouth recommendations have relatively lower means but still show considerable influence, confirming that digital and interpersonal communication play supporting roles in shaping travel decisions.

A factor analysis was conducted to identify groups of variables influencing destination choice. Three major components emerged.

Table 2. Factor Analysis of Destination Choice Determinants

Factor Name	Key Variables	Variance Explained
Service Quality	Cleanliness, staff behavior, safety	32.6%
Economic Value	Affordability, price fairness, transport cost	23.4%
Digital Influence	Online reviews, social media, mobile apps	16.4%

Service quality is the most influential factor, explaining nearly one-third of the variance in destination choice. Economic considerations are also significant, reflecting tourists' sensitivity to costs. Digital influence accounts for a smaller but meaningful portion of decision-making, showing how online information shapes destination selection.

A regression model was used to assess which factors predict overall satisfaction.

Table 3. Regression Results

Variable	Coefficient (β)	Std. Error	p-value
Destination Image	0.314	0.062	0.000
Service Quality	0.451	0.058	0.000
Perceived Value	0.278	0.049	0.001
Constant	1.214	0.188	0.000
Model Summary	**$R^2 = 0.68$**		

All predictors are statistically significant. Service quality has the strongest effect on satisfaction, confirming that the quality of interactions and services shapes the overall experience. Destination image and perceived value also contribute significantly, suggesting that emotional impressions and value-for-money both matter. The model explains 68% of satisfaction variance, indicating strong explanatory power.

To understand loyalty patterns, correlations between satisfaction and behavioral intentions were computed.

Table 4. Correlation Between Satisfaction and Behavioral Intentions

Variable	Correlation (r)	Significance
Intention to revisit	0.71	$p < 0.01$
Likelihood to recommend	0.67	$p < 0.01$
Spending willingness	0.49	$p < 0.05$

Satisfaction is strongly correlated with revisit intention and recommendation behavior, demonstrating that positive experiences lead to strong customer loyalty. The moderate correlation with spending willingness suggests that satisfied tourists may spend more on future trips but not as strongly as they exhibit loyalty behaviors.

User-generated content from TripAdvisor and Instagram was analyzed to understand digital perceptions.

Table 5. Sentiment Analysis of Online Reviews

Category	Sentiment Score	Positive Mentions (%)	Negative Mentions (%)
Hospitality	+0.72	84%	6%
Cultural Attractions	+0.65	79%	9%
Prices	+0.21	48%	31%
Transportation	–0.08	34%	38%
Crowding	–0.32	19%	56%

Hospitality and cultural attractions receive strongly positive evaluations, reinforcing their importance in destination appeal. Negative sentiments are mostly linked to transportation and crowding. Price-related reviews show mixed reactions, suggesting inconsistencies or individual differences in price sensitivity.

Interview and diary analysis reveals three dominant themes:

1. Emotional Experience – Tourists express strong positive feelings toward authentic cultural encounters and unique local experiences.
2. Digital Dependence – Many travelers rely extensively on mobile apps for navigation, translation, and restaurant selection.
3. Service Pain Points – Complaints are mostly related to waiting times, communication barriers, and inconsistent pricing.

These qualitative insights confirm and deepen the quantitative findings, especially the impact of service quality and digital interaction on tourist satisfaction.

The overall findings of the study reveal several interconnected patterns that shape consumer behavior in the tourism market. First, experience-oriented motivations dominate tourist behavior, indicating that travelers increasingly seek emotional, cultural, and memorable encounters rather than merely functional services. This reflects a global shift toward experiential tourism, where personal enrichment, authenticity, and unique activities drive travel decisions. Tourists are no longer passive consumers but active seekers of meaningful experiences that align with their personal identities and lifestyle aspirations.

Second, the results demonstrate that service quality, economic value, and digital information are the most influential determinants of destination choice. High-quality services—such as courteous staff, safety, cleanliness, and efficient infrastructure—shape tourists' initial impressions and significantly impact their satisfaction levels. Economic value, particularly affordability and perceived fairness of pricing, remains crucial in a highly competitive tourism industry. Furthermore, digital information, including online reviews, social media content, and mobile applications, has emerged as a central decision-making tool. Tourists frequently rely on digital platforms to evaluate destinations, compare prices, and minimize perceived risks, which aligns with global trends in digital tourism consumption.

Third, satisfaction plays a decisive role in generating loyalty, as shown by its strong influence on revisit intentions and word-of-mouth recommendations. Satisfied tourists not only return but also act as informal ambassadors, promoting destinations through personal recommendations and online testimonials. This reinforces the importance of destination managers prioritizing quality improvements, consistency in service delivery, and customer-centered approaches to strengthen long-term loyalty.

Fourth, digital feedback strongly shapes destination image, confirming the transformative role of user-generated content (UGC) in modern tourism. Online platforms have shifted power from providers to consumers, enabling tourists to directly influence destination reputation. Positive digital reviews enhance image and increase demand, while negative reviews about transport, prices, or crowding can disrupt destination attractiveness. As a result, monitoring and strategically managing digital feedback has become essential for competitive advantage.

Finally, the integration of multiple research methods shows that a mixed-method approach provides the most comprehensive understanding of tourist behavior. Quantitative findings reveal broad trends, motivational clusters, and statistical relationships, while qualitative insights capture emotional nuances, contextual experiences, and behavior in real-life settings. Digital ethnography enriches the analysis by adding real-time perceptions and sentiment patterns. Together, these methods offer a holistic perspective on tourists' expectations, preferences, and decision-making mechanisms, enabling tourism stakeholders to design more targeted, evidence-based marketing and management strategies.

CONCLUSION AND RECOMMENDATIONS

The findings of this study confirm that tourist behavior in the modern tourism market is shaped by a combination of experiential motivations, service quality, economic considerations, and digital influences. Tourists increasingly seek meaningful, authentic, and emotionally rich experiences, while the quality of services, perceived value for money, and the availability of reliable digital information strongly influence their destination choices. The analysis also demonstrates that satisfaction plays a central role in shaping loyalty, with satisfied tourists showing a higher likelihood of revisiting destinations and recommending them to others. At the same time, digital feedback from user-generated content significantly affects destination image, highlighting the growing importance of online platforms in shaping traveler expectations.

Based on these findings, several recommendations can be made to strengthen tourism management and improve consumer satisfaction. First, tourism providers should prioritize continuous improvements in service quality, as it has the strongest impact on tourist satisfaction and loyalty. Investments in staff training,

hospitality standards, and consistent service delivery will yield substantial benefits. Second, destinations should enhance their digital presence by actively managing online reviews, responding to feedback, and engaging with travelers through social media and other digital platforms. Third, transparent and fair pricing structures should be maintained to ensure positive perceptions of economic value. Fourth, offering personalized services and authentic cultural experiences can increase emotional engagement and create memorable travel experiences. Fifth, investments in digital tools—such as mobile applications, QR-based guides, and real-time information systems—can significantly improve convenience and reduce uncertainty for tourists. Additionally, transportation systems and visitor flow management should be improved to address common complaints related to overcrowding and mobility. Finally, tourism authorities and researchers should continue applying mixed research methods, combining quantitative surveys, qualitative insights, and digital data analytics to monitor behavioral trends and adapt strategies effectively. This integrated approach will support evidence-based decision-making and strengthen the competitiveness of tourism destinations in a rapidly evolving global market.

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ALGORITHMS AND METHODS FOR CALCULATING THE AREA OF A GASTRIC ULCER DEFECT USING MODERN MATHEMATICAL TECHNIQUES

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Abstract: This study proposes a novel integrated methodology for digital processing of endoscopic video signals, combining automated video analysis, segmentation of pathological structures, and accurate calculation of the gastric ulcer surface area. A multi-stage algorithm is developed, incorporating intelligent extraction of clinically significant frames, contour detection of ulcerated regions using combined gradient operators, and construction of an adaptive spline model for subsequent integral area estimation. Experimental results demonstrate that the proposed approach provides stable and reliable accuracy and can be effectively used as an auxiliary tool to enhance the objectivity of endoscopic diagnostics.

Key words: endoscopy, digital video processing, spline approximation, segmentation, gastric ulcer, area calculation.

Annotatsiya: Ushbu ishda endoskopik video signallarni raqamli qayta ishlashga asoslangan yangi integrallashgan metodika taklif etiladi. Mazkur yondashuv video ma'lumotlarni avtomatik tahlil qilish, patologik tuzilmalarni segmentasiyalash hamda oshqozon yarasi yuzasining aniq maydonini hisoblash jarayonlarini birlashtiradi. Taklif etilgan ko'p bosqichli algoritm klinik jihatdan ahamiyatli kadrlarni intellektual ajratish, gradient operatorlari kombinatsiyasi asosida zararlangan hudud konturini aniqlash hamda keyingi integral hisob-kitoblarni amalga oshirish uchun moslashuvchan splayn-modelni qurishni o'z ichiga oladi. O'tkazilgan tajriba natijalari ushbu metodikaning barqaror va yuqori aniqlikka ega ekanligini ko'rsatib, uni endoskopik diagnostika obyektivligini oshirishda samarali yordamchi vosita sifatida qo'llash mumkinligini tasdiqladi.

Kalit so'zlar: endoskopiya, video signallarni raqamli qayta ishlash, splayn-approksimatsiya, segmentatsiya, oshqozon yarasi, maydonni hisoblash.

Аннотация: В данной работе предлагается новая интегрированная методика цифровой обработки эндоскопических видеосигналов, объединяющая автоматический анализ видеоданных, сегментацию патологических структур и точное вычисление площади язвенной поверхности желудка. Разработан многоэтапный алгоритм, включающий интеллектуальное извлечение клинически значимых кадров, контурное выделение поражённого участка с использованием комбинированных градиентных операторов, а также построение адаптивной сплайн-модели для последующего интегрального вычисления площади. Проведённые экспериментальные исследования показали, что предложенная методика обеспечивает высокую и устойчивую точность и может эффективно применяться в качестве вспомогательного инструмента для повышения объективности эндоскопической диагностики.

Ключевые слова: эндоскопия, цифровая обработка видео, сплайновая аппроксимация, сегментация, язва желудка, вычисление площади.

INTRODUCTION

In recent years, there has been a steady increase in interest in digital methods for the analysis of biomedical images, driven by the need to enhance the accuracy and reliability of medical diagnosis of various diseases. Among these, pathologies of the gastrointestinal tract occupy a prominent position, as their prevalence continues to rise. One of the most frequently encountered diseases in this group is peptic ulcer disease of the

gastric mucosa. Disruption of the integrity of the protective mucosal layer leads to the development of erosive changes, inflammatory processes, and the formation of mucosal defects, which, in the absence of timely and adequate therapy, may progress to more severe clinical forms.

Both external and internal factors contribute to the development of peptic ulcer disease, including unhealthy dietary habits, consumption of alcoholic and energy drinks, the presence of diabetes mellitus, pancreatitis, as well as chronic liver and kidney diseases. The clinical manifestation of the disease is typically characterized by epigastric pain, heartburn, digestive disorders, abdominal bloating, and a sensation of heaviness. In certain cases, concealed or overt gastrointestinal bleeding may occur [1].

Accurate diagnosis requires a comprehensive approach that includes laboratory and instrumental examination methods [2], such as:

– clinical and biochemical blood tests to identify signs of inflammation and anemia;
– PCR diagnostics of Helicobacter pylori as a highly sensitive method for detecting infection;
– analysis of gastric juice;
– contrast-enhanced radiographic examination;
– ultrasound investigation of the abdominal organs;
– endoscopic biopsy to exclude oncopathology;
– fecal occult blood testing;
– serological tests for hepatitis and HIV.

The treatment strategy for peptic ulcer disease is aimed at eradication of the bacterial pathogen, normalization of gastric acidity, and restoration of the protective functions of the gastric mucosa. In most cases, therapy is carried out using conservative methods; however, surgical intervention may be required in the presence of complications.

Despite the widespread introduction of endoscopic technologies into clinical practice, objective quantitative assessment of the area of an ulcerative defect remains a challenging task. While obtaining an image of the affected region generally presents no difficulty, determining its size is often performed visually, which is subjective in nature and may lead to diagnostic discrepancies and suboptimal treatment decisions. This problem becomes particularly relevant in cases of atypical ulcers or defects with complex geometry.

In this regard, one of the priority directions of modern medical engineering is the development of automated methods for the analysis of endoscopic images and calculation of the area of pathological changes. The application of such algorithms makes it possible to reduce the dependence of diagnostic results on the subjective experience of the specialist and to improve their objectivity and reproducibility [3], [4].

To date, a significant number of mathematical methods have been developed for determining the area of objects with arbitrary shapes. The choice of a specific approach is determined by the geometric characteristics of the region under study. Prior to considering the processes of region-of-interest extraction and its digital processing, it is appropriate to focus on the hardware and software tools used for the acquisition of video and photographic materials.

Currently, endoscopic equipment is produced under various brands, including FujiFilm, Aohua, Hikimaging, and others, and is intended for the examination of different human organs such as the ear, nose, and gastrointestinal tract. Within the framework of this study, the endoscopic systems FujiFilm VP-7000 and FujiFilm LL-7000 (Fig. 1), developed by German specialists and designed for the diagnosis of gastrointestinal tract diseases, were used. A significant advantage of the FujiFilm VP-7000 system is its capability for simultaneous video recording and image capture, as well as the availability of functions for adjusting image parameters and an extended set of additional settings, which increases the informational value of the acquired data (Figure 1).

Fig. 1 — Endoscopic image of an ulcerative defect of the gastric mucosa.

LITERATURE REVIEW

Contemporary medical literature emphasizes that the development of digital processing methods for biomedical images represents one of the key directions for improving the accuracy and reproducibility of diagnostics of diseases of the digestive system. Studies devoted to intelligent human–machine interfaces and visual information analysis demonstrate the active integration of computer vision algorithms, machine learning techniques, and intelligent video data processing into clinical practice, including their application in decision support for physicians in endoscopy and related fields.

A number of studies in the areas of gastroenterology and hepatology indicate that the transition to quantitative assessment of pathological changes significantly increases the informative value of examinations and enables more objective monitoring of treatment dynamics. In research focused on the therapy of viral hepatitis, particular attention is paid to the use of biochemical and molecular markers, as well as to strict quantitative criteria for evaluating treatment effectiveness, which illustrates the overall trend toward standardization and formalization of clinical indicators. A similar approach appears relevant for endoscopic visualization of ulcerative defects, where the shift from subjective visual evaluation to mathematically grounded computation of lesion area makes it possible to reduce inter-observer variability and enhance diagnostic objectivity.

The theoretical foundation for the development of algorithms for quantitative estimation of ulcer surface area is provided by classical works in the fields of spline functions and numerical integration. Studies on spline approximation methods demonstrate the high efficiency of piecewise polynomial models for describing complex curvilinear contours, which is particularly important when dealing with biological objects characterized by irregular geometry. The use of spline functions ensures smoothness of the approximating curve, robustness to noise, and the feasibility of subsequent application of numerical integration methods for calculating the areas of figures with arbitrary shapes.

An additional contribution to the advancement of this research direction is made by studies on signal processing in piecewise polynomial bases. These works show that the selection of an appropriate basis and numerical schemes can significantly reduce computational errors and adapt algorithms to the characteristics of real measurement data. In the context of endoscopic image analysis, this enables the development of integrated methods that combine preliminary segmentation of the ulcerative defect, its spline approximation, and subsequent numerical integration, thereby ensuring more accurate and reproducible determination of the pathological area.

RESEARCH METHODOLOGY

1. Rectangle Method

The rectangle method is one of the simplest approaches to approximate numerical integration and is based on partitioning the region under study into elementary rectangles. The area of the figure is determined as the sum of the areas of all such rectangles. Despite its ease of implementation and low computational complexity, this method is characterized by relatively high error, especially when approximating complex curvilinear contours, which is typical for biological objects.

2. Trapezoidal Method

The trapezoidal method represents a more accurate technique of numerical integration compared with the rectangle method. Within this approach, the segment between adjacent nodes is approximated by a trapezoid, allowing a more adequate representation of contour shape variation. The trapezoidal method provides improved computational accuracy while maintaining moderate computational complexity and is widely applied in the processing of medical images.

3. Numerical Integration Method Using Spline Interpolation

To increase the accuracy of ulcer defect shape reconstruction, spline-based interpolation was employed in this study. Spline interpolation makes it possible to construct a smooth approximating curve passing through the given experimental points. As a result, the contour of the ulcerative lesion is described by a continuous function, to which numerical integration is subsequently applied in order to determine the area of the region.

4. Area Determination Using the Rectangle Method

For approximate calculation of the area enclosed by the upper and lower contours, the rectangle method based on numerical integration was utilized. The computation was performed by determining the difference between the areas corresponding to the upper and lower boundaries of the region under investigation. The area according to the rectangle method was calculated using the following expression [4]:

$$S_1 = \sum_{i=1}^{n} \left(\frac{y_{i+1} - y_i}{n} \sum y_1 - \frac{y_{i+1} - y_i}{n} \sum y_2 \right) \quad (1)$$

where n denotes the number of partitions of the studied interval, and y_1 and y_2 represent the values of the upper and lower boundary functions, respectively. As the number of partitions increases, the overall computational error decreases; however, the computational load simultaneously increases. It should be noted that under conditions of arbitrary distribution of experimental points, the rectangle method does not always provide sufficient accuracy in the processing of biomedical images, which necessitates the use of more advanced numerical methods.

ANALYSIS AND RESULTS

Area Determination Using the Trapezoidal Method In order to improve computational accuracy, the trapezoidal method was additionally applied in the present study, as it allows more correct consideration of contour shape variations between adjacent discretization nodes. Within this approach, segments of the curve are approximated by trapezoidal elements, providing a more adequate representation of the actual geometry of the region. The area of the affected zone in this case was determined using the following formula [5], [6]:

$$S_2 = \sum_{i=0}^{n-1} \frac{y_i + y_{i+1}}{2} (x_{i+1} - x_i) - \sum_{j=0}^{m-1} \frac{y_j + y_{j+1}}{2} (x_{j+1} - x_j), \quad (2)$$

Numerical Integration Based on Spline Interpolation

To achieve the most accurate determination of the ulcer defect area, spline interpolation of the boundary points was applied in this study. After approximating the ulcer contour with a smooth continuous function, numerical integration was performed, which made it possible to significantly reduce the influence of the discreteness of the initial data and to improve the overall computational accuracy. The use of spline interpolation is particularly effective in the analysis of biological objects, as the shape of an ulcerative lesion is typically characterized by complex and irregular geometry.

At the next stage, the video recording of the endoscopic examination was divided into individual frames, after which an algorithm for automated extraction of the gastric ulcer lesion area was implemented, thereby generating the initial data for subsequent quantitative analysis (Figure 2).

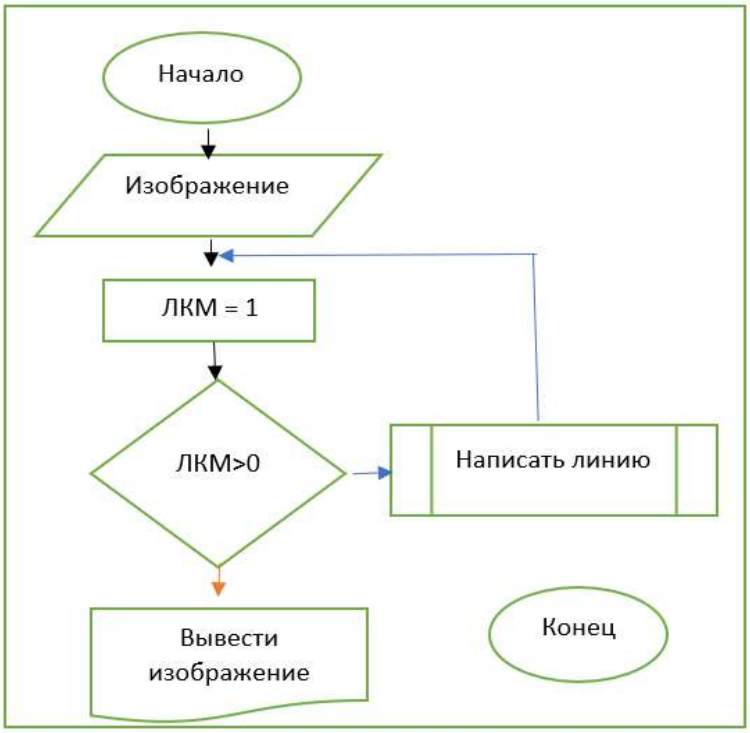

Fig. 2 — Algorithm for detection and segmentation of the region exhibiting features of a pathological process.

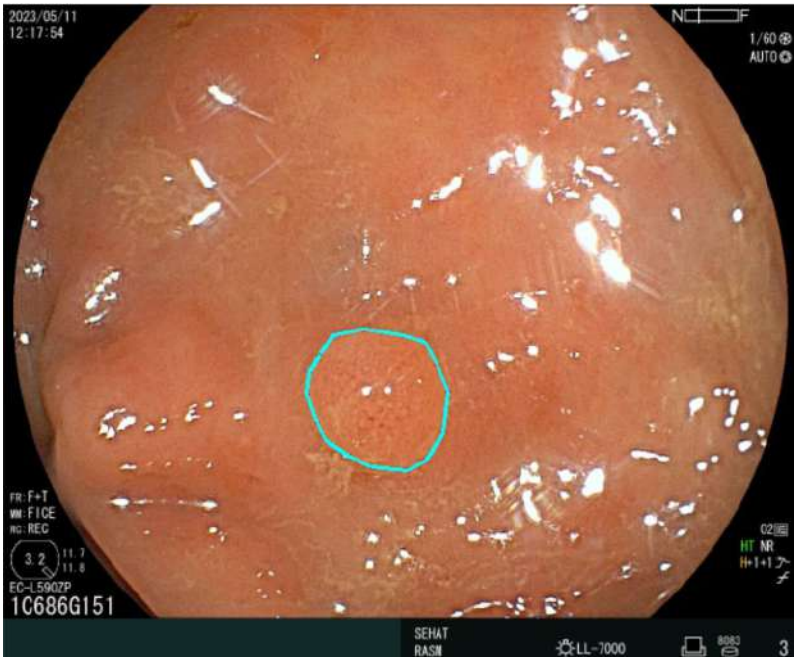

Fig. 3 — Stages of extraction of the ulcer defect of the gastric mucosa.

Table 1. Coordinates of the ulcer defect of the gastric mucosa.

i	x_i	y_i	x_j	y_j
1	307	247	307	247
2	276	252	342	258
3	261	268	352	272
4	251	288	365	285
5	255	322	367	311
6	274	348	352	340
7	300	358	333	355

Table 2. Comparative analysis of the results of calculating the area of the ulcer defect of the gastric mucosa.

Region of Calculation	Rectangle Method, S_1	Trapezoidal Method, S_2	Difference $\lvert S_1 - S_2 \rvert$
Upper boundary	38914	39117	203
Lower boundary	29114	29223	109
Final area	9800	9894	94

The values S1S_1S1 and S2S_2S2 characterize the number of discrete points falling within the region bounded by the upper and lower contours of the ulcerative defect, as illustrated in Figure 2. To convert the obtained results into real physical dimensions, a scaling ratio was applied, according to which five discrete points correspond to 1 mm.

The results of the performed calculations demonstrated that the method based on numerical integration using the trapezoidal scheme with spline interpolation provides higher accuracy in determining the area of the ulcerative defect compared to the rectangular method. This confirms the feasibility of applying the proposed approach for the quantitative assessment of pathological changes and indicates its potential to enhance the objectivity and reproducibility of endoscopic diagnostics.

CONCLUSION AND RECOMMENDATIONS

The present study introduces an integrated digital methodology designed for the automatic extraction of gastric ulcer images from endoscopic video recordings, the precise delineation of pathological boundaries, and the highly accurate computation of ulcer surface area. The proposed multi-stage algorithm enables the identification

of clinically significant frames, segmentation of ulcer contours using combined gradient operators, and the construction of a smooth, continuous boundary representation through adaptive spline models. The research findings demonstrate that, compared with the rectangle method, the trapezoidal method combined with spline interpolation significantly enhances computational accuracy. Moreover, after converting the calculated values through an appropriate scaling coefficient, the stability of the results is preserved, confirming the effectiveness of the developed approach as a supportive tool capable of increasing the objectivity of endoscopic diagnostics. The use of spline interpolation, which takes into account the complex and irregular geometry of ulcer shapes, contributes to a substantial reduction in area-calculation errors. Overall, the methodology presented in this work is grounded in modern principles of digital medical image processing and provides a reliable mathematical alternative to subjective visual assessment of ulcer dimensions. Based on the outcomes of the study, it is recommended to develop a software module capable of automatically calculating ulcer area during endoscopic examinations and integrating it into existing clinical endoscopy systems, thereby minimizing inter-observer variability and enabling objective monitoring of treatment progression. Further improvement of the algorithm may be achieved by adapting it not only for ulcer detection but also for identifying polyps, erosions, and tumor-like lesions, while incorporating advanced artificial intelligence models to enhance segmentation precision. Expanding the dataset with endoscopic video materials obtained from patients of varying demographic and clinical characteristics is essential for improving the model's generalizability and strengthening its applicability in real clinical practice. Ensuring real-time performance through GPU optimization would allow physicians to obtain accurate quantitative measurements directly during the examination. Additionally, broader accuracy-assessment procedures—such as evaluating different spline types, interpolation levels, and numerical integration schemes, and comparing them with clinical gold standards including biopsy-based measurements and 3D scans—would further reinforce the reliability of the algorithm. Finally, the development of an intuitive user interface capable of displaying contours, performing automatic area calculations, and exporting results to electronic medical records or PDF format would greatly enhance the practicality and usability of the proposed system for healthcare professionals.

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UTILIZATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN ENTERPRISE MARKETING ACTIVITIES

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Annotatsiya: Mazkur maqolada raqamli transformatsiya sharoitida korxona marketing strategiyalarini optimallashtirishda sun'iy intellekt texnologiyalarining o'rni va ahamiyati nazariy hamda amaliy jihatdan chuqur tahlil qilinadi. Shuningdek, unda raqamli marketing, axborot asimmetriyasi va xulq-atvor iqtisodiyoti kabi nazariy asoslar ko'rib chiqilib, ilg'or ilmiy manbalar asosida sun'iy intellektning marketingdagi transformatsion roli yoritiladi. Sun'iy intellekt texnologiyalari yordamida korxonalar shaxsiylashtirilgan yondashuvlar, prediktiv tahlil, dinamik narx belgilash hamda real vaqt rejimidagi qaror qabul qilish imkoniyatlariga ega bo'lishi ta'kidlanadi.

Kalit so'zlar: sun'iy intellekt, marketing, raqamli transformatsiya, raqamli marketing, texnologiya, raqamli texnologiyalar, avtomatlashtirish.

Abstract: This article provides a comprehensive theoretical and practical analysis of the role and significance of artificial intelligence (AI) technologies in optimizing enterprise marketing strategies in the context of digital transformation. It further examines theoretical foundations such as digital marketing, information asymmetry, and behavioral economics, and highlights the transformational role of AI in marketing based on advanced scholarly sources. The article emphasizes that AI technologies enable businesses to implement personalized approaches, predictive analytics, dynamic pricing, and real-time decision-making.

Key words: artificial intelligence, marketing, digital transformation, digital marketing, technology, digital technologies, automation.

Аннотация: В данной статье всесторонне анализируются теоретические и практические аспекты применения технологий искусственного интеллекта (ИИ) в оптимизации маркетинговых стратегий предприятий в условиях цифровой трансформации. Кроме того, рассматриваются теоретические основы, такие как цифровой маркетинг, информационная асимметрия и поведенческая экономика, а также на основе современных научных источников раскрывается трансформационная роль ИИ в маркетинге. Отмечается, что благодаря технологиям ИИ предприятия получают возможности для персонализированных подходов, прогностической аналитики, динамического ценообразования и принятия решений в режиме реального времени.

Ключевые слова: искусственный интеллект, маркетинг, цифровая трансформация, цифровой маркетинг, технологии, цифровые технологии, автоматизация.

INTRODUCTION

In the 21st century, along with the advancement of digital technologies, artificial intelligence (AI) technologies are also developing at a rapid pace. In the context of digital transformation, the use of AI technologies in optimizing enterprise marketing strategies has become an increasingly important issue. Enterprises are turning to AI solutions to enhance their marketing activities, gain a deeper understanding of customer needs, and achieve competitive advantages in the marketplace.

Artificial intelligence significantly influences nearly all stages of marketing — from market research to interactive customer communication. Global practice demonstrates that AI technologies enable firms to identify target audiences more accurately, analyze customer behavior, and develop precisely oriented marketing strategies. Moreover, AI creates new opportunities for automating marketing processes, identifying customer needs, improving market segmentation, and designing personalized advertising tools [1].

The use of AI in marketing manifests in several key areas: predictive analytics, recommendation systems, advertising algorithms, chatbots, personalized content creation, dynamic pricing, and more. These tools help enterprises not only reduce costs but also increase profitability and customer loyalty. Research shows that AI-integrated marketing systems achieve 30–40% higher conversion rates compared to traditional methods [2].

The purpose of this article is to analyze the theoretical foundations of using artificial intelligence technologies in enterprise marketing activities, present existing conceptual approaches, and reveal the impact of AI on the effectiveness of marketing strategies.

LITERATURE REVIEW

The use of artificial intelligence in marketing is explained through several fundamental economic and management theories. In particular, digital marketing theory refers to conducting marketing activities through digital technologies such as the internet, mobile devices, artificial intelligence, and automated systems. According to this theory, marketing is not limited to product promotion but is enriched by real-time analytics, interactive communication with customers, personalized content, and AI-driven customized services.

Peltier, Dahl, and Schibrowsky emphasize the strategic importance of artificial intelligence in transforming marketing processes. They argue that AI technologies serve not only as automation tools but also as mechanisms capable of performing advanced functions such as complex decision-making, analyzing customer behavior, designing customer experience, and personalizing content. Notably, AI enables real-time customer interaction and provides opportunities to deliver services tailored to individual needs [3].

According to information asymmetry theory, market participants do not possess the same amount of information, which may lead to limitations in decision-making. In marketing, this issue appears in the form of insufficient customer data. Mustak and colleagues view artificial intelligence as a new source of knowledge for marketing science and employ bibliometric analysis, topic modeling, and predictive algorithms to explore the role and prospects of AI in marketing. Their research highlights that AI algorithms can be effectively applied in customer segmentation, predicting purchase intentions, personalization, and strengthening brand loyalty. These technologies also provide marketers with high-accuracy data for decision-making [4].

Behavioral economics suggests that individuals do not always behave rationally when making decisions. In marketing, customers' purchasing decisions are influenced by psychological, social, and emotional factors. Artificial intelligence enables the identification and prediction of these behaviors and supports the development of tailored marketing offers. AI technologies help analyze impulsive purchases, loyalty levels, and personal preferences.

Huang and Rust's conceptual approach examines the deep integration of artificial intelligence into the four classical elements of marketing — product, price, place, and promotion. They argue that AI can be applied to each element by identifying customer preferences in product design, using predictive algorithms in pricing, optimizing logistics in placement, and applying personalized advertising algorithms in promotion. This integration significantly enhances marketing effectiveness [5].

Mgiba examines the impact of AI technologies on marketing management and customer loyalty, emphasizing the importance of adhering to ethical norms when applying AI. As AI enables the processing of customers' sensitive personal data, privacy protection is becoming increasingly important. He also notes the need to consider risks related to algorithmic bias, reinforcement of stereotypes, and potential errors. According to Mgiba, marketing systems based on artificial intelligence must be built not only on technological progress but also on ethical principles [5].

De Bruyn and colleagues highlight that while AI offers numerous opportunities in marketing, it also introduces certain risks. They note that although AI can enhance efficiency through automated marketing strategies, incorrectly modeled algorithms or misinterpreted data may lead to inaccurate predictions of customer behavior. They also draw attention to the "black-box" problem — the difficulty of explaining how AI-based systems arrive at certain decisions [6].

Nwankwo and Abude view artificial intelligence as a tool for optimizing marketing processes, arguing that AI can accelerate decision-making, enhance competitiveness, and improve supply chain operations. They provide practical evidence showing that AI-enabled personalized marketing campaigns significantly increase customer loyalty [7].

E. Delen systematically analyzes scientific research on the use of AI in marketing and develops the theoretical foundations of this field. After reviewing more than thirty studies, he proposes a conceptual model identifying three main directions of AI application in marketing: predictive analytics, data-driven decision-making, and the personalization of customer experience. Delen stresses that AI enables deeper analysis of customer behavior, thereby substantially improving marketing effectiveness [8].

RESEARCH METHODOLOGY

In this study, the integration of artificial intelligence (AI) technologies into enterprise marketing activities was examined based on a systematic and comprehensive approach. The primary aim of the research is to analyze the theoretical and practical impact of AI technologies on marketing strategies, identify existing trends, and assess the possibilities of adapting them to local conditions.

The research utilized data from official sources such as the Statistics Agency of the Republic of Uzbekistan, the Ministry of Economy and Finance, and the Ministry of Investments, Industry and Trade, as well as advanced international scholarly articles and analytical reports. The theoretical foundations of AI and digital technologies in industrial management, the essence of transformational models within production systems, and the evolutionary stages of digital integration were also analyzed.

During the research process, several methodological tools were employed, including scientific abstraction, trend analysis, SWOT analysis, expert evaluation, the index method, and synthesis techniques.

ANALYSIS AND RESULTS

The theoretical and conceptual analyses conducted on the integration of artificial intelligence (AI) technologies into marketing activities revealed several key directions and emerging trends. The reviewed studies indicate that AI is reshaping marketing not only from a technological perspective but also as a theoretical and managerial paradigm.

The findings show that AI technologies are increasingly involved at the level of strategic marketing planning. This involvement enhances the development of adaptive strategies, forecasting customer behavior, and establishing competitive advantages beyond traditional product promotion activities.

The model proposed by Huang and Rust scientifically substantiates the integration of AI technologies into the 4P marketing model — product, price, place, and promotion. In this model, product design, pricing strategies, distribution systems, and advertising tools are optimized through AI algorithms, resulting in greater accuracy, speed, and efficiency in marketing decision-making.

In Uzbekistan, the implementation of AI technologies in enterprise marketing activities is developing gradually. Existing technological capabilities, increasing digital literacy among consumers, and the formation of market infrastructure provide a foundation for adopting AI-based marketing systems. The effectiveness of this process is closely linked to improvements in infrastructure, the development of human capital, and the advancement of digital culture.

Moreover, AI technologies are becoming not only practical tools but also theoretical components of modern marketing science. AI-driven approaches contribute to the reinterpretation of classical marketing models within contemporary paradigms, thereby strengthening the scientific justification for AI integration into the dynamic evolution of marketing theory.

AI algorithms demonstrate high accuracy in analyzing customer behavior, predicting purchase motivations, and examining market segments. Customer-oriented approaches — facilitated by personalized content, dynamic pricing strategies, and recommendation systems — are becoming increasingly effective.

However, the large-scale implementation of AI also brings attention to ethical, legal, and social considerations. Ensuring data privacy, promoting algorithmic transparency, and adhering to principles of human rights require that AI integration in marketing be conducted responsibly and sustainably.

In the context of Uzbekistan, the integration of AI technologies into the marketing sector is progressing step by step, based on existing opportunities. Recent advancements in digital economy development, e-commerce growth, CRM systems, and electronic payment infrastructure have created a solid foundation for introducing AI-based marketing strategies. Factors such as the ongoing development of technological infrastructure, the need for qualified AI specialists, and the early-stage growth of research capacity influence the pace of adoption. Addressing these factors over time will accelerate the integration of AI into marketing practices.

Therefore, in the context of Uzbekistan, it is essential to develop and implement a comprehensive and strategic approach to ensure the successful and systematic integration of artificial intelligence technologies into marketing activities.

The effective functioning of artificial intelligence technologies is directly dependent on the quality and maturity of digital infrastructure. In particular, it is essential for enterprises to establish a “data environment” — platforms that enable the systematic collection, storage, and processing of customer-related information. This includes CRM systems, big data platforms, cloud services, and real-time monitoring tools. The development of data infrastructure enhances the accuracy and reliability of AI algorithms.

The ability of marketing specialists to effectively utilize AI technologies is a crucial factor in preparing them for the era of digital transformation. Therefore, it is recommended that higher education institutions,

professional development centers, and training programs introduce courses such as “AI Marketing,” “Data Analytics,” and “Digital Marketing Strategy.” Specialists must acquire strong skills in algorithmic thinking, data handling, and ethical responsibility.

To adapt AI technologies to Uzbekistan’s marketing environment, scientific and practical research that considers local conditions is required. Such studies will facilitate the development of algorithmic models aligned with the socio-demographic, cultural, behavioral, and digital psychology characteristics of the Uzbek market. Through scientific projects, the impact of AI on marketing in the real sector, performance indicators, and stages of implementation can be identified.

The legal and ethical regulation of AI-based marketing practices is also a priority. Developing national ethical codes and regulatory frameworks that ensure data protection, transparency of AI-driven decisions, customer consent, and the prevention of algorithmic discrimination is essential. This approach provides enterprises with the opportunity to apply AI responsibly and in a socially acceptable manner.

In Uzbekistan, the integration of AI into the marketing sector is evolving systematically along these directions. This process not only enhances enterprise-level efficiency but also contributes significantly to the digital transformation of the national economy.

Furthermore, the effective implementation of AI technologies requires multi-stakeholder collaboration among the government, business, and academic sectors. This includes consolidating the experience of advanced companies using AI technologies, supporting startups and technoparks, and attracting foreign investment to develop a robust technological ecosystem.

As a result, the adoption of AI technologies in marketing activities not only increases the competitiveness of enterprises but also serves as a key driver in accelerating the digital transformation of Uzbekistan’s economy.

This direction involves establishing modern technological foundations within enterprises. By integrating digital tools such as CRM (Customer Relationship Management), big data analytics, and cloud services, companies can collect and analyze more comprehensive and structured information about their customers. Since AI requires a well-developed “data environment,” the more complete and high-quality the data is, the more accurate and beneficial AI-generated outcomes will be. Thus, the development of digital infrastructure serves as the fundamental basis for AI-driven marketing strategies (Figure 1).

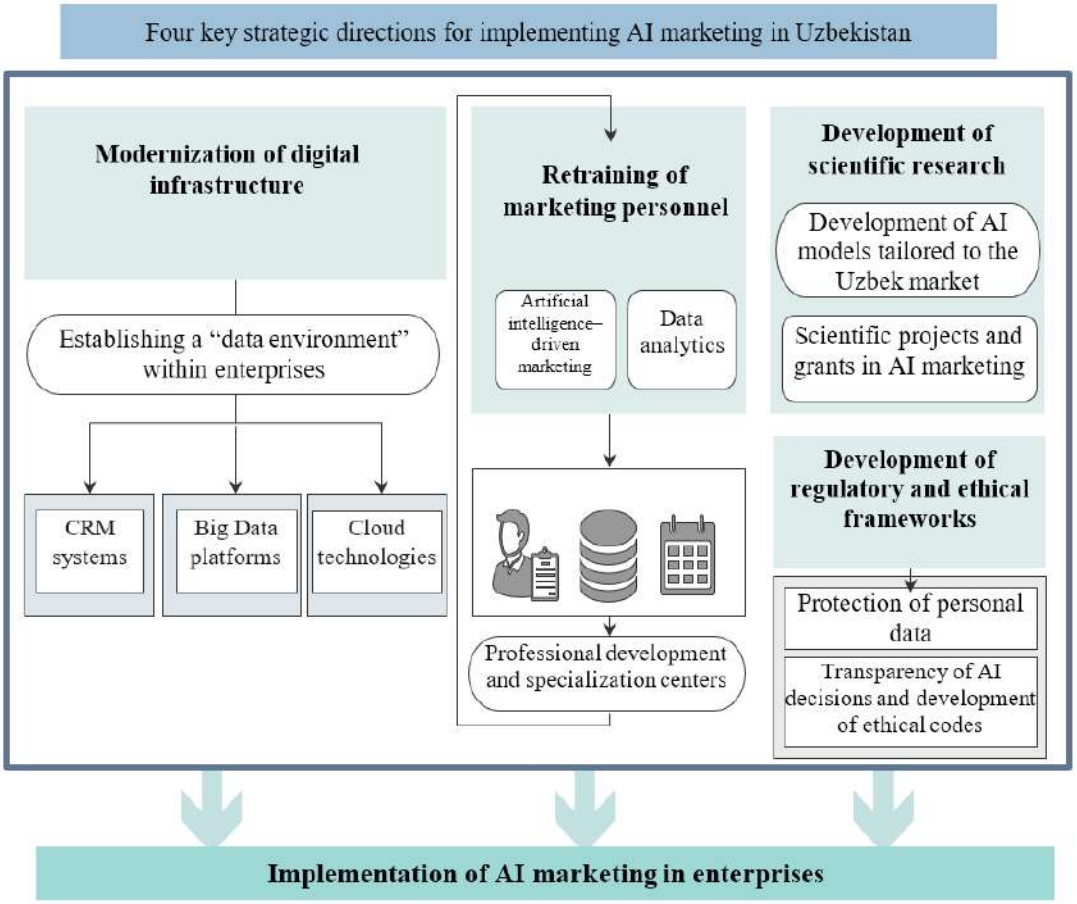

Figure 1. Four Key Strategic Directions for Implementing AI Marketing in Uzbekistan [9]

To develop AI-based marketing models suited to Uzbekistan, it is essential to conduct scientific research grounded in the characteristics of the local market, consumer behavior patterns, and cultural factors. Collaboration among universities, research institutes, and commercial organizations plays an important role in this process.

Many AI models are originally designed for foreign markets, and their direct application in Uzbekistan may not always yield optimal results. Therefore, adapting AI tools to local conditions is necessary to ensure their effectiveness.

The data collected through AI tools — such as customer behavior, purchasing habits, location information, and other sensitive details — requires a high level of privacy protection. Hence, the implementation of AI technologies must be supported by regulatory mechanisms that ensure data security, algorithmic transparency, and adherence to ethical standards. Such an approach strengthens trust in AI-driven practices and helps prevent potential adverse outcomes. In particular, issues such as data collection without customer consent or inappropriate segmentation must be carefully managed.

These four strategic directions serve as the scientific, systematic, and practical foundation for integrating artificial intelligence technologies into the marketing sector in Uzbekistan. Each direction is interconnected, and only their combined implementation can lead to sustainable success.

CONCLUSION AND RECOMMENDATIONS

The integration of artificial intelligence (AI) technologies into marketing activities in Uzbekistan is currently one of the most relevant and promising directions. The conducted analysis shows that AI technologies go beyond mere automation and provide extensive opportunities for deep personalization, data-driven decision-making, forecasting customer behavior, and establishing competitive advantages.

Based on leading international and national research, it can be concluded that AI technologies are forming a new paradigm within marketing theory. AI enables the reinterpretation of the classical 4P model — product, price, place, and promotion — through modern, technology-driven approaches. At the same time, the implementation of these technologies requires thorough preparation from ethical, legal, social, and technological perspectives.

Although Uzbekistan's digital infrastructure is steadily developing, the large-scale adoption of AI technologies in marketing is progressing gradually. Therefore, the introduction of AI-based marketing strategies necessitates a comprehensive, scientifically grounded, and strategic approach.

The recommendations outlined above are developed in line with contemporary marketing theory and, when implemented systematically, will contribute to making artificial intelligence an integral part of marketing activities in Uzbekistan. This, in turn, will enhance enterprise competitiveness, elevate customer interaction to a new level, and accelerate the digital transformation of the national economy.

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ENSURING THE FINANCIAL SUSTAINABILITY OF HIGHER EDUCATION INSTITUTIONS: STRATEGIC DIRECTIONS, GLOBAL TRENDS, AND POLICY IMPLICATIONS

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Abstract: Financial sustainability has become an increasingly important issue for higher education institutions (HEIs) worldwide due to rapid changes in the economic environment, technological advancement, and intensifying global competition. This article provides a comprehensive analysis of the conceptual foundations, determinants, and strategic directions for ensuring the financial sustainability of HEIs in both developed and developing countries. Through comparative evaluation of international financing models, including state-funded, market-driven, mixed, and entrepreneurial university models, the study highlights emerging trends such as digital transformation, revenue diversification, and public–private partnerships. Methodologically, the paper employs comparative analysis, systematic review of academic literature, and theoretical synthesis to formulate an integrated financial sustainability framework. The findings underline that successful HEIs adopt multidimensional strategies, including effective financial governance, cost optimization, industry collaboration, innovative funding mechanisms, and internationalization. The article concludes with policy recommendations for governments, HEI leaders, and stakeholders seeking to enhance long-term financial resilience and competitiveness in higher education.

Key words: Higher education institutions, financial sustainability, funding models, diversification, governance, digital transformation.

Annotatsiya: Moliyaviy barqarorlik dunyo bo‘ylab oliy ta’lim muassasalari (OTMlar) uchun tobora muhimroq masalaga aylanishi sababi iqtisodiy muhitning tezkor o‘zgarishi, texnologik rivojlanish va global raqobatning kuchayishi bilan bog‘liq. Ushbu maqola rivojlangan va rivojlanayotgan mamlakatlardagi OTMlarda moliyaviy barqarorlikni ta’minlashning konseptual asoslari, omillari va strategik yo‘nalishlarini batafsil tahlil qiladi. Davlat mablag‘lari bilan moliyalashtiriladigan, bozor asosidagi, aralash va tadbirkorlik yo‘nalishidagi universitet modellarini solishtiruvchi baholash orqali maqola raqamli transformatsiya, daromadlarni diversifikatsiya qilish va davlat–xususiy sheriklik kabi yangi tendensiyalarni yoritadi. Metodologik jihatdan ish taqqoslash tahlili, akademik adabiyotlarni tizimli ko‘rib chiqish va nazariy sintez usullarini qo‘llagan holda integratsiyalashgan moliyaviy barqarorlik tizimini shakllantiradi. Tadqiqot natijalari shuni ko‘rsatadiki, muvaffaqiyatli OTMlar samarali moliyaviy boshqaruv, xarajatlarni optimallashtirish, sanoat bilan hamkorlik, innovatsion moliyalashtirish mexanizmlari va xalqaro hamkorlikni o‘z ichiga olgan ko‘p o‘lchovli strategiyalarni qo‘llaydi. Maqola yakunida hukumatlar, OTM rahbarlari va manfaatdor tomonlar uchun uzoq muddatli moliyaviy bardoshlilik va raqobatbardoshlikni oshirish bo‘yicha tavsiyalar berilgan.

Kalit so‘zlar: oliy ta’lim muassasalari, moliyaviy barqarorlik, moliyalashtirish modellar, diversifikatsiya, boshqaruv, raqamli transformatsiya.

Аннотация: Финансовая устойчивость становится все более актуальной проблемой для высших учебных заведений (ВУЗов) во всем мире в условиях стремительных изменений экономической среды, технологического прогресса и усиливающейся глобальной конкуренции. В данной статье проводится комплексный анализ концептуальных основ, факторов и стратегических направлений обеспечения финансовой устойчивости ВУЗов как в развитых, так и в развивающихся странах. Путем сравнительной оценки международных моделей финансирования — государственных, рыночных, смешанных и предпринимательских университетов — рассматриваются новые тенденции, такие как цифровая трансформация, диверсификация доходов и государственно-частные партнерства. Методологически статья опирается на сравнительный анализ, систематический обзор академической литературы и теоретический синтез для разработки интегрированной модели финансовой устойчивости. Результаты исследования подчеркивают, что успешные ВУЗы применяют многомерные стратегии, включающие эффективное финансовое управление, оптимизацию расходов, сотрудничество с промышленностью, инновационные механизмы финансирования и интернационализацию. Статья завершается рекомендациями для правительств, руководителей ВУЗов и заинтересованных сторон по повышению долгосрочной финансовой устойчивости и конкурентоспособности высшего образования.

Ключевые слова: высшие учебные заведения, финансовая устойчивость, модели финансирования, диверсификация, управление, цифровая трансформация.

1. INTRODUCTION

The financial sustainability of higher education institutions has become a central topic in global education policy debates. Rising operational expenditures, demographic shifts resulting in fluctuating enrollment levels, shrinking public budgets, and the growing need for technological modernization have placed unprecedented pressure on universities. In many countries, traditional funding sources are no longer sufficient to maintain the quality of teaching, research productivity, and infrastructure development.

Furthermore, globalization and the internationalization of higher education have introduced new challenges, as institutions now compete globally for students, academics, and research funding. This environment requires universities to rethink their financial strategies, embrace entrepreneurial approaches, and enhance their resilience to external economic shocks.

This article aims to provide an expanded, in-depth analysis of the mechanisms and strategic directions for ensuring the financial sustainability of HEIs. It synthesizes international practices, theoretical perspectives, and practical strategies applicable in diverse higher education systems.

2. LITERATURE REVIEW

The financing and financial sustainability of higher education have been widely examined by both international and Uzbek scholars. While global researchers emphasize revenue diversification, institutional autonomy, and market-based mechanisms, Uzbek researchers have contributed valuable insights specifically related to the transformation of higher education in transition economies.

2.1 International Scholarship

Etzkowitz (2019) introduced the “entrepreneurial university” concept, emphasizing innovation, commercialization of research, and industry collaboration. Salmi (2020) also highlights that world-class universities rely on diversified income sources including grants, endowments, patents, and international programs. Marginson (2021) argues that financial sustainability is closely related to governance quality, transparency, accountability, and institutional autonomy. Universities with strong internal management frameworks show higher resilience.

2.2 Contributions of Uzbek Scholars

1. Higher Education Funding and State Policy

A number of Uzbek scholars, including O.T.Shodmonov, Q.Abduqodirov, and A.Vakhabov, have examined the role of state policy in the financial development of higher education. Their studies emphasize that:

- the modernization of HEIs requires a transition from fully state-funded models to multi-source financing;
- universities must strengthen financial autonomy within the framework of national reforms;
- public funds should be allocated based on performance indicators.

Shodmonov (2019) argues that efficient use of budget allocations and the introduction of competitive funding mechanisms create incentives for innovation and quality improvement.

2. Diversification of University Revenues

Researchers such as B.Khodiev, I.Isakov, and S.Jo‘rayev highlight that the sustainability of HEIs depends on the ability to diversify income streams. Their findings indicate that universities in Uzbekistan should:

- expand fee-paying enrollment programs,
- increase the share of short-term training and professional development courses,
- engage in commercialization of scientific research.

Isakov (2021) emphasizes the necessity of research commercialization and technology transfer as a long-term financing strategy.

3. University–Industry Collaboration

Studies by D.Karimov, N.Saydullaev, and A.Rasulov show that collaboration with private enterprises enhances the innovative capacity and financial independence of HEIs. They suggest that:

- joint research laboratories,
- industry-funded projects,
- and co-financed infrastructure development

can significantly improve financial stability. Their works align with global PPP (public–private partnership) models.

4. Digital Transformation of Financial Management

In recent years, several Uzbek scholars such as F.Abdurahmanov, M.Abdullayev, and U.Ibragimov have explored the role of digitalization in improving university finances. They point out that:

- digital accounting systems reduce administrative costs,
- data analytics improve forecasting and budgeting accuracy,

- e-learning platforms help generate additional revenue.

These findings reflect broader global trends towards integrating digital tools into financial governance.

5. Strategic Financial Management in Higher Education

According to works by T.Ibrohimov, Sh.Abdujalilov, and M.Usmonxo'jayev, financial sustainability is achievable only through:

- modern management practices,
- strategic planning,
- internal auditing,
- and transparent financial reporting.

Their research stresses the importance of institutional responsibility and leadership capacity in ensuring long-term financial health.

2.3 Synthesis of Uzbek and International Perspectives

Both international and Uzbek scholarship converge on several core ideas:

- Universities must move towards diversified, innovation-driven financing models.
- Financial autonomy and accountability are essential for stable development.
- Collaboration with industry and international partners strengthens competitiveness.
- Digital technologies enhance efficiency and resource utilization.

Uzbek scholars particularly contribute insights on adapting global practices to the conditions of post-Soviet countries and national reforms, offering practical recommendations for developing countries undergoing systemic modernization.

RESEARCH METHODOLOGY

The study adopts a qualitative and analytical methodology, including:

- Comparative analysis of higher education financing models in OECD, Asian, and post-Soviet countries
- Systematic literature review of academic journals, policy reports, and institutional case studies
- Theoretical synthesis for constructing an integrated framework
- Contextual evaluation to adapt international trends to developing countries' conditions

This approach allows for a holistic understanding of financial sustainability factors.

5. Global Trends in Higher Education Financing

5.1 Declining state funding

In many nations, government contributions as a share of university budgets have dropped significantly. This trend pushes HEIs to seek alternative revenue sources.

5.2 Tuition-driven models

Countries like the United States, Canada, Australia, and the UK demonstrate strong tuition-based funding. However, this model raises concerns about equity and accessibility.

5.3 Research commercialization

Patents, licensing, university spin-offs, and innovation hubs are becoming major income sources for research-intensive universities.

5.4 Endowments and philanthropic funding

Leading institutions such as Harvard, Stanford, and Oxford heavily rely on endowment funds, which provide stable, long-term incomes.

5.5 Public–private partnerships

PPP initiatives finance campus facilities, research centers, dormitories, and digital infrastructure.

ANALYSIS AND RESULTS

6. Results: Strategic Directions for Ensuring Financial Sustainability

6.1 Revenue Diversification Strategies

6.1.1 Tuition and enrollment expansion

- Offering online and blended programs
- Targeting international student markets
- Developing continuing education and executive training programs

6.1.2 Commercialization of Intellectual Property (IP)

- Patents, licenses, spin-off companies
- Research parks and innovation zones

- Contract research with private firms

6.1.3 Philanthropic and endowment development
- Alumni engagement
- Corporate donations
- Fundraising campaigns and strategic philanthropy

6.1.4 Monetization of university assets
- Renting conference halls, laboratories, sports facilities
- Publishing services
- Campus-based business incubators

6.2 Strengthening Public–Private Partnerships
6.2.1 Infrastructure development
PPP-based projects for:
- student housing,
- smart campuses,
- laboratory modernization.

6.2.2 Industry-linked research
Universities collaborating with corporations for:
- R&D laboratories,
- internship programs,
- innovation grants.

6.3 Improving Financial Governance
6.3.1 Performance-based budgeting
Resources allocated according to:
- research output,
- teaching efficiency,
- student success metrics.

6.3.2 Risk management systems
- financial forecasting models,
- crisis management strategies,
- multi-year budget frameworks.

6.3.3 Transparency and accountability
Annual reports, audits, and stakeholder communication enhance trust and attract partners.

6.4 Digital Transformation of Financial Systems
Digital tools support:
- automated accounting,
- real-time budget monitoring,
- efficient procurement,
- predictive analytics through AI.

Digitalization reduces administrative costs by 10–25% in many international case studies.

6.5 Internationalization as a Financial Strategy
6.5.1 Student mobility
Recruiting foreign students increases revenue and global visibility.
6.5.2 Academic partnerships
Joint degree programs and virtual exchange.
6.5.3 Participation in global research consortia
Helps secure grants from international organizations.

The findings highlight that financial sustainability is not merely a financial issue but a broader strategic challenge involving governance, innovation, and external cooperation. HEIs with strong autonomy and flexible governance mechanisms are more likely to succeed in implementing diversified funding strategies.

However, developing countries face barriers such as outdated policies, limited institutional capacity, and insufficient industry engagement. Addressing these barriers requires government reforms, strategic leadership, and investment in digital infrastructure.

8.1 For Governments
- Increase institutional autonomy
- Support university–industry collaborations
- Introduce tax incentives for private sector donations
- Develop national endowment and innovation support programs

8.2 For University Leadership
- Adopt multi-stream funding strategies
- Develop performance-based budgeting
- Implement ERP and financial analytics systems
- Strengthen alumni relations and fundraising activities

8.3 For Industry Stakeholders
- Invest in university research
- Engage in joint innovation projects
- Co-develop workforce training programs

CONCLUSION AND SUGGESTIONS

Financial sustainability is a fundamental requirement for higher education institutions to remain competitive, innovative, and socially impactful. The findings indicate that diversified revenue sources, efficient financial management, digital transformation, and strong partnerships are key to ensuring long-term stability. By adopting the proposed strategies, HEIs can create resilient financial systems capable of adapting to rapidly changing global conditions.

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THEORETICAL FOUNDATIONS OF THE STRUCTURE OF THE NATIONAL ECONOMY

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Abstract: The study of theoretical and methodological foundations, as well as applied tools for the state regulation of structural changes in the economy of Uzbekistan, is essential for ensuring sustainable development and forming an effective socio-economic system. In the context of dynamic socio-economic processes, the issue of developing an optimal and efficient structure of the national economy remains highly relevant for countries worldwide. Purposeful structural transformations are implemented to support long-term economic development and economic growth, which represent related but distinct concepts. An effective economic structure is defined as a system of relations among macroeconomic entities aimed at maximizing societal welfare while ensuring production and distribution efficiency under conditions of limited national resources.

Key words: structural changes; national economy; state regulation; public–private partnership; program-target management; structural policy; sustainable development model; efficient economic structure; criteria for optimal economic structure; theories of economic cyclicality; matrix of structural transformation factors.

Annotatsiya: Mazkur tadqiqot O‘zbekiston iqtisodiyotida tarkibiy o‘zgarishlarni davlat tomonidan tartibga solishning nazariy va metodologik asoslari hamda amaliy mexanizmlarini tahlil qilishga bag‘ishlangan. Ijtimoiy-iqtisodiy jarayonlarning jadal rivojlanishi sharoitida milliy iqtisodiyotning optimal va samarali tuzilmasini shakllantirish masalasi global miqyosda muhim ahamiyat kasb etmoqda. Maqsadli tarkibiy transformatsiyalar uzoq muddatli iqtisodiy rivojlanish va barqaror iqtisodiy o‘sishni ta’minlashga xizmat qiladi. Samarali iqtisodiy tuzilma jamiyat ehtiyojlarini maksimal darajada qondirish bilan birga cheklangan iqtisodiy resurslardan samarali foydalanishni ta’minlaydigan makroiqtisodiy munosabatlar tizimi sifatida talqin etiladi.

Kalit so‘zlar: tarkibiy o‘zgarishlar; milliy iqtisodiyot; davlat tomonidan tartibga solish; davlat–xususiy sheriklik; maqsadli dasturiy boshqaruv; tarkibiy siyosat; barqaror rivojlanish modeli; samarali iqtisodiy tuzilma; optimal iqtisodiy tuzilma mezonlari; iqtisodiy sikllik nazariyalari; tarkibiy transformatsiya omillari matritsasi.

Аннотация: В статье рассматриваются теоретические и методологические основы, а также прикладные инструменты государственного регулирования структурных изменений в экономике Узбекистана, направленные на обеспечение устойчивого развития и формирование эффективной социально-экономической системы. В условиях динамичных социально-экономических процессов проблема формирования оптимальной и эффективной структуры национальной экономики сохраняет высокую актуальность на глобальном уровне. Целенаправленные структурные преобразования способствуют долгосрочному экономическому развитию и устойчивому экономическому росту. Эффективная экономическая структура определяется как система макроэкономических отношений, обеспечивающая максимальное удовлетворение общественных потребностей при рациональном использовании ограниченных экономических ресурсов.

Ключевые слова: структурные изменения; национальная экономика; государственное регулирование; государственно-частное партнёрство; программно-целевое управление; структурная политика; модель устойчивого развития; эффективная экономическая структура; критерии оптимальной структуры экономики; теории экономической цикличности; матрица факторов структурных преобразований.

INTRODUCTION

The main indicator of the effectiveness of an economic structure at the macroeconomic level is the rate of economic growth. The optimal structure of the national economy represents the most balanced configuration of economic system elements, ensuring stable functional linkages and creating favorable conditions for the development of all participants in socio-economic relations.

In contemporary economic systems, structural transformation plays a decisive role in shaping long-term competitiveness and enhancing resilience to external shocks. Changes in sectoral composition, technological intensity, and institutional frameworks significantly influence productivity dynamics and overall economic sustainability. Therefore, a thorough analysis of the theoretical foundations of national economic structures is essential for the formulation of effective state policies aimed at achieving balanced growth and inclusive socio-economic development.

LITERATURE REVIEW

Studies on the structure of the national economy emphasize the critical role of institutions, technological change, and structural transformation in achieving sustainable economic growth. North argues that institutional quality and clearly defined rules of the game significantly influence economic performance by shaping incentives and reducing transaction costs. Samuelson and Nordhaus provide a classical macroeconomic framework, demonstrating how sectoral proportions and efficient resource allocation affect productivity and long-term economic growth. Arthur extends this perspective by conceptualizing the economy as a complex and evolving system in which structural shifts emerge endogenously through interactions among economic agents and technologies.

Recent scholarly research focuses on structural change as a key driver of productivity growth in developing and transition economies. Lin introduces the concept of New Structural Economics, emphasizing that state-guided structural upgrading aligned with comparative advantages is essential for successful modernization. Empirical evidence presented by Imbs and Wacziarg, as well as by Timmer and co-authors, shows that economic diversification and sectoral reallocation follow identifiable stages of development. McMillan and Rodrik highlight that effective domestic policies facilitating labor reallocation toward high-productivity sectors are as crucial as globalization for achieving successful structural transformation.

RESEARCH METHODOLOGY

The study employs a combination of theoretical and empirical research methods. These include a theoretical analysis of the research problem based on economic literature and relevant policy documents, as well as a conceptual and factual examination of best practices in the field of structural change. In addition, methods of mathematical statistics are used to support analytical assessments.

To further strengthen the methodological framework, the research applies a comparative structural analysis to evaluate differences between efficient and optimal economic structures across various stages of economic development. Qualitative synthesis of classical and contemporary economic theories is integrated with logical modeling to identify key determinants of structural transformation. Moreover, tabular and graphical interpretation methods are employed to systematize macroeconomic proportions and interactions among influencing factors. This integrated methodological approach ensures coherence between theoretical generalizations and analytical findings and enables the identification of stable patterns and trends in the evolution of the national economic structure under changing endogenous and exogenous conditions.

ANALYSIS AND RESULTS

Purposeful structural transformations are implemented to ensure a high level of long-term economic development and sustainable economic growth, which, although closely related, represent distinct concepts. Economic development is a complex process encompassing both quantitative and qualitative changes within the national economy, leading to more advanced forms of economic organization. This process contributes to sustainable growth while simultaneously enhancing the productive potential of the economy.

The effectiveness of the national economic structure is reflected in the ability of its actors to generate the maximum socio-economic benefits, as illustrated in Figure 1.

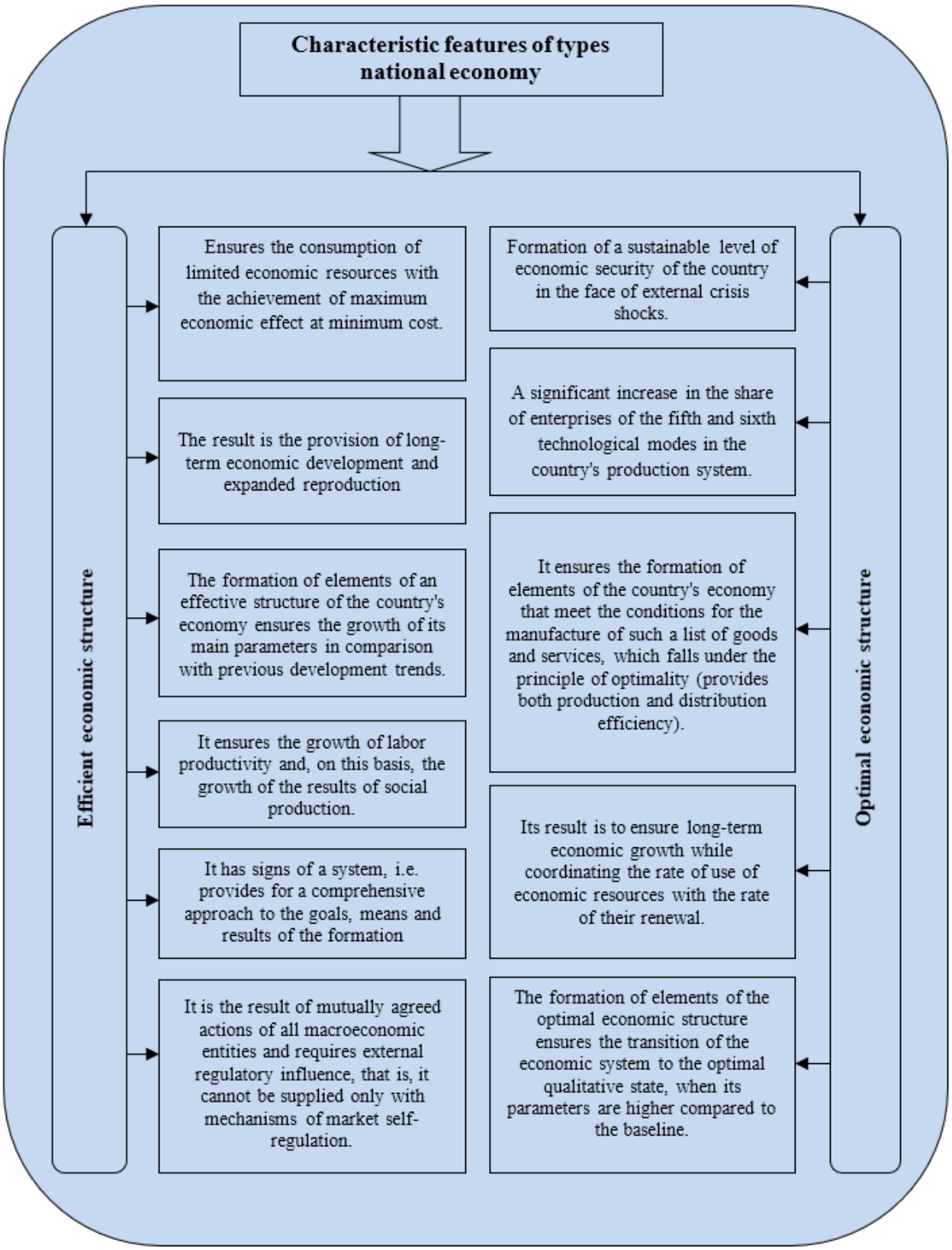

Figure 1. A complex of characteristic features of the types of structure of the national economy [1]

The optimal economic structure represents the most effective configuration of relationships among the interconnected components of a country's economy, ensuring the efficient use of limited economic resources

1 Compiled by the author.

to maximize the satisfaction of societal needs. At the same time, three principal groups of national economic structures can be identified, each reflecting specific requirements for the formation and functioning of a post-industrial society, as presented in Table 2. In this context, the structure of the national economy inherently reflects the macroeconomic proportions of its core elements and their systematic interaction within the overall economic framework (Table 1).

Table 1. Criteria for the optimal structure of the national economy[2]

Criteria for the optimal structure of the national economy	production of goods and services that, on the one hand, ensure the maximum satisfaction of social needs, on the other hand, their production is associated with minimizing the cost of economic resources
	promoting long-term economic growth while matching the rate of use of economic resources with the rate of their renewal
	ensuring the transition of the economic system to a higher, not only quantitative, but also qualitative state; stimulation of the greatest use of the results of scientific and technological progress, the country's specialization in the global division of labor, integration actions

Macroeconomic proportions represent the quantitative and qualitative relationships among various structural elements of the national economy, simultaneously reflecting the type of national economic reproduction, including both simple and expanded forms (Table 2).

Table 2. Requirements for the structure of national economies of a post-industrial society[3]

Type of economic structure	Requirements
Industry structure national economy	20% - processing industries; 25% - financial sector; 22% - service sector; 33% - other industries
Technological structure national economy	20% - high-tech production; 30% - medium-tech production; 20% - medium-low technology production; 30% - low-tech industries
Technological structure of processing industries (within 20% of the structure of the national economy)	50% - the total share of high-tech and medium-high-tech industries, of which: - 20% - high-tech; - 30% - medium technology. 50% - the total share of medium-low-tech and low-tech industries

The global economic system exhibits a non-linear, cyclical, or wave-like pattern of development, a phenomenon that was scientifically substantiated during the twentieth century. Its dynamics are shaped by periodic fluctuations that differ in structure and duration, forming cyclical processes whose combined effects explain the complex temporal and spatial evolution of the world economic system.

Cyclicality, as an objective pattern of economic development, is multifaceted in nature. When duration is used as the primary classification criterion, six major types of economic cycles can be identified (see Table 2). At the same time, cyclical conditions within national economies remain dynamic and may vary across countries due to differences in the number and intensity of endogenous and exogenous influencing factors. In this context, W. Rostow's theory of stages of economic growth has played a significant role in explaining the regular transformation of economic development structures (Table 3).

Table 3. Cyclicity as an objective regularity of economic development in its content[4]

№	The main criteria for the classification of cyclicity pattern of economic development
1	Agrarian ultra-small cycles for up to 1 year - seasonal short-term fluctuations in agriculture.
2	Financial and economic small cycles for a period of 3-5 years (on average 4 years) - short-term fluctuations in financial and business activity.
3	Industrial (business) average cycles for a period of 7–11 years (on average 9 years) - medium-term fluctuations associated with the renewal of the active part of fixed capital in industry.
4	Construction average cycles for a period of 16–20 years (on average 18 years) are medium-term fluctuations associated with the renewal of the passive part of fixed capital, primarily housing.
5	Large cycles of economic conditions for a period of 50-60 years (on average 54-55 years) - long-term «long waves» of changes in technological patterns.
6	Super-large age cycles - long-term fluctuations for a period of 100-120 years (on average 108-112 years), for example, age cycles of changes in economic and political leadership.

2 Compiled by the author.
3 Compiled by the author.
4 Compiled by the author.

W. Rostow identified the following stages of societal development: traditional society; the formation of preconditions for takeoff; takeoff; the drive toward maturity; and the era of mass consumption. These stages were revealed through the natural evolution of technology, economic sectors, capital accumulation within national income, and consumption patterns.

In his later works, W. Rostow added a sixth stage, namely the search for quality of life. Concepts comparable to Rostow's model were proposed by D. Bell and E. Toffler within the framework of the "three waves of societal development," which include pre-industrial, industrial, and post-industrial stages. However, unlike Rostow, Bell and Toffler did not interpret the transition to more advanced forms of social development through the lens of economic cyclicality. In general, the evolution of theories of cyclical development can be systematized according to the nature of structural changes they emphasize (see Table 3).

The economic literature presents diverse approaches to the classification and systematization of factors influencing structural transformation in national economies. Nevertheless, these factors are predominantly examined through the analysis of cyclical fluctuations, primarily using evidence from developed countries (Table 4).

Table 4. Evolution of the basic theories of cyclical development of the economy[5]

Stages of theory (author)	Scientific works (years)	Characteristic
Stage I Theory cyclical crises (M. Tugan Baranovsky)	«Industrial crises in modern England their reasons and Influence at people's life «(1894)	The cyclicality of the national economy in the capitalist countries is determined primarily by sectoral changes due to changes in the movement of capital and the emergence of new technologies. The duration of the phases of the economic cycle is heterogeneous and depends on the characteristics of the economic conditions of development
Stage II Theory innovative development (I. Schumpeter)	«Theory economic development» (1912)	The sectoral structure of the national economy is changing due to the accumulation and investment of capital in new technologies, which is due to the phases: the emergence, diffusion of innovations, the next accumulation of capital and its subsequent reinvestment.
Stage III Theory of long waves (M. Kondratiev)	«World economy and its conjuncture during and after war» (1922)	The structure of the national economy is changing due to short, medium and longest waves of the economic situation (K-waves, lasting 50-60 years). Economic cycles, according to Kondratiev, are accompanied by spontaneous reverse and irreversible evolutionary processes.
Stage IV Theory of linear stages of development (W. Rostow)	«Stages of economic growth» (1959) and «Politics and Stages growth «(1971)	The cyclical development of the economy takes place along an ascending trajectory and goes through six stages of the development of society (traditional society, maturation of the prerequisites for a breakthrough, a breakthrough to self-sustaining growth, the transition to technological maturity, the era of mass consumption, the search for quality of life) at the heart of the transition between which is the accumulation of a critical level of capital and investing it in the economic and institutional components of the national economy

5 Compiled by the author.

However, in developing and transitional economies, the determinants of development and structural change often remain insufficiently systematized. Consequently, this study proposes a classification and systematic framework for analyzing the factors influencing structural transformations in developing countries, based on a comprehensive and integrated analytical approach, as presented in Table 5.

Table 5. Matrix of factors of structural transformations in the national economy[6]

	Economic	Non-economic
Endogenous	➢ number of economically active population; ➢ the level of material well-being of the population; ➢ labor productivity; ➢ state of fixed production assets; ➢ level of investment in human and physical capital; ➢ total tax burden on the subject of economic relations; ➢ economic independence; ➢ degree of openness of the national economy; ➢ attraction of direct foreign investments; ➢ volume of state consumption; ➢ level of consumer prices; ➢ state of the financial market; ➢ expenses for technological innovations; ➢ average per capita income of the population; ➢ level of development of the domestic market	➢ protection of property rights and legal norms; ➢ level of corruption and shadow market; ➢ state of infrastructure; ➢ state and procedure for compliance with regulatory and legal support; ➢ political stability; ➢ favorable climatic conditions; ➢ access to the sea; ➢ degree of bureaucratization; ➢ geographic location; ➢ the level of development of the institutional environment; ➢ degree of ecologization of socio-economic processes; ➢ Cultural and religious traditions.
Exogenous	➢ world energy prices; ➢ US dollar exchange rate; ➢ financial and economic assistance from international organizations; ➢ degree of integration into global economic networks; ➢ state of the balance of payments; ➢ access to international markets; ➢ Competitiveness in foreign markets.	➢ the impact of scientific and technological progress; ➢ degree of integration into international organizations; ➢ participation in military conflicts.

The proposed classification-matrix approach to the analysis of concepts and theories of structural reform enables the selection of theoretical and methodological tools that correspond to a specific type of economic growth and the nature of structural transformations within the national economy. In particular, the framework distinguishes key classification criteria, including the period of implementation of changes (current, prospective), the complexity of changes (advanced, simple), the direction of changes (objective, subjective), the nature of change (preventive, situational, adaptive), the degree of change management (permanent, discrete, cyclical), the scale of changes (systemic, point-based), the duration of change (long-term, medium-term, short-term), and the type of change (evolutionary, revolutionary).

To provide a more comprehensive perspective on the spectrum of structural reform concepts in socio-economic systems, this study systematizes these concepts according to the intensity of structural changes and the levels at which they are implemented, as illustrated in Figure 2. Within this framework, the indifferent type of structural reform should not be interpreted as a lack of engagement in transformation processes, but rather as the relative neutrality of such processes with respect to the development dynamics of socio-economic systems.

6 Compiled by the author.

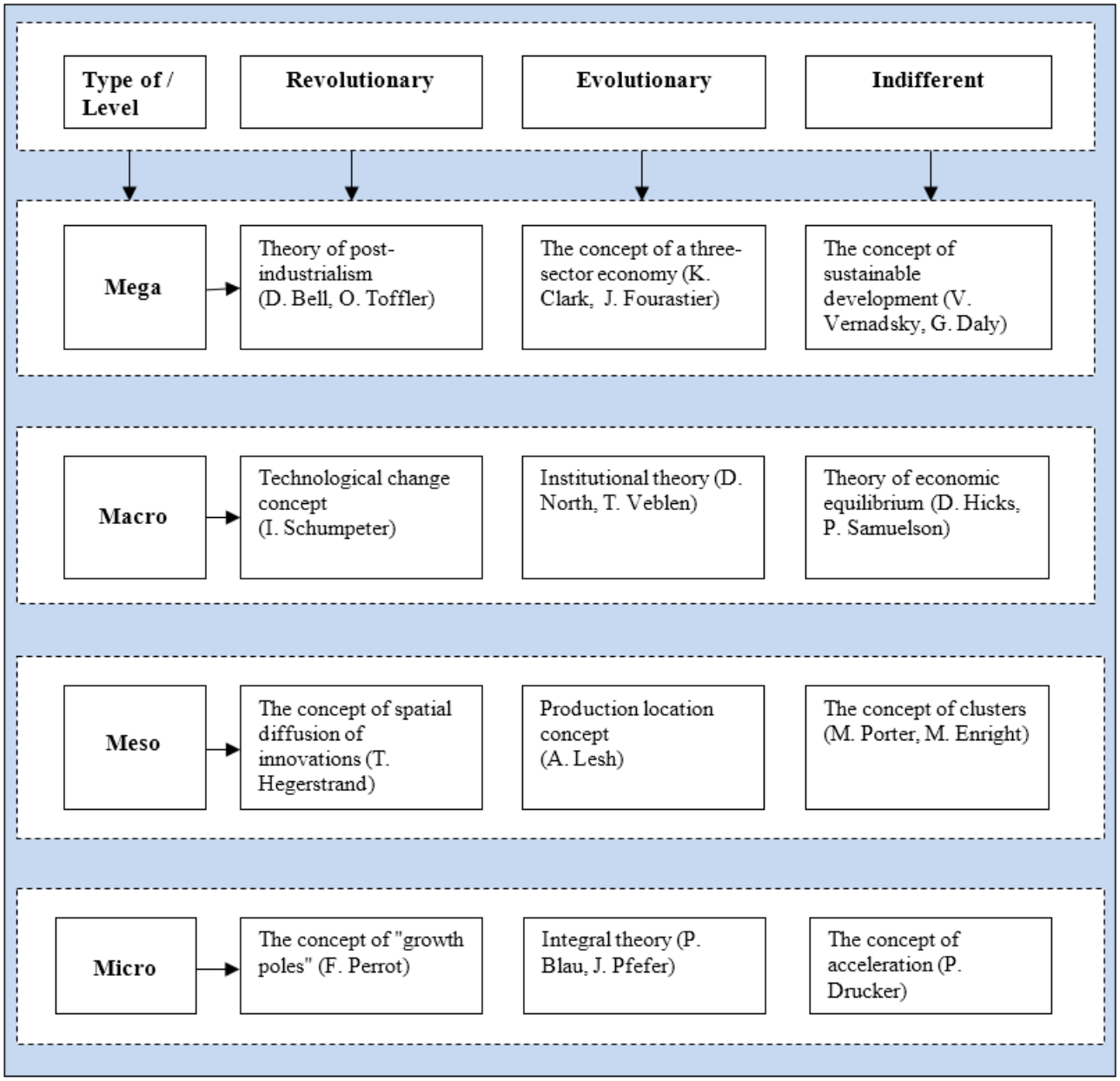

Figure 2. Classification of concepts and theories of structural reform[7]

CONCLUSION AND RECOMMENDATIONS

Studies of the theoretical foundations of the structure of the national economy demonstrate that it represents a hierarchical system composed of interrelated organizational and economic elements, including economic entities, object levels, institutional formations, regulatory mechanisms, principles, characteristics, criteria, and indicators, which interact closely with political, social, humanitarian, and ecological components of the state. As a result, the structure of the national economy—sectoral, spatial, reproductive, and other forms—exhibits a dynamic character and is determined by both the intensity and the combination of endogenous and exogenous influencing factors. Furthermore, the application of a classification-matrix approach to the analysis of concepts and theories of structural reform enables the selection of theoretical and methodological instruments that correspond to specific types of economic growth and the nature of structural transformations within the national economy.

To enhance the overall effectiveness of structural transformation processes, it is advisable to align state industrial policy with national comparative advantages and technological potential. Particular emphasis should be placed on the development of high- and medium-technology sectors, the strengthening of institutional

7 Compiled by the author.

quality, and the improvement of coordination mechanisms between public and private stakeholders. In this context, program-target management tools can play a crucial role in supporting balanced resource allocation and ensuring sustainable long-term economic growth.

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IMPORTANT CHARACTERISTICS OF THE DEVELOPMENT OF E-COMMERCE SERVICES

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Abstract: This article examines the essential characteristics that influence the development of e-commerce services in modern digital environments. The analysis identifies structural, technological, and interaction-based features that shape the operational performance and quality of e-commerce service systems. The study draws on established scientific literature and reviews widely recognized determinants such as system accessibility, service reliability, process standardization, user interaction, operational efficiency, transparency, and digital integration. The article contributes to the academic understanding of e-commerce services by presenting a clear conceptual framework that explains how these core characteristics support sustainable digital service development.

Key words: E-commerce services, service development, digital systems, service reliability, user interaction, service processes, digital integration.

Annotatsiya: Ushbu maqolada zamonaviy raqamli muhitda elektron tijorat xizmatlarining rivojlanishiga ta’sir ko‘rsatuvchi asosiy xususiyatlar tahlil qilinadi. Tadqiqotda e-xizmatlar tizimlarining ishlash samaradorligi va sifatini belgilovchi tarkibiy, texnologik va o‘zaro ta’sirga asoslangan omillar aniqlangan. Ilmiy adabiyotlar tahlili asosida tizimdan foydalanish qulayligi, xizmat ishonchliligi, jarayonlarning standartlashtirilishi, foydalanuvchi bilan o‘zaro aloqalar, operatsion samaradorlik, shaffoflik va raqamli integratsiya kabi omillar o‘rganiladi. Maqola elektron tijorat xizmatlari rivojlanishini izohlovchi konseptual yondashuvni ishlab chiqish orqali ilmiy tushunchalarni boyitadi.

Kalit so‘zlar: elektron tijorat xizmatlari, xizmatlarni rivojlantirish, raqamli tizimlar, xizmat ishonchliligi, foydalanuvchi bilan o‘zaro aloqa, xizmat jarayonlari, raqamli integratsiya.

Аннотация: В данной статье рассматриваются основные характеристики, влияющие на развитие услуг электронной коммерции в современных цифровых условиях. Анализ выявляет структурные, технологические и взаимодействующие факторы, определяющие операционную эффективность и качество систем электронных услуг. Исследование опирается на научную литературу и анализирует такие ключевые детерминанты, как доступность системы, надежность услуг, стандартизация процессов, взаимодействие с пользователями, операционная эффективность, прозрачность и цифровая интеграция. Статья способствует углублению научного понимания электронных услуг, предлагая концептуальную модель устойчивого развития цифровых сервисов.

Ключевые слова: услуги электронной коммерции, развитие услуг, цифровые системы, надежность услуг, взаимодействие с пользователями, сервисные процессы, цифровая интеграция.

INTRODUCTION

E-commerce services have become a pivotal driver of digital transformation across various sectors of the global economy. Unlike traditional service models, they rely entirely on digital infrastructures for their design, delivery, and execution. Scholarly literature commonly defines e-commerce services as online activities in which interaction, information exchange, and service provision are conducted fully through electronic systems.

The evolution of e-commerce services reflects a dynamic interplay of structural and functional components. These include the reliability of digital platforms, the organization of service processes, and the quality of user engagement. Gaining a clear understanding of the characteristics that shape these components is essential for explaining how digital service ecosystems achieve efficiency, scalability, and long-term sustainability. This article examines the fundamental features that support the development of e-commerce services, drawing on well-established academic perspectives while maintaining an objective, evidence-based approach.

LITERATURE REVIEW

Studies on e-commerce services draw from several established research streams. From a strategic viewpoint, service-dominant logic considers digital services as part of wider service ecosystems in which value is co-created by multiple actors over digital platforms; e-commerce services are seen as innovation on configurable, networked resource platforms rather than just online sales channels.

On the technical side, the ISO/IEC 25010 software quality model identifies key quality characteristics – such as functional suitability, reliability, performance efficiency, usability and security – that are directly applicable to e-commerce platforms and define their structural and operational robustness. Within this framework, accessibility, stability and performance are treated as core prerequisites for dependable digital service environments. Recent interpretations of ISO/IEC 25010 further emphasize its relevance for web-based and high-traffic systems typical of e-commerce.

User-focused research has concentrated on electronic service quality (e-service quality). The E-S-QUAL scale developed by Parasuraman, Zeithaml and Malhotra (2005) identifies efficiency, system availability, fulfilment and privacy as central dimensions of perceived online service quality, linking platform accessibility, reliability and information handling directly to user evaluations. Later work by Tan, Benbasat and Cenfetelli (2016) shows that both functional and technical service failures significantly influence satisfaction and continued use, underscoring the importance of stable processes, transparent information and integrated digital workflows in e-commerce service development.

RESEARCH METHODOLOGY

This study employs a qualitative synthesis of widely recognized academic sources related to digital service systems, service management, and online operations. Only scientifically validated concepts are included, ensuring the accuracy and credibility of the analysis. Rather than focusing on assumptions or speculative interpretations, the study highlights recurring elements that consistently appear in research on digital service development, thereby establishing a solid conceptual foundation for understanding e-commerce services.

ANALYSIS AND RESULTS

The development of e-commerce services is shaped by a combination of structural, technological, and interaction-based characteristics that collectively define the functionality and maturity of digital service environments. Widely recognized digital quality models, including ISO/IEC 25010, demonstrate that system accessibility—in terms of uninterrupted availability, consistent operational stability, and intuitive usability—forms a foundational requirement for supporting continuous user engagement within digital service channels. Ensuring platform responsiveness across varying user loads and device types is essential, as accessibility directly contributes to improved user retention and higher service completion rates.

Reliability also plays a central role in the effectiveness of digital processes. Empirical findings in software reliability and digital transaction management highlight that accurate data presentation, predictable system behavior, and stable workflows significantly enhance user trust and support smooth transaction experiences. Reliable service execution not only strengthens confidence but also contributes to more efficient and error-free service interactions.

The standardization of service procedures, widely emphasized in service operations theory, ensures consistent service delivery, minimizes variability, and maintains quality even as service volume increases. Standardized workflows promote interoperability, enabling diverse technological components within the service infrastructure to function cohesively and efficiently.

The quality of user interaction, grounded in human–computer interaction principles and validated through usability research, substantially enhances user satisfaction and increases perceived service value. Clear communication pathways, logically structured interfaces, and transparent feedback mechanisms support efficient task completion and create a frictionless service experience.

Operational efficiency, frequently analyzed in digital operations management literature, represents another key characteristic. Automation, algorithmic optimization, and effective data management improve service cycle times, reduce the likelihood of human error, and foster scalable service delivery models capable of handling high transaction volumes.

Transparency, identified in consumer behavior and digital trust research as a crucial factor influencing user confidence, involves the clear presentation of service terms, accurate real-time updates, and honest communication of service conditions. Transparent systems empower users to make informed decisions and strengthen long-term trust in digital service environments.

Finally, the integration of digital components—an established principle within digital systems engineering—ensures that technological, informational, and operational subsystems function as a coordinated ecosystem rather than isolated units. Effective integration enhances data consistency, prevents communication gaps, and supports uninterrupted service flows, thereby increasing the reliability and coherence of the overall e-commerce service environment.

Taken together, these scientifically grounded characteristics illustrate that the advancement of e-commerce services depends not on a single factor but on the coordinated interaction of structural and functional components that collectively promote service quality, operational efficiency, and sustainable development in digital contexts.

The development of e-commerce services relies on several strategic directions that collectively strengthen the structural and functional foundations of digital service ecosystems. A central direction involves enhancing digital accessibility by improving the stability, usability, and responsiveness of online platforms, as reliable access serves as a key factor for maintaining continuous user engagement. Another important direction focuses on reinforcing process reliability and ensuring that digital service workflows operate with precision, consistency, and high performance — an aspect widely acknowledged in service science as essential for fostering user trust.

A further strategic priority is the advancement of standardized service procedures that promote uniformity, support predictable outcomes, and ensure smooth scalability as transaction volumes increase. Enhancing the quality of user interaction also represents a major development direction, as research in human–computer interaction consistently emphasizes the value of intuitive interfaces, clear communication channels, and effective feedback mechanisms in shaping user satisfaction and encouraging broader service adoption.

Operational efficiency serves as an additional strategic focus, calling for the integration of automated tools, optimized data flows, and streamlined digital operations to support faster service cycles and improved system performance. Transparency in service information also plays a pivotal role by ensuring that users receive clear, accurate, and timely updates, thereby enabling well-informed decisions and strengthening confidence in digital environments.

Finally, the integration of technological, informational, and operational subsystems forms a vital development direction that promotes cohesive service delivery, enhances data consistency, and contributes to the overall stability and harmony of e-commerce systems. Collectively, these strategic directions establish a strong conceptual foundation for advancing e-commerce services in a way that promotes service quality, system sustainability, and user-centered digital transformation.

CONCLUSION AND RECOMMENDATIONS

The analysis of the key strategic directions for the development of e-commerce services shows that sustainable advancement in digital service ecosystems relies on the harmonious integration of structural, operational, and interaction-oriented priorities. Enhancing system accessibility, ensuring process reliability, and strengthening standardized service procedures form a strong technical foundation that supports consistent and high-quality service delivery. Alongside these components, improving user interaction quality and advancing operational efficiency represent important pathways for elevating user satisfaction and optimizing digital workflows.

Transparency in service information further contributes to informed user participation and reinforces confidence within digital environments. Likewise, the integration of technological and operational subsystems ensures cohesive, resilient, and scalable service execution. Together, these strategic directions underscore the multidimensional nature of e-commerce service development and provide a clear conceptual basis for guiding future improvements in digital service infrastructures, service management practices, and user-centered design initiatives.

Their alignment establishes a comprehensive framework that supports enhanced performance, improved reliability, and long-term sustainability of e-commerce services across evolving digital economies.

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AGRICULTURE PROMOTION AND DEVELOPMENT IN MOUNTAIN AND MOUNTAIN REGIONS

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Abstract: The article focuses on specialization in the cultivation of agricultural products in mountain and sub-mountain regions, the development of agriculture, and the rational use of the opportunities presented by these regions. In addition, the rational and reasonable use of regional network capacity, the development of agriculture in mountainous and sub-mountainous regions, and their opportunities in this regard are described.

Key words: mountain and sub-mountain, agriculture, specialization, product, region, and market.

Annotatsiya: Ushbu maqolada tog‘ va tog‘oldi hududlarida qishloq xo‘jaligi mahsulotlarini yetishtirishda ixtisoslashuv, qishloq xo‘jaligini rivojlantirish hamda mazkur hududlarning imkoniyatlaridan oqilona foydalanish masalalari yoritilgan. Shuningdek, hududiy tarmoq salohiyatidan ratsional va maqsadga muvofiq foydalanish, tog‘ va tog‘oldi hududlarida qishloq xo‘jaligining rivojlanishi hamda bu boradagi mavjud imkoniyatlar bayon etiladi.

Kalit so‘zlar: tog‘ va tog‘oldi, qishloq xo‘jaligi, ixtisoslashuv, mahsulot, hudud, bozor.

Аннотация: В статье рассматриваются вопросы специализации при выращивании сельскохозяйственных продуктов в горных и предгорных районах, развитие сельского хозяйства, а также рациональное использование возможностей, которые предоставляют данные территории. Кроме того, описываются рациональное и целесообразное использование регионального сетевого потенциала, развитие сельского хозяйства в горных и предгорных зонах и их возможности в этом направлении.

Ключевые слова: горные и предгорные районы, сельское хозяйство, специализация, продукция, регион и рынок.

INTRODUCTION

In the reforms carried out in the agrarian sector of our republic, it is considered an important task to support the specialization of regions for the cultivation of certain types of agricultural products, taking into account the natural climate and soil conditions, and a number of measures are being implemented to ensure its implementation.

Mountain and sub-mountain regions have nearly all production opportunities for growing food products such as fruits, grapes, potatoes, vegetables, meat, and meat, which can meet demand from both domestic and international markets. One of the ways to activate these opportunities is to make the mountain and sub-mountain regions specialize in the cultivation of certain types of agricultural products by introducing a system of rational and balanced use of agricultural resources.

The purpose of this system is to provide our domestic markets with high-quality and environmentally friendly products by increasing the volume of food production in mountain and sub-mountain areas and to increase their export potential.

The organizational structure of such a system consists of clusters, cooperatives, farmers, and peasant farms specializing in the cultivation of fruit, including traditional and non-traditional tropical fruits, grapes, vegetables, cattle, and sheep.

REVIEW OF LITERATURE ON THE SUBJECT

Scholarly research on the development of agriculture in mountain and sub-mountain regions underscores the decisive role of natural–geographical conditions, resource management, and institutional mechanisms in shaping sustainable sectoral growth. Abdulkhaeva (2022) emphasizes that agricultural development in high-

altitude territories requires a differentiated approach based on soil quality, climate variability, and the spatial distribution of production factors. Her analysis shows that specialization of territories and the rational allocation of resources significantly enhance productivity and ecological stability in these regions. Complementing this view, Abdulkhaeva (2020) investigates foreign experience and concludes that innovative technologies—such as precision agriculture, climate-adaptive crop selection, and cooperative-based land management—serve as key instruments for addressing structural constraints typical of mountain agriculture.

Further contributions highlight the socioeconomic dimension of agrarian development. Abdulkhaeva (2022) stresses that supporting women's entrepreneurship in mountain and sub-mountain areas contributes to the diversification of agricultural markets and strengthens rural economic resilience. In parallel, Abdulkhaeva et al. (2022) explore the theoretical foundations of land-use regulation, arguing that efficient regulatory mechanisms and transparent land governance form the backbone of sustainable territorial development.

The relationship between climate change and agricultural productivity is another critical theme in the literature. Abdulkhaeva et al. (2018) demonstrate that rising temperatures, increased drought frequency, and changes in hydrological cycles have already altered crop yields in Uzbekistan's mountainous zones. Their research highlights the necessity of adaptation measures such as drought-resistant crops, improved irrigation technologies, and strengthened agro-ecological monitoring.

Studies conducted outside Uzbekistan provide a comparative perspective. Gashkina (2007) analyzes the organizational and economic mechanisms that ensure sustainable agricultural development in the mountainous regions of the Altai Republic. Her findings show that integrated management systems, cooperative models, and landscape-adaptive farming practices are essential for maintaining long-term ecological balance and economic viability. Similarly, Mukhtorov et al. (2018) examine agricultural production strategies and propose improvements in the organizational and economic methods of cultivating oilseed crops, which are relevant for highland agriculture where soil and climate conditions impose additional constraints.

On a broader theoretical level, Mukhtorov (2016) argues that the modernization of the global agrarian sector is shaped by economic globalization, technological renewal, and institutional reforms. His monograph provides a conceptual framework for understanding how mountain and sub-mountain agricultural systems can integrate into global value chains while preserving ecological sustainability.

Collectively, these studies highlight that the development of mountain and sub-mountain agriculture depends on a combination of environmental, organizational, socioeconomic, and technological factors. They also underline the need for region-specific strategies that integrate climatic adaptation, land-use optimization, market diversification, and institutional modernization—an approach that forms the conceptual foundation for the present research.

RESEARCH METHODOLOGY

The research methodology is based on the collection of primary data through field observations, soil analyses, and structured interviews with farmers operating in mountain and sub-mountain areas, while secondary data were obtained from regional statistical reports and scientific publications. The collected information was systematized and analyzed using comparative, geospatial, and statistical evaluation methods to identify patterns influencing agricultural specialization and development.

ANALYSIS AND RESULTS

According to our research, the mountain and sub-mountain agriculture of Surkhandarya region differs from other mountain and sub-mountain agriculture of our country in some ways, such as soil types and their spread and fertility level, formed in altitude regions and zones that show strong soil-geographic laws due to their geographical location and hydrometric regime, the organization of the agricultural management system, and the organizational-economic possibilities.

In this regard, indicators such as soil composition and productivity, degree of degradation, precipitation amount, and camera temperature collector are analyzed and compared, and conclusions and suggestions are made regarding the specialization and support of agriculture in certain areas and branches of the mountain and sub-mountain regions. It is recommended to prepare conclusions and proposals.

According to the analysis, there are 12 types of soil types used in mountain and sub-mountain agriculture in the Surkhandarya region. 27.1% of them are light brown meadow steppe and brown soils, and 37.1% are typical gray and light gray soils.

In terms of soil composition, 66.4 percent of the land used in mountain and sub-mountain agriculture is heavy and medium sandy soil, but the soil erosion index is only 0.15 (the average erosion index is 0.06 and the strong erosion index is 0.09). (Table 1).

Table 1. The mechanical composition of the soils of the cultivated lands used in agriculture in the mountainous and sub-mountainous regions, in percentage of the total[1], 2023

Areas	Broadcast lands, in percent, to a thousand	Soil type			
		Heavy sand	Medium sand	Light san	Sand
Mountain and sub-mountain areas	100	30,8	35,6	24,5	9,1
	244,9	75,4	87,3	59,9	22,3
Smoothness	100	34,1	32,2	24,9	8,8
	73,0	24,9	23,5	18,2	6,4
Total by regions	100	31,6	34,7	24,5	9,2
	317,9	100,5	110,3	77,9	29,3

Note: The sum is expressed as a percentage of the total, and the denominator is 1,000

In the mountain and sub-mountain agriculture of the Surkhandarya region, mountain brown and dark-hairy, typical and light-hairy gray soils (in pre-mountain and pre-mountain terrains) are distributed; the amount of humus in the upper horizon of the soil is 5-7% on the northern slopes and 2-3% on the southern slopes. It is explained by the fact that carbonates have been washed away from the soil (Table 2).

Table 2. The degree of erosion of the soils of cultivated lands used in agriculture in mountain and sub-mountain areas[2], 2023

Areas	Irradiated lands	Uneroded lands	Less eroded lands	Average eroded lands	Strongly eroded lands
Mountain and sub-mountain areas	100	77,0	6,7	6,4	9,1
	244,9	188,7	16,5	15,8	22,4
Smoothness	100	96,1	2,5	1,5	-
	73,0	70,2	1,6	1,1	-
Total by regions	100	81,6	8	6,1	7,0
	317,9	259,4	25,4	1,9	22,4

Note: the sum is expressed as a percentage of the total, and the denominator is thousand

One of the important criteria that should be taken into account in the development of mountain and sub-mountain agriculture is the salinity level of the cultivated land.

Today, 81.4% of the arable land used for agriculture in the mountainous regions is not saline; this indicator is 43.2% in the mountainous regions, and only 13.2% in the plains (Table 3).

Table 3. The degree of salinity of irrigated lands used in agriculture in mountain and sub-mountain areas, in percentage of the total[3], 2023

Areas	Broadcast lands, as a percentage of the total	Degree of salinit			
		To salinit	Weak	Average	Strong
Mountainous	100	81,4	17,3	0,8	0,5
sub-mountain areas	100	43,2	31,1	14,2	11,5
Smoothnes	100	13,2	44,4	30,5	11,9
by regions	100	73,0	21,1	4,2	1,7

1 The author's calculations are based on the data of the Department of Land Resources, Geodesy, Cartography, and State Cadaster of Surkhandarya Region, 2023.

2 The author's calculations based on the data of the Land Resources, Geodesy, Cartography and State Cadaster Department of Surkhandarya Region, 2023

3 The author's calculations based on the data of the Land Resources, Geodesy, Cartography and State Cadaster Department of Surkhandarya Region,2023

That is, 46.0% of the irrigated land used in mountain and sub-mountain agriculture is not saline. This is 48.5% of the total non-saline land in the region.

According to the analysis, during the last two decades, the share of moderately and strongly saline lands has decreased, both in absolute terms and in relative terms. Therefore, the above-mentioned situation and this situation should be taken into account in the development of mountain and sub-mountain agriculture.

One of the next important factors that should be taken into account in the development of mountain and sub-mountain agriculture is the relief of the agricultural area. Erosion, cave migration, ravine migration, wide and deep branching of riverbeds, as well as erosion of mountain rocks, influence the formation of relief in mountain and sub-mountain regions. Given the presence of tree groves, shrubs, semi-shrubs, ephemerals, ephemerides, and large trees in the regions of the region formed by the height of the topography of the agricultural sector and areas (mountainous (hills), mountain, and high mountain regions), fruit and horticulture, viticulture, and pasture are used in these areas. in accordance with the development of animal husbandry and sheep breeding.

Mountain and mountain agriculture are characterized by small-scale plow farming and mountain irrigation, “terrace” (“terracnoe zemledelie”) and dry farming, medicinal and medicinal horticulture, mountain horticulture, viticulture and viticulture, and the development of mountain and mountain pasture livestock.

Taking into account the conditions and opportunities created by our government at the national level regarding the use of pastures during the last 2-3 years, we believe that it is necessary to develop mountain and sub-mountain pasture cattle breeding with the introduction of the “smart pasture” system and in the form of “pasture user cooperatives” management.

Studies show that during the last 20–30 years, the productivity level of pastures in mountain and sub-mountain areas has decreased by 1.5–2.0 t/h, erosion has increased by 4–5%, and the degree of dusting has increased by 8–12%[4]. As a result, improving the ameliorative condition of pastures in mountain and sub-mountain pastures, establishing plantations of valuable and nutrient-rich crops that have high nutritional value and are appreciated by livestock, planning and graphic ecocide of pastures, and pastures surrounded by grasses that give positive camaracini in practice It is recommended to introduce a system of use. It will be possible to increase the productivity of pastures up to 10–12 ts/ha by establishing plantations of valuable fodder such as ecpartset, actragul, izen, terecken, and shuvok. As a result, conditions will be created to optimize and reduce the amount of pasture that was created due to unsystematic grazing of livestock, increasing the volume of meat production by 7.5-10.0 percent (11.1-14.7 thousand tons) within 2-3 years due to the increase in pasture productivity, cut production by 10.0-12.0 percent (67.0-80.4 thousand tons), and meat production by 12.0-15.0 percent (17.7-22.1 thousand tons) after 4-5 years due to the increase in pasture productivity.

That is, the application of an innovative approach and best practices for the use of pastures in mountain and foothill agriculture, pasture use management, the introduction of a planning system and the establishment of a form of economic management (pasture user cooperatives) based on the principles of cooperation profits increase by 8-1.1 billion y.e.

Research shows that global climate change and deterioration of the ecological situation have become a factor determining not only the stability of agricultural production, but also the future development trends of this field and its industries. Today, regional agriculture serves as both an base and a factor in determining the structure of the network and its diversification directions.

We believe that in the development of mountain and sub-mountain agriculture, it is necessary to pay attention to the selection of types and varieties of crops planted not only in a single crop, but also in a repeated - “toqsonbosti” (the method of sowing crops in autumn and leaving them under snow is called “tuqsonbosti”) system. It is worth noting that the development of mountain and sub-mountainous areas of the Surkhandarya region, such as Boysun, Sariosiyo, Denov, and Uzun, and the implementation of a long-term support system for horticulture and viticulture are beneficial both from an agrotechnical point of view and from the point of view of production and economics[5]. This serves to grow fruit and grape products that can be competitive not only in domestic but also in foreign markets in terms of ecological and consumption characteristics. Therefore, it is appropriate to organize activities in this direction in a system of fruit and horticultural clusters or a complex operating on the principles of clusters and cooperatives based on the principles of cooperation.

In our opinion, the factors related to the development of economic activity in the specialization of mountain and sub-mountain agriculture; factors related to consumption; agrotechnological factors; factors related to changes in the organization of the management system and its monitoring system; we believe that taking into account the classification of regulatory and legal factors (both related to support and restrictions) will serve to increase the economic and social efficiency of specialization.

4 Davronov O.O., Norkulov M.N., G‘aniev O.O. Current condition of pastures and hayfields of Boysun district of Surkhandarya region.// Journal. “THE LAND OF UZBEKISTAN” - Issue 2, 2019. Page 18.

5 Dorohova E.A., Baymetov K.I., Akhmedov Sh.M. “Description of sorting and form template”. - T.: “Science and technology”, 2016, pp. 188-189.

In accordance with the unique natural and climatic conditions of the mountain and sub-mountainous regions, the main directions of agricultural development and its sustainable development are the cultivation of grain, potatoes, medicinal plants, non-traditional tropical fruits in horticulture, i.e. walnuts, almonds, which are in great demand for export, in animal husbandry, cattle breeding in cut direction, goat breeding in meat direction, partridge breeding[6] in poultry breeding, breeding of domestic and useful partridge and deer, in addition, special attention should be paid to the development of rabbit breeding, fishing, especially beekeeping.

CONCLUSIONS AND SUGGESTIONS

Within the framework of the study, the scientific and practical proposals and recommendations of regulatory-legal, organizational-economic and economic-financial character in determining, justifying and ensuring the stability of the main directions of agricultural development in the mountain and sub-mountain areas of our republic are used to determine the prospective directions of further development of agriculture in all the mountain and sub-mountain areas of ours.

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6 Explanation. 100 g of fried partridge meat contains 250 kcal. Source: Selo-Exp.com.

IMPROVING MECHANISMS FOR ENHANCING ECONOMIC EFFICIENCY IN SERVICE ENTERPRISES

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Abstract: The essence of the problem of improving economic efficiency at a service enterprise lies in increasing economic results per unit of cost while utilizing existing resources. Therefore, improving the economic efficiency of an enterprise is one of the central issues of sustainable development. Improving efficiency at service enterprises is the main strategic goal of service enterprises for effectively addressing various economic and social issues.

Key words: enterprise innovation, government, private sector, joint-stock company and staff, technological transformation, modern technologies.

Annotatsiya: Xizmat ko'rsatish korxonasida iqtisodiy samaradorlikni oshirish muammosining mohiyati mavjud resurslardan foydalanish jarayonida har bir xarajat birligi uchun olinadigan iqtisodiy natijalarni ko'paytirishga qaratilgan. Shunday ekan, korxonada iqtisodiy samaradorlikni oshirish barqaror rivojlanishning markaziy vazifalaridan biri hisoblanadi. Xizmat ko'rsatish korxonalarida yuzaga keladigan turli iqtisodiy va ijtimoiy muammolarni samarali hal qilish uchun samaradorlikni oshirish asosiy strategik maqsad sifatida e'tirof etiladi.

Kalit so'zlar: korxonaning innovatsion faoliyati, davlat, xususiy, aksiyadorlik va jamoaviy shakllar, texnologik transformatsiya, zamonaviy texnologiyalar.

Аннотация: Суть проблемы повышения экономической эффективности на предприятии сферы услуг заключается в увеличении экономических результатов на единицу затрат в процессе использования имеющихся ресурсов. Поэтому повышение экономической эффективности предприятия является одной из центральных проблем устойчивого развития. Повышение эффективности на предприятиях сферы услуг является главной стратегической целью предприятия сферы услуг для эффективного решения различных экономических и социальных проблем.

Ключевые слова: инновационная деятельность предприятия, государство, частный сектор, акционерное общество и коллектив, технологическая трансформация, современные технологии.

INTRODUCTION

The objective of a service enterprise is to provide services of a specified volume and quality within a given period. At the same time, when determining the scope of services, the enterprise must consider not only fully meeting consumer demand for a particular type of service but also increasing its economic efficiency. Therefore, the economic performance of a service enterprise should primarily be evaluated by determining the economic efficiency of the services provided.

The essence of the issue of improving economic efficiency in a service enterprise lies in increasing economic outcomes for each unit of cost incurred during the utilization of existing resources. Thus, enhancing economic efficiency within the enterprise becomes one of the central challenges of sustainable development. Improving efficiency in service enterprises represents a key strategic objective aimed at effectively addressing various economic and social problems.

The economic efficiency of an enterprise is characterized by a relatively narrow range of indicators. However, each indicator is influenced by an entire system of factors. A systematic approach is defined by a comprehensive assessment of the influence of various factors and a targeted study of their interaction.

REVIEW OF LITERATURE ON THE SUBJECT

Studies on economic efficiency in enterprises emphasize the necessity of rational resource utilization, structural improvement, and innovation-driven development. Abdukarimov et al. (2013) highlight that the economic efficiency of an enterprise is fundamentally determined by the optimal use of labor, material, and financial resources, as well as by the ability to reduce production and service delivery costs. Their textbook provides a comprehensive methodological basis for assessing enterprise performance and forming mechanisms that enhance efficiency in competitive markets. Further, Abdukarimov and Pardaev (2007) explore the economic potential of enterprises, arguing that efficiency improvements stem from a systematic evaluation of internal capacities, including production structure, technological readiness, and human resource competencies.

In the context of service enterprises, theoretical and practical approaches to improving efficiency increasingly emphasize innovation. Zarikeeva (2023) demonstrates that innovative activity in the service sector plays a decisive role in raising service quality, meeting customer expectations, and ensuring long-term competitiveness. She stresses that service enterprises must integrate modern technologies and digital tools to enhance service delivery mechanisms and operational performance. This aligns with broader economic trends in which digital transformation reshapes business models and efficiency metrics.

Measuring efficiency in service enterprises is a complex task, as noted by Belyaev (1999), who discusses methodological difficulties in evaluating enterprise costs and outcomes. He argues that traditional cost measurement models often fail to capture the intangible and dynamic nature of service processes, suggesting the need for more flexible and adaptive evaluation tools. Rubtsova (2006) similarly emphasizes the multidimensional nature of service efficiency assessment. Her research proposes a structured methodology for analyzing service performance that incorporates qualitative characteristics, customer satisfaction, and organizational capabilities, thereby expanding beyond purely financial indicators.

Overall, the reviewed literature underscores that improving mechanisms for enhancing economic efficiency in service enterprises requires a comprehensive and integrated approach. This includes developing innovation-based strategies, optimizing internal processes, strengthening human capital, implementing modern technologies, and improving system-wide evaluation tools. Scholars collectively conclude that efficiency in service enterprises is shaped not only by cost management but also by the ability to generate higher-quality services, maintain customer orientation, and adapt to technological and market changes.

RESEARCH METHODOLOGY

The research methodology is based on the collection of primary and secondary data through literature analysis, statistical reports, and enterprise performance indicators. The study applies comparative analysis, economic efficiency evaluation methods, and factor analysis to identify key determinants affecting service enterprise performance. Data were interpreted using analytical and synthetic approaches to develop evidence-based conclusions.

ANALYSIS AND RESULTS

Factors affecting the enhancement of economic efficiency in service enterprises may be classified according to different criteria. Accordingly, factors may be general—affecting a range of indicators—or specific to a given indicator. The generalizing nature of many factors is explained by the relationship and interdependence among individual indicators.

In our view, all types of factors influencing the improvement of economic efficiency in service enterprises can be classified based on three criteria:

1) Sources of increased economic efficiency, the main ones being: reducing labor, material, capital, and asset intensity of production; rational use of natural resources; saving time; and improving product (service) quality.

2) Key directions for developing and improving production (service delivery), which include: accelerating innovation activities; increasing the technical and economic level of production (service delivery); improving the structure of production (service delivery); introducing organizational systems to enhance management efficiency; and improving forms and methods of organizing, planning, incentivizing, and structuring labor activities.

3) The degree to which factors influencing economic efficiency are incorporated into the production (service delivery) management system, which includes:

a) Internal (within production/service delivery) factors such as developing new types of products (services); mechanization and automation; introduction of advanced technologies and modern equipment; improved use of raw materials, fuel, and energy; enhancement of management practices; and others.

b) External factors, which include improving the industry structure of service delivery, state economic policy, the formation of market relations and market infrastructure, and other influences.

Such a classification of factors makes it possible to model economic activity and comprehensively identify internal reserves for increasing economic efficiency. In this context, the most important factors for improving the economic efficiency of service enterprises include:

1. Developing the innovative activities of the enterprise, increasing the technical level of service delivery processes (improving their quality), and implementing an effective innovation policy.
2. Improving the structure of capital investment reproduction within the enterprise (prioritizing the reconstruction and technical re-equipment of existing enterprises) and accelerating the development of high-technology production (service delivery).
3. Diversifying and specializing service delivery processes within the enterprise and improving the organization of these processes.
4. Enhancing the efficiency of labor resource utilization in service enterprises and improving the system of employee motivation.
5. Strengthening social and psychological factors within the enterprise, adhering to democratic management principles, developing human capital, increasing employee responsibility and creative initiative, ensuring the comprehensive development of individuals, and enhancing social attention in the development of production (improving general and professional training levels, ensuring safe and healthy working conditions, and developing service culture within the enterprise).

In our view, the main directions for improving the economic efficiency of service enterprises include increasing the volume and quality of services; improving labor productivity; reducing production (service delivery) costs; expanding sales markets; increasing the efficiency of fixed asset utilization; optimizing inventories; strengthening relationships with suppliers; introducing cutting-edge technologies; and applying modern technologies for managing production (service delivery) processes using appropriate software solutions (Figure 1).

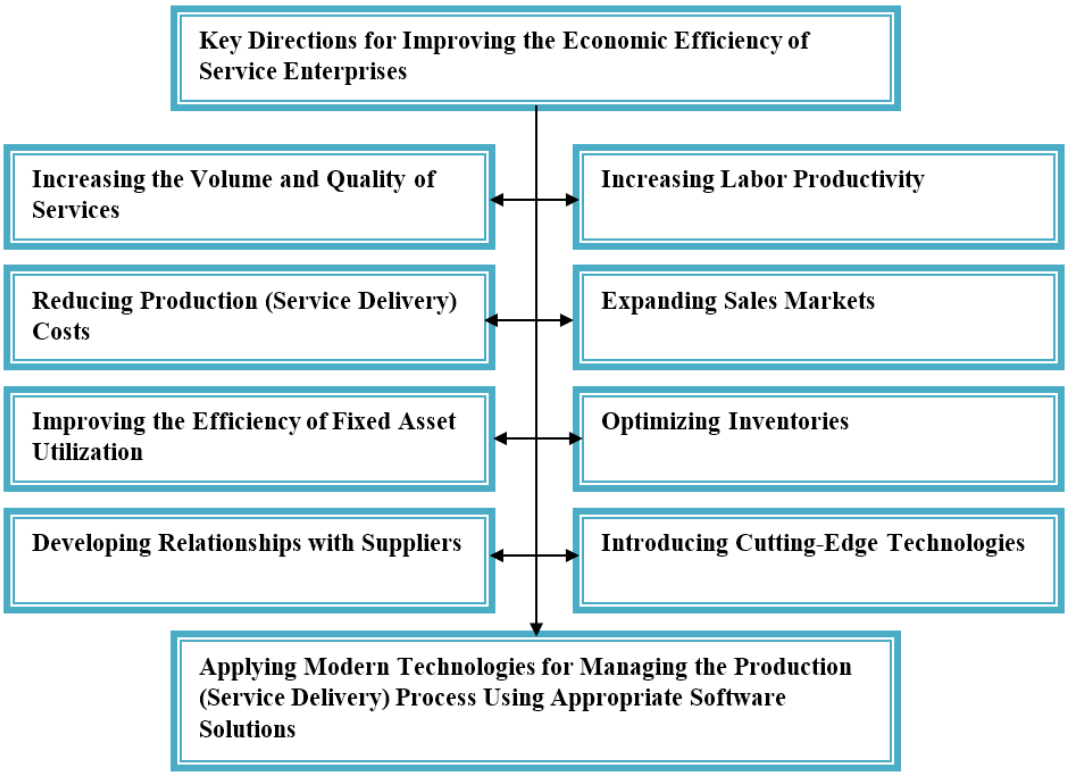

Figure 1. Key Directions for Improving the Economic Efficiency of Service Enterprises

It should be emphasized that today one of the most important factors for increasing economic efficiency in service enterprises is achieving effective enterprise management. There are numerous ways to improve management efficiency. These may relate to leadership, the personal and professional qualities of managers, and elements of managerial activity. Efforts aimed at improving the effectiveness of enterprise management may begin with any element—whichever is most suitable for the enterprise. The only requirement is to account for the interdependence among components of the management system.

The ways to improve enterprise management efficiency are conventionally divided into eight groups:

• improving the enterprise's management structure by simplifying it as much as possible, decentralizing and delegating authority, and defining managerial responsibilities based on qualifications and personal attributes;

• developing a strategy for enterprise development based on analyzing activities, evaluating strengths and weaknesses, and formulating the enterprise's mission and policy;

• designing and implementing an information system that ensures effective communication among employees and departments;

• establishing a system for developing and adopting managerial decisions, defining principles and procedures of management, and implementing an incentive system;

• creating and introducing a continuous development system through employee training, retraining, and enhancing initiative and creativity;

• developing a system, procedure, or algorithm for selecting, training, and evaluating the competencies of managerial staff;

• applying the most effective methods of personnel selection and evaluation, developing an efficient and well-matched workforce, and creating the most favorable socio-psychological environment;

• undertaking measures to build enterprise culture and develop shared values recognized and supported by employees.

Achieving economic efficiency and ensuring sustainable development of service enterprises increasingly depends on employees' ability to maintain enterprise performance. However, before making new managerial decisions that ensure sustainable development, it is necessary to consider potential obstacles that may arise on the path to achieving efficiency. Therefore, when developing effective management technologies, it is extremely important to study the essence of efficiency, examine all indicators of economic efficiency, and understand the difference between economic effect and efficiency.

Improving employee qualifications is a key factor influencing enterprise performance, as it enhances labor potential and operational efficiency—both of which represent the enterprise's capacity to solve assigned tasks under specific organizational and technical conditions.

The labor potential of a service enterprise can be characterized by its structure, which reflects the relationships among the psychophysical, demographic, and other attributes of employee groups. Quantitative indicators of labor potential typically represent total working time.

Achieving economic efficiency in a service enterprise requires identifying the main directions for improving staff performance (Figure 2).

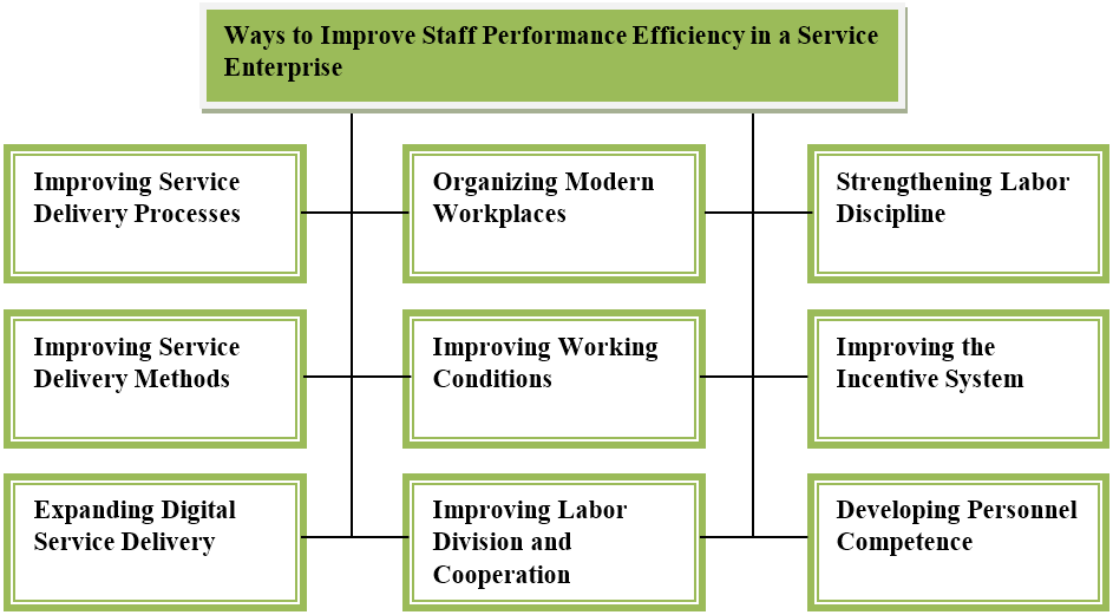

Figure 2. Ways to Improve Staff Performance Efficiency in a Service Enterprise

The status of employees in a service enterprise, their qualifications and professional skills, as well as the ability of hired personnel to optimally solve production (service delivery) problems and generate profit for the enterprise, are directly linked to theoretical approaches and practical methods of working with people. These factors, without doubt, influence the enterprise's efficiency.

High service quality ensures efficient use of material and labor resources, stabilizes the production (service delivery) process, supports economic growth, proportionality, competitiveness, and export potential, and affects the economic efficiency of a specific enterprise.

For consumers, along with product (service) quality, the price of the offered goods is also important. Therefore, entrepreneurs must ensure competitive quality and competitive pricing for their products and services to achieve success.

In our view, effective performance in the service sector essentially means achieving the intended (planned) profit, reducing non-production costs and losses, efficiently using labor tools and labor resources, increasing labor productivity, and improving service quality.

The digital transformation taking place in the economy has significantly changed the ability of service enterprises to influence all factors that increase economic efficiency. This situation is associated with the following structural changes:

• adapting service and operational activities to consumer needs;

• modernizing key sectors of the service industry—trade, transport, information and communication, and financial services—using advanced (digital) technologies;

• adapting to global scientific and technological progress;

• forming a diversified economy based on various forms of ownership (state, private, joint-stock, and collective);

• transforming all forms of economic activity in the sector;

• expanding the export of services through digital technologies, and so on.

The main methods for increasing the efficiency of service enterprise activities include:

• optimizing business processes. This method focuses on analyzing and improving core processes affecting enterprise goals;

• introducing modern technologies and systems. The use of modern information technologies and management systems helps automate and optimize business processes, improve data availability and analytical capabilities, reduce task completion time, and enhance operational accuracy. Implementing enterprise resource planning systems, customer relationship management systems, and other tools helps reduce costs, increase efficiency, and ensure effective communication with customers and partners;

• staff training and professional development. Skilled and motivated employees play a crucial role in improving enterprise performance. Training and development enhance their knowledge and skills, enable adaptation to new technologies and work methods, and foster leadership and creativity;

• improving employee motivation systems. Creating a motivational environment and an effective incentive system helps attract, retain, and encourage qualified staff;

• setting clear goals and monitoring their achievement. Clearly defined goals and systematic monitoring are integral to improving enterprise efficiency. In today's business environment, change is inevitable; therefore, the enterprise must actively manage change processes.

The methods for increasing economic efficiency in service enterprises are interconnected and mutually reinforcing. Their successful implementation requires a systematic approach, adaptation to the specific needs of the enterprise, and continuous monitoring of results.

A combination of these methods allows the enterprise to achieve high economic efficiency and competitiveness in the market. One of the essential aspects of successfully applying methods to improve economic efficiency is leadership and support from top management. Moreover, when choosing and applying methods to increase economic efficiency, it is important to consider the specific characteristics of the sector (industry) and individual enterprise. Each sector has its own characteristics, requirements, and challenges, and approaches to improving economic efficiency must be adapted accordingly.

It should be emphasized that economic efficiency in a service enterprise is a dynamic process. It requires constant renewal and improvement. A company must be prepared for changes in the external environment, ensure intensive internal development, respond to new trends and technologies, and strive for innovation and growth.

Therefore, efficiency methods play a central role in achieving economically effective outcomes. They contribute to process optimization, quality improvement, cost reduction, and enhanced competitiveness. However, applying these methods requires consideration of each enterprise's specific characteristics and readiness for continuous development and changes in the business environment.

CONCLUSIONS AND SUGGESTIONS

The analysis confirms that improving economic efficiency in service enterprises requires a systemic approach integrating innovation, human capital development, digital transformation, and effective resource

management. Strengthening managerial capabilities, enhancing service quality, and optimizing internal processes create a foundation for sustainable growth and competitiveness in a rapidly changing economic environment. The findings show that enterprises that strategically invest in modern technologies and workforce competence achieve higher productivity and operational stability.

For further sectoral development, it is essential to expand digital service models, improve data-driven decision-making, and support continuous professional training within organizations. Establishing stronger partnerships with suppliers, refining cost management practices, and adopting advanced monitoring tools will enhance operational transparency and efficiency. Encouraging innovation-friendly institutional frameworks and supporting technological integration across service industries will contribute to long-term economic resilience and higher value creation.

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INTEGRATION OF INTELLIGENT CONTROL IN DRYING SYSTEMS: PROCESS OPTIMIZATION THROUGH SENSORS, ARTIFICIAL INTELLIGENCE, AND MODULAR DRYING

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Abstract: The article analyzes the integration of intelligent control systems—based on sensors, artificial intelligence, hybrid, and modular approaches—into industrial drying technologies. Traditional drying equipment typically operates according to predefined parameters such as temperature, airflow, and time, which often fail to deliver optimal results under varying conditions, raw material properties, and external factors. Therefore, the paper explores modern approaches including neural networks, neuro-fuzzy regulators, model-based control, data fusion, multimodal monitoring (hyperspectral imaging, computer vision), and cloud-based management systems.

The analysis shows that intelligent control-based drying systems can reduce energy consumption by up to 10–15%, shorten drying time, maintain consistent product moisture and quality, and significantly minimize operator errors. Moreover, modular and multi-agent architectures improve adaptability for various raw materials, while cloud monitoring enables remote control and large-scale data analysis. Integration with environmental monitoring raises drying technologies to a new level of energy efficiency and ecological safety.

Key words: Intelligent control systems, drying process optimization, artificial intelligence, sensor technologies, neural networks and fuzzy logic, hybrid control models, modular drying systems, cloud-based control, multimodal monitoring (data fusion), ecological monitoring and energy efficiency.

Annotatsiya: Maqolada sensorlar, sun'iy intellekt, gibrid va modulli yondashuvlarga asoslangan aqlli boshqaruv tizimlarining sanoat quritish texnologiyalariga integratsiyasi tahlil qilinadi. An'anaviy quritish uskunalari odatda harorat, havo oqimi va vaqt kabi oldindan belgilangan parametrlarga muvofiq ishlaydi, bu esa ko‘pincha turli sharoitlarda, xom ashyo xususiyatlari va tashqi omillar ostida optimal natijalarni bermaydi. Shuning uchun, maqolada neyron tarmoqlari, neyro-loyqa regulyatorlar, modelga asoslangan boshqaruv, ma'lumotlarni birlashtirish, multimodal monitoring (giperspektral tasvirlash, kompyuter ko‘rish) va bulutga asoslangan boshqaruv tizimlari kabi zamonaviy yondashuvlar o‘rganiladi.

Tahlil shuni ko‘rsatadiki, aqlli boshqaruvga asoslangan quritish tizimlari energiya sarfini 10-15% gacha kamaytirishi, quritish vaqtini qisqartirishi, mahsulot namligi va sifatini doimiy ravishda saqlab turishi va operator xatolarini sezilarli darajada kamaytirishi mumkin. Bundan tashqari, modulli va ko‘p agentli arxitekturalar turli xom ashyolar uchun moslashuvchanlikni yaxshilaydi, bulutli monitoring esa masofadan boshqarish va keng ko‘lamli ma'lumotlarni tahlil qilish imkonini beradi. Atrof-muhit monitoringi bilan integratsiya quritish texnologiyalarini energiya samaradorligi va ekologik xavfsizlikning yangi darajasiga ko‘taradi.

Kalit so‘zlar: Aqlli boshqaruv tizimlari, quritish jarayonini optimallashtirish, sun'iy intellekt, sensor texnologiyalari, neyron tarmoqlari va noaniq mantiq, gibrid boshqaruv modellari, modulli quritish tizimlari, bulutga asoslangan boshqaruv, multimodal monitoring (ma'lumotlarni birlashtirish), ekologik monitoring va energiya samaradorligi.

Аннотация: В статье анализируется интеграция интеллектуальных систем управления — на основе датчиков, искусственного интеллекта, гибридных и модульных подходов — в промышленные технологии сушки. Традиционное сушильное оборудование обычно работает в соответствии с предопределенными параметрами, такими как температура, поток воздуха и время, что часто не позволяет достичь оптимальных результатов в различных условиях, при различных свойствах сырья и внешних факторах. Поэтому в статье рассматриваются современные подходы, включая нейронные сети, нейро-нечеткие регуляторы, управление на основе моделей, слияние данных, многомодальный мониторинг (гиперспектральная визуализация, компьютерное зрение) и облачные системы управления. Анализ показывает, что интеллектуальные системы сушки на основе управления могут снизить энергопотребление на 10–15%, сократить время сушки, поддерживать постоянную влажность и качество продукта, а также значительно минимизировать ошибки оператора. Кроме того, модульные и многоагентные архитектуры повышают адаптивность к различным видам сырья, а облачный мониторинг обеспечивает дистанционное управление и крупномасштабный анализ данных. Интеграция с мониторингом окружающей среды выводит технологии сушки на новый уровень энергоэффективности и экологической безопасности.

Ключевые слова: интеллектуальные системы управления, оптимизация процесса сушки, искусственный интеллект, сенсорные технологии, нейронные сети и нечеткая логика, гибридные модели управления, модульные системы сушки, облачное управление, многомодальный мониторинг (слияние данных), экологический мониторинг и энергоэффективность.

INTRODUCTION

The drying process is one of the most essential and energy-intensive operations across many industrial sectors, including food processing, chemical production, pharmaceuticals, biomass, wood processing, and others. Traditional drying systems are typically configured based on static parameters such as temperature, airflow, and drying time; initial settings are predetermined and remain almost unchanged throughout the process. Although this approach is simple and convenient, it often leads to significant challenges when dealing with complex equipment designs, variable raw materials, and fluctuating external conditions — resulting in uneven drying, reduced product quality, excessive energy consumption, or instability in control performance.

Moreover, the complexity of drying processes increases due to the interdependence of factors such as moisture content, temperature, airflow, product type and properties, load volume, material and air movement, as well as heat and mass transfer mechanisms. Conventional automated control methods (e.g., static PID or temperature-based control, fixed airflow, predefined operating modes) are insufficient for ensuring optimal performance under such dynamic and uncertain conditions.

In recent years, the introduction of intelligent control systems into industrial dryers has led to substantial technological advancements. These systems enable real-time data acquisition from sensors, continuous monitoring of product and process parameters, adaptive control algorithms, artificial intelligence (AI) and machine learning techniques, neural and neuro-fuzzy regulators, multimodal monitoring (hyperspectral, optical, and other sensor technologies), and optimal/adaptive control strategies [1].

LITERTURE REVIEW

Intelligent control, unlike conventional automated control, relies on sensor data, real-time monitoring, model-based prediction, and adaptive algorithms (such as neural networks, neuro-fuzzy inference systems, and evolutionary/optimization algorithms). The drying process involves heat and mass transfer and often exhibits highly delicate, uncertain, or variable behavior: factors such as material composition, initial moisture content, air temperature/humidity, and airflow velocity are interdependent. Traditional control methods (e.g., static PID, PI, or fixed operating modes) may be insufficient for maintaining optimal performance under such complex conditions. Therefore, intelligent control systems are essential [2].

Intelligent control systems enable effective management of uncertainty and variability in drying processes. Parameters such as product type, moisture level, air conditions, and load volume are monitored in real time, and the process is automatically adjusted accordingly. As a result, energy consumption decreases, and efficiency improves by reducing excessive heating and airflow.

These systems also enhance product quality — ensuring uniform drying while preserving color, texture, and aroma in heat-sensitive materials. Process stability and reliability increase, operator errors are reduced, and labor costs decline.

Moreover, intelligent dryers are flexible and adaptable to various raw material types, operating efficiently across a wide range of conditions. Data collected during the drying process is stored and later used for process analysis and optimization, enabling continuous technological improvement. This approach elevates automated drying to a new stage — “smart, adaptive, data-driven, and optimized drying.”

In one study, a control system integrating sensors, artificial intelligence, and fuzzy logic algorithms was implemented in a real drying unit, resulting in a 12–15% reduction in drying time, a 10–12% decrease in energy consumption, and improved moisture uniformity [3]. Another study showed that applying an artificial neural network–based NARMA-L2 controller to a conveyor dryer during fruit drying reduced stabilization time by 57% and errors by 74% compared to classical PID control — leading to more consistent product quality and greater energy savings [4].

Thus, industrial drying technologies are shifting from simple, rigid operating modes to adaptive, intelligent systems driven by real-time data. This transition is rapidly expanding both technically and practically. Modern sensor technologies, machine learning, neuro-regulators, fuzzy logic, model-based control, and optimization algorithms make drying processes significantly more efficient, higher in quality, and environmentally friendlier.

In the future, it is expected that drying systems will increasingly integrate IoT, 5G, cloud technologies, high-precision sensors, and real-time data analytics platforms. Such “factory-to-cloud” control architectures will enable global analysis, remote monitoring, and comprehensive supervision of drying operations [5].

RESEARCH METHODOLOGY

In the study, real-time data from sensors installed in the drying system (moisture, temperature, and airflow) were collected. These data were processed using artificial intelligence and fuzzy logic algorithms to determine the optimal drying regimes. The results of the intelligent control were compared with those of conventional control, and differences in energy consumption, drying time, and product quality were evaluated. Finally, the developed algorithm was tested on a modular dryer, and its effectiveness was confirmed.

ANALYSIS AND RESULTS

Current state and methods of intelligent control systems. At present, intelligent systems based on artificial intelligence and neural networks are widely used in controlling drying processes.

In one study, a NARMA-L2 type neural network controller operating in real time was applied to a conveyor dryer designed for fruit drying. With the help of this intelligent control system, the relative humidity inside the drying chamber is continuously monitored, and the process is controlled accurately and stably [4]. According to the research results, compared to the classical PID controller, the stabilization time of the process was reduced by 57%, and the overshoot was reduced by 74%. This significantly decreased energy consumption, increased the efficiency of the drying process, and made it possible to maintain product quality at a stable level.

Combining control methods — hybrid control systems. Hybrid control systems are among the most promising directions in modern drying processes, especially under complex and variable conditions. For example, in a study on sliced tobacco, an intelligent control system is applied to an industrial rotary dryer: in this case, the moisture content at the dryer outlet is selected as the main controlled parameter, while the temperature of the drying air serves as the manipulating variable [2]. The system operates without operator intervention, based on continuous real-time monitoring and readjustment, maintaining moisture at an optimal level, preventing overdrying, and significantly improving product uniformity and quality. At the same time, a reduction in waste and energy consumption has been observed, which confirms the practical effectiveness of hybrid control.

In another modern work [6], a hybrid approach consisting of a physics-based model and a data-driven component is proposed for pneumatic drying processes. The authors use a conventional mechanical/thermal model to describe the main physical laws of the process and employ artificial intelligence methods to learn the residual dynamics in order to capture remaining uncertainties and nonlinearities. As a result, very high accuracy is achieved for outlet moisture and temperature (mean absolute error of about 0.016% moisture and about 0.015 °C temperature), along with a stable model suitable for control. Such a hybrid structure increases robustness against disturbances caused by external factors, ensures system stability, and is developed in a form that can be directly connected to model-based control (MPC and others).

Data fusion and multimodal monitoring. In recent years, in order to control drying processes more precisely, data fusion of sensor signals—i.e., jointly analyzing data obtained from different sources such as temperature, air flow, time, and images—has been widely used. In one study on apple drying, not only process parameters but also images of the dried pieces were used [7]. This approach has been shown to be much more effective than traditional parameter-only methods in accurately predicting moisture content and controlling the drying process.

Furthermore, in [Zhe Wang, Min Zhang, Arun S. Mujumdar, Jiacong Lin, Dongxing Yu, AI technology in smart drying of foods: A critical review of research and applications, Innovative Food Science & Emerging Technologies, Volume 103, 2025], artificial intelligence, IoT sensors, computer vision, hyperspectral imaging, and other advanced technologies are highlighted as key directions for online monitoring, quality control, energy saving, and process optimization in drying operations.

Through such integrated systems, every stage of the drying process can be monitored with high accuracy, enabling the preservation of product quality and the improvement of energy efficiency.

Modular and optimized drying processes + optimization algorithms. In one study, it is recommended to design and optimize the drying process in a modular manner, that is, to create systems in which several drying methods (convection, vacuum, pneumatic, and others) are used sequentially [8]. This method achieved up to a 12% reduction in energy consumption compared to a single-stage system.

This approach is particularly beneficial for enterprises working with various types of raw materials (grain, biomass, fruit, polymers, etc.), as maximum efficiency can be achieved by configuring the modules in the required sequence and with appropriate parameters.

Advantages and disadvantages of the intellectualization of drying processes. The advantages of intelligent drying systems and the aspects that must be considered when implementing them manifest themselves in several directions. First of all, in such systems, processes are under continuous control, and many parameters such as moisture, temperature, and air flow are measured and automatically regulated in real time. This ensures the stability of product quality and reduces production errors. The combination of artificial intelligence, sensor networks, multimodal monitoring, and modular design enhances energy efficiency and resource savings. Studies show that such systems significantly reduce energy consumption and drying time [3].

In addition, intelligent control systems are flexible with respect to different types of raw materials and drying methods, and they can be tuned according to the required quality specifications. Automated control reduces human intervention, minimizes operator errors, and continuously stores monitoring results for further analysis and optimization.

At the same time, it is necessary to pay attention to certain risks and limitations when implementing such systems. Reliable operation of artificial intelligence and hybrid models requires large-scale real data, dense sensor networks, and monitoring infrastructure. This leads to high initial investment and technical costs. In some cases, due to the complexity of the control algorithms, incorrect parameter tuning may negatively affect product quality. Moreover, the accuracy and reliability of sensor and data transmission systems are of critical importance—even small errors can disrupt control. For different products and drying methods, separate models, testing procedures, and optimization are required, since there is no universal solution.

New approaches to the implementation of intelligent control systems in drying technologies. Today, intelligent control systems remain an area that is not yet fully explored and is still in the development stage. Scientific research shows that deeper integration of artificial intelligence into drying technologies, automation of data analysis, and the creation of self-learning systems have not yet been fully implemented. Below are some promising, but not yet widely applied, new approaches:

Self-learning drying systems. Traditional physical models that describe drying processes (heat–mass transfer, evaporation kinetics, etc.) are often insufficient for real-time control and optimization [9]. At the same time, drying processes depend on numerous variable factors: moisture content, product type, air conditions, load volume, raw material properties, and others. These factors make accurate prediction and optimization difficult [10]. Therefore, data-driven, adaptive control—i.e., systems that “learn” from their own experience and can automatically select optimal parameters in subsequent cycles—can significantly improve drying efficiency, product quality, and energy efficiency [9].

Cloud-based control. All drying processes are connected to a single central platform via the Internet. This allows enterprises to remotely control several drying lines simultaneously and analyze their data. Cloud-based control systems make it possible to monitor the drying process remotely—an operator can manage all parameters via the Internet without being physically present. This is a convenient solution for large enterprises and branch networks, as multiple lines are controlled from a single center.

The system can store and analyze data, keeping process efficiency and product quality under constant supervision. Through automation and algorithmic control, energy and labor costs are reduced. As a result, product quality remains stable, parameters are standardized, and quality control becomes more reliable [11, 12, 13].

Digital twin technology. A virtual copy of the real dryer is created. Through this digital twin, the process is simulated, results are predicted in advance, and optimal control regimes are tested without affecting actual production [14].

AI-assisted energy consumption optimization. Artificial intelligence continuously analyzes energy usage and maintains heat transfer in the most efficient regime. This not only reduces electricity consumption but also enables the reuse of waste heat.

Drying processes are among the most energy-intensive operations in industry. However, traditional control parameters (fixed temperature, air flow, time) are not always optimal, given the great variety in product type, initial moisture content, and ambient conditions.

It is noted in the research that machine learning algorithms are an effective tool for reducing energy consumption in drying processes, using different energy sources, and increasing energy efficiency [10].

Vision-based quality control. This refers to continuously monitoring the surface condition, color, structure, moisture state, and other visual or spectral properties of the raw material or product being dried, using cameras or hyperspectral imaging. If the system is combined with artificial intelligence (such as machine learning or neural networks), it automatically analyzes the information obtained from the images and decides whether to stop or continue the drying process at the appropriate stage.

This method has advantages over traditional moisture measurement techniques (gravimetric, chemical analysis, etc.): it is fast, non-destructive, and allows real-time monitoring of the entire batch, not just individual samples.

It is particularly effective when drying fruits and vegetables, grains, nuts, biomass, and other natural raw materials with uneven moisture distribution, heterogeneity, and delicate structure [15].

Multi-agent control. In multi-agent control, several intelligent drying modules are interconnected and exchange information with each other. Each module analyzes its own state and contributes to improving the efficiency of the overall system.

Although there are currently few publications specifically on multi-agent control in drying, this method is widely used in industrial control, energy systems, and complex process management, which suggests that its application to drying systems is likely to be beneficial.

The article “A Survey of Multi-Agent Systems for Smartgrids” shows that multi-agent control is widely used in energy systems to manage complex and variable conditions [16].

In [17], examples of integrating multi-agent control into industrial control networks are discussed. They demonstrate that legacy control systems can be extended with an agent-based layer, turning them into flexible systems with multi-module control.

Integration with environmental monitoring. In the future, drying systems will monitor not only product quality but also their impact on the environment. For example, real-time monitoring will be established for waste heat, carbon dioxide emissions, and air pollution levels. Drying processes are often associated with high energy consumption, heat sources, and emissions to the atmosphere (gases, steam, pollutants). If these are not controlled, they can cause environmental harm, air pollution, and energy waste.

In the current context of environmental and climate change, there are strict requirements regarding the carbon footprint, emissions, and efficient use of resources in industrial processes. Drying processes also need to be analyzed within this framework [18].

Integration with environmental monitoring—i.e., adding sensors and monitoring systems that measure emissions, waste heat, air quality, and exhaust gases to the dryer—ensures real-time monitoring and control of these factors.

Thus, the drying system should be reconsidered not merely as a tool to reduce product moisture content but as a process that combines “efficient use of resources + no harm to the environment.”

Although these approaches have not yet been fully implemented in practice, they are expected to determine the direction of development for industrial dryers in the coming years. Their main goal is to transform the process into a more intelligent, environmentally safe, energy-efficient, and human-independent control system.

CONCLUSION AND RECOMMENDATIONS

The analyses carried out show that drying systems based on traditional static regimes can no longer fully meet current industrial requirements—high quality, energy efficiency, environmental safety, and flexibility. Since the drying process is inherently multi-variable, highly uncertain, and nonlinear, its effective control requires data-driven intelligent control systems that are rich in sensors and equipped with real-time monitoring.

Regulators built on neural networks, neuro-fuzzy algorithms, and hybrid (physical model + data-driven) approaches have been shown in the scientific literature to shorten the stabilization time of the drying process, reduce overshoot and errors, and maintain outlet moisture more accurately. Through data fusion and multimodal monitoring, it becomes possible to assess not only process parameters but also the actual state of the product (color, structure, moisture distribution), which raises quality control to a new level.

Solutions based on cloud control and IoT technologies create wide opportunities for remote monitoring, centralized control of multiple drying lines, maintaining a historical database, and further optimization. Multi-agent architectures and modular drying lines, in turn, make it possible to expand the system step by step, adapt it to different raw materials and regimes, and increase fault tolerance.

Integration with environmental monitoring—real-time control of emissions, waste heat, and energy balance—allows intelligent drying systems to be aligned with “green technology” principles, reducing the carbon footprint and enabling efficient use of resources. Overall, intelligent drying systems that combine sensors,

artificial intelligence, hybrid models, cloud control, and environmental monitoring represent the main direction for future industrial drying technologies, and their in-depth study and practical implementation constitute an urgent scientific and applied task.

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THEORETICAL MODELS AND CONCEPTS OF ECONOMIC DEVELOPMENT IN THE ENERGY SECTOR

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Abstract: The paper examines fundamental scientific approaches that explain the dynamics of the energy sector under contemporary transformational conditions. The study aims to identify methodological foundations that enable the assessment of qualitative changes within the industry, the formulation of strategic priorities, and the improvement of management tools. The necessity of conducting a systematic analysis of factors shaping the long-term development trends of energy infrastructure - including institutional reforms, technological innovation, modernization of production capacities, and environmental constraints - is substantiated. Through critical evaluation of theoretical concepts, the research demonstrates the significance of an integrated approach that accounts for the interrelation of economic, social, and environmental parameters. The findings may serve as a methodological basis for developing effective regulatory strategies and enhancing the resilience of the energy sector at both national and regional levels.

Key words: sector resilience; innovative approaches; institutional reforms; infrastructure modernization; strategic management; environmental constraints; resource efficiency; transformational processes.

Annotatsiya: Maqolada zamonaviy transformatsion sharoitlarda energetika sektorining dinamikasini tushuntiruvchi fundamental ilmiy yondashuvlar o‘rganiladi. Tadqiqot sanoatdagi sifat o‘zgarishlarini baholash, strategik ustuvorliklarni shakllantirish va boshqaruv vositalarini takomillashtirish imkonini beruvchi metodologik asoslarni aniqlashga qaratilgan. Energetika infratuzilmasining uzoq muddatli rivojlanish tendentsiyalarini shakllantiruvchi omillarni, jumladan, institutsional islohotlar, texnologik innovatsiyalar, ishlab chiqarish quvvatlarini modernizatsiya qilish va ekologik cheklovlarni tizimli tahlil qilish zarurati asoslanadi. Nazariy tushunchalarni tanqidiy baholash orqali tadqiqot iqtisodiy, ijtimoiy va ekologik parametrlarning o‘zaro bog‘liqligini hisobga oladigan integratsiyalashgan yondashuvning ahamiyatini namoyish etadi. Olingan natijalar samarali tartibga solish strategiyalarini ishlab chiqish va energetika sektorining ham milliy, ham mintaqaviy darajada barqarorligini oshirish uchun metodologik asos bo‘lib xizmat qilishi mumkin.

Kalit so‘zlar: sektor barqarorligi; innovatsion yondashuvlar; institutsional islohotlar; infratuzilmani modernizatsiya qilish; strategik boshqaruv; ekologik cheklovlar; resurslar samaradorligi; transformatsion jarayonlar.

Аннотация: В статье рассматриваются фундаментальные научные подходы, объясняющие динамику энергетического сектора в современных условиях трансформации. Цель исследования — выявить методологические основы, позволяющие оценивать качественные изменения в отрасли, формулировать стратегические приоритеты и совершенствовать инструменты управления. Обосновывается необходимость проведения систематического анализа факторов, формирующих долгосрочные тенденции развития энергетической инфраструктуры, включая институциональные реформы, технологические инновации, модернизацию производственных мощностей и экологические ограничения. Путем критической оценки теоретических концепций исследование демонстрирует значимость комплексного подхода, учитывающего взаимосвязь экономических, социальных и экологических параметров. Полученные результаты могут служить методологической основой для разработки эффективных стратегий регулирования и повышения устойчивости энергетического сектора как на национальном, так и на региональном уровнях.

Ключевые слова: устойчивость сектора; инновационные подходы; институциональные реформы; модернизация инфраструктуры; стратегическое управление; экологические ограничения; ресурсоэффективность; трансформационные процессы.

INTRODUCTION

The modern development of the energy sector is acquiring critical importance for ensuring sustainable economic growth, enhancing the competitiveness of national economies, and achieving strategic objectives in the fields of environmental and energy security. In the context of the global transformation of the world economy, the expanding consumption of energy resources, and the tightening requirements for their efficient use, scientific interest is increasingly focused on examining the theoretical foundations, models, and concepts of energy sector development as a complex socio-economic system. In this regard, the need for a comprehensive understanding of the internal mechanisms of the energy sector, the factors shaping its dynamics, and the criteria for assessing its long-term sustainability becomes particularly relevant.

The theoretical models developed in domestic and international academic literature reflect diverse approaches to interpreting the essence of economic development in the energy sector—ranging from resource-driven and inertial models to innovation-technological and institutional concepts. Each of these conceptual frameworks offers its own explanation of the patterns of energy potential formation, the interaction between supply and demand for energy resources, the role of the state and private sector in infrastructure modernization, as well as the impact of technological transformation and environmental constraints on the strategic development trajectories of the industry. Nevertheless, existing approaches often remain fragmented and require further methodological refinement within the framework of the contemporary sustainable development paradigm, which prioritizes energy efficiency, de-carbonization, and the formation of “smart” energy systems.

A scientific synthesis and systematization of theoretical models of economic development in the energy sector makes it possible to uncover the internal logic of the industry’s evolution, identify methodological foundations for analyzing its structural transformations, and formulate a conceptual basis for strategic decision-making under conditions of a rapidly changing global energy landscape. The purpose of this article is to critically examine key theoretical approaches and concepts that reveal the essence of economic development in the energy sector, as well as to identify their methodological limitations and practical relevance for shaping long-term energy policy.

RESEARCH METHODOLOGY

The methodological framework of the study is based on general scientific methods, including analysis and synthesis, induction and deduction, as well as comparative and systemic approaches. The informational basis of the research consists of official statistical data, regulatory and legal documents, reports of international organizations, and scientific publications by domestic and foreign authors.

LITERATURE REVIEW

To deepen the theoretical and methodological foundations of the economic development of the energy sector, it is essential to consider the evolution of scholarly perspectives shaped within modern foreign and domestic research schools.

D.V. Fedorov notes that “the energy sector of a state constitutes a strategic core that concentrates life-supporting resources and forms the basis of civilizational development. Its role in the economy goes far beyond the traditional dynamics of financial indicators and requires an integrated approach.” According to the author, development priorities must be defined not by the interests of individual actors but by the long-term sustainable development goals of the country. The energy sector should be viewed as a system of interaction among economic agents aimed at effectively realizing energy and economic interests while considering current and future needs [1]. In our view, implementing such an approach requires close coordination between the state and business, as well as the integration of innovative technologies and environmental standards into strategic planning. This will make it possible to combine economic efficiency, energy security, and environmental sustainability—an especially relevant goal in the era of the global green transition.

Analyzing global approaches to defining the category of “sustainable development of energy enterprises,” T.G. Zorina offers the following definition: “a process of technological and economic progress of energy enterprises under conditions of uncertainty, oriented toward achieving strategic goals, increasing consumer satisfaction, fulfilling obligations to counterparties, and minimizing negative impacts on the environment, ultimately contributing to improved efficiency of the energy industries” [2]. This definition reflects key aspects of the sustainable development concept; however, under modern conditions it should be supplemented by emphasizing innovative transformation and process digitalization, the development of green technologies, and the integration of ESG principles into strategic management. Such an expanded approach would not only enhance the economic performance and competitiveness of energy enterprises but also ensure their adaptation to global challenges and the ongoing transition to a low-carbon economy.

According to T.K. Salina and her co-authors, “energy resources, energy carriers, and energy itself are the result of the functioning of a powerful national economic complex—energy. This sector can be viewed as an integrated system encompassing the processes of reproduction, primary delivery, conversion, distribution, and final consumption of energy resources.” These interrelated processes form the consecutive stages of a unified energy supply cycle for the economy and society [3]. While this approach accurately highlights the systemic nature of the energy sector, it should be complemented today by emphasizing the integration of innovative technologies, digital platforms, and sustainability principles into every stage of the energy cycle. This would not only improve resource-use efficiency but also ensure the resilience of the energy system in the face of global challenges such as decarbonization and the shift to renewable energy sources.

L.N. Ustinova and her colleagues argue that “long-term and orderly growth of the energy industry, ensured by the uninterrupted operation of its core production segments, forms a solid foundation for the country’s energy security” [4]. Such a development path supports stable industrial functioning and represents a crucial factor in strengthening the socio-economic well-being of the state as a whole.

G.Zh. Allaeva emphasizes that “energy saving now occupies one of the key positions in national energy policy, as this vector can comprehensively address several strategic tasks: reducing the extraction of primary energy resources, decreasing pollutant emissions during electricity and heat production, and lowering the need for large-scale investments in the energy sector, which in the long run stimulates economic growth.” Nevertheless, persistent issues—such as worn-out equipment, outdated technologies, and significant levels of gas flaring—continue to constrain real improvements in energy efficiency [5]. Under these conditions, the priority of energy policy becomes the systemic enhancement of efficiency in the use of all types of fuel and energy resources through the introduction of advanced technologies, modern equipment, and world-class engineering solutions. Allaeva notes that this requires “a comprehensive application of innovations aimed at forming an environmentally safe energy system, optimizing the structure of the energy balance, and implementing modern approaches to energy management” [5]. From our perspective, the success of these transformations depends on synchronizing technical, managerial, and regulatory initiatives, enabling tangible improvements in energy efficiency in both production and final consumption.

G.Sh. Khangeldieva argues that “to successfully achieve the key benchmarks of the long-term socio-economic strategy and implement the priority goals of modernizing Uzbekistan’s electric power infrastructure by 2030, a significant strengthening of the state’s role as a strategic regulator and coordinator of sectoral development is required.” Under such conditions, the economic growth of the energy sector directly depends on the state’s ability to create a favorable institutional and investment environment and to balance the interests of producers, consumers, and society at large [6]. The mechanisms of state regulation, according to the author, should not only ensure the stability of energy supply but also stimulate innovation, attract investment, and enhance the competitiveness of the national power industry in domestic and international markets. This necessitates the creation of effective economic, legal, and institutional tools; the development of comprehensive technical policies with appropriate financial, human, and organizational support; and ensuring affordable and competitively priced electricity for all categories of consumers. An important element is the development of the scientific and technological base of the sector, the introduction of advanced technologies and management systems, and the formation of a new generation of human capital. In our view, it is the integration of technical, innovative, and educational components into the strategic agenda of energy development that will allow the sector to become one of the key drivers of the country’s economic progress.

L.N. Khazratkulova emphasizes that “modern concepts of energy development are based on the transition from extensive capacity expansion models to integrated approaches focused on structural modernization, technological innovation, and greater adaptability of energy systems to external challenges.” According to the author, the evolution of theoretical models reflects a global shift from traditional resource-oriented views toward a comprehensive understanding of the energy sector as a key driver of sustainable economic development [7]. These conclusions, in our opinion, confirm the need to rethink methodological approaches to energy sector development. Contemporary conditions require integrated concepts that combine innovation, institutional transformation, and environmental considerations. Only through such models can the sector achieve sustainable growth, reduce economic vulnerability to external shocks, and establish scientifically grounded priorities for energy policy. The application of conceptually robust models creates the prerequisites for long-term modernization of the sector and the formation of an efficient, competitive, and technologically advanced energy system.

ANALYSIS AND RESULTS

The conducted research made it possible to systematize and deepen the theoretical and methodological approaches to understanding the essence of economic development in the energy sector, revealing its multi-

level and interdisciplinary nature. The analysis of contemporary scientific concepts shows that the development of the energy sector cannot be viewed solely through the prism of increasing production capacity or expanding the extraction of energy resources. Rather, it represents a complex process that includes technological modernization, optimization of institutional frameworks, improvement of energy efficiency, and sustainable resource management.

One of the key results of the study is the clarification of a structural model of economic development in the energy sector, based on the integration of innovative, resource-based, institutional, and environmental components. This model demonstrates that the economic dynamics of the sector are determined not only by the volume of investment but also by the quality of the technological base, the level of innovation readiness, the effectiveness of state regulatory mechanisms, and the degree to which the system adapts to global energy trends.

Furthermore, the study establishes that a balanced institutional architecture—ensuring coherence among the interests of the state, business, and society—is a significant factor in the sustainable development of the energy sector. It is demonstrated that the use of traditional economic growth concepts without accounting for energy constraints and environmental risks leads to structural imbalances, confirming the need to shift toward models based on the principles of the green economy and low-carbon development.

A separate scientific contribution of the study is the author's refined definition of economic development in the energy sector, integrating production, technological, institutional, and environmental components, thereby expanding the conceptual framework of modern energy economics. The proposed approach creates methodological prerequisites for developing a universal toolkit for assessing the development of the energy sector and designing strategic decisions under intensifying global challenges.

Thus, the results confirm the necessity of rethinking traditional theoretical models and transitioning to comprehensive concepts oriented toward sustainability, innovation, and increased efficiency in the use of energy resources. The presented findings can serve as a basis for further theoretical research and the development of applied recommendations in strategic planning for the energy sector at national and regional levels.

The analysis of contemporary theoretical approaches to economic development in the energy sector shows that this category possesses a complex and multidimensional character, combining economic, technological, institutional, and environmental dimensions. Academic literature demonstrates a clear trend toward expanding the content of the concept "economic development of the energy sector"—from the traditional focus on expanding energy capacity and ensuring energy security to the integration of sustainability, innovation, and resource efficiency principles.

As noted, "classical growth models, including neo-Keynesian and neoclassical concepts, interpret the energy sector as a key factor of production that determines the pace of macroeconomic dynamics" [8]. Within these approaches, energy is seen primarily as a resource base necessary for economic functioning. However, modern research shows that such a view is insufficient for explaining structural shifts occurring in the energy system under the influence of technological modernization, de-carbonization, and global transformation of energy markets.

Sustainable development concepts, by contrast, place at their core the balance of economic, environmental, and social parameters. According to these models, economic development in the energy sector is impossible without improving energy efficiency, implementing innovative technologies, and reducing the carbon footprint. These approaches are complemented by institutional economic theories emphasizing the importance of regulatory quality, legal frameworks, investment climate, and mechanisms for industry modernization.

Special attention in the literature is paid to the role of innovation as a driver of structural change in the energy sector. "Models of innovative development view the energy sector as an open system in which technological breakthroughs, digitalization, and smart distribution solutions become the basis for improved efficiency and competitiveness, while state energy policy determines the speed and direction of transformation processes" [9].

The analysis shows that none of the existing concepts can fully describe the modern processes in the energy sector. Only their integration makes it possible to form a holistic theoretical foundation that accounts for macroeconomic patterns, institutional features, technological change, and environmental requirements. Thus, the theoretical examination confirms the need for a comprehensive, interdisciplinary approach to defining the essence and content of economic development in the energy sector—an approach essential for forming modern methodological solutions and sectoral development strategies.

The theoretical analysis also indicates that the development of the energy sector under current conditions requires a rethinking of traditional approaches and the formulation of integrated concepts that take into account the interconnectedness of economic, technological, and environmental factors. Differences among existing models—from neoclassical views emphasizing investment and capital intensity to institutional theories focusing on regulatory quality and governance—highlight the need for a comprehensive understanding of the mechanisms that ensure the sector's sustainable growth.

It is also important to emphasize that the energy sector, as a strategically significant industry, forms the foundation of industrial development and exerts a multiplier effect on related sectors. Therefore, models relying solely on economic indicators of efficiency are insufficient to explain the sector's dynamics under the conditions of market transformation, rising environmental requirements, and the need for greater technological flexibility. The results show that the key drivers of development are the synergy of three areas: infrastructure modernization, digitalization of processes, and the transition to resource-saving technologies.

A central issue revealed during the comparison of various concepts is the limited applicability of universal models to countries with differing levels of economic development. For states undergoing structural modernization, such as Uzbekistan, the adaptation of theoretical models to national specifics—energy balance, institutional maturity, investment scale, and innovation capacity—becomes especially important. The discussion shows that an effective model of energy development must incorporate both global trends (decarbonization, digitalization, decentralization) and regional context.

Thus, the investigation of theoretical approaches and models has made it possible to identify a number of discussion points related to the role of the state in sectoral governance, the optimal balance between traditional and renewable energy, and mechanisms for ensuring investment attractiveness. The analysis confirms that further scientific development of this topic requires a combination of theoretical exploration and applied research aimed at developing adaptive, scientifically grounded tools for strategic planning in the energy sector.

CONCLUSION AND RECOMMENDATIONS

The study of theoretical models and conceptual approaches to the economic development of the energy sector has made it possible to form a comprehensive understanding of the internal logic, mechanisms, and transformation drivers of the energy industry under intensifying global challenges. The analysis of domestic and international scholarly sources confirms that the economic development of the energy sector is a multi-level and dynamic process requiring coordinated interaction among production, technological, institutional, and environmental components.

It has been established that a key condition for the sustainable development of the energy sector is the transition from an extensive model of functioning to an innovation- and institution-oriented model based on improving energy efficiency, digitalizing production processes, diversifying the energy mix, and actively integrating renewable energy sources. The theoretical generalization of existing approaches shows that the modern paradigm of energy development is shifting from a narrow sectoral interpretation toward an interdisciplinary concept that accounts for macroeconomic constraints, energy security requirements, and the objectives of the "green transition."

The author's definition of economic development in the energy sector, formulated in the course of the study, expands the existing conceptual framework by framing this process as a structurally balanced and progressive development of the sector's production, technological, and institutional potential. This interpretation provides a methodological foundation for a more accurate assessment of current trends and for the formulation of effective strategies for public administration in the energy sector at both national and regional levels.

Thus, the results of the study confirm the need for a systemic approach to the analysis and governance of energy sector development—one that integrates economic, technological, and environmental factors. The findings can serve as a theoretical basis for further scientific research in strategic planning, energy policy, sustainable growth modeling, and the assessment of the investment potential of the energy sector.

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STATISTICAL ANALYSIS OF REGIONAL ECONOMIC POTENTIAL (A CASE STUDY OF NAMANGAN REGION)

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Abstract: This article presents theoretical views on the economic potential, infrastructure, and changes in the welfare of the population of Namangan region based on the analysis of statistical data. It also provides conclusions and recommendations through studying and analyzing the problems emerging in the region’s economy.

Key words: economic growth, volume of investments, per capita income, GDP, industrial enterprises, agriculture, export volume.

Annotatsiya: Ushbu maqolada statistik ma’lumotlar tahlili asosida Namangan viloyatining iqtisodiy salohiyati, infratuzilmasi hamda aholi farovonligining qay darajada o‘zgarayotgani yuzasidan nazariy fikrlar bayon etilgan. Shuningdek, viloyat iqtisodiyotida yuzaga kelayotgan muammolarni o‘rganish va tahlil qilish orqali asoslangan xulosa hamda takliflar ishlab chiqilgan.

Kalit so‘zlar: iqtisodiy o‘sish, investitsiyalar hajmi, aholi jon boshiga to‘g‘ri keladigan daromad, YIM, sanoat korxonalari, qishloq xo‘jaligi, eksport hajmi.

Аннотация: В данной статье, на основе анализа статистических данных, представлены теоретические взгляды на экономический потенциал, инфраструктуру и изменения уровня благосостояния населения Наманганской области. Также даны выводы и рекомендации через изучение и анализ проблем, возникающих в экономике региона.

Ключевые слова: экономический рост, объем инвестиций, доход на душу населения, ВВП, промышленные предприятия, сельское хозяйство, объём экспорта.

INTRODUCTION

The sustainable economic development of countries is primarily determined by the extent to which they effectively utilize their regional economic potential. Rational use of available natural, economic, and labor resources in the regions, the proper location of production enterprises, the establishment of modern industrial zones, and support for the activities of business entities are among the most pressing issues today. The introduction of modern equipment and technologies into production processes, as well as the adaptation of foreign experience to local conditions, contributes to increasing efficiency and enhancing labor productivity in enterprises.

These issues are also identified as priority areas within state policy aimed at ensuring regional development. In particular, the Resolution of the President of the Republic of Uzbekistan No. PQ-3182[1] dated August 8, 2017, “On Priority Measures to Ensure Accelerated Socio-Economic Development of Regions,” defines key objectives such as the effective use of the natural, economic, and human potential of regions, rational use of production

1 https://lex.uz/docs/-3302438

and land resources, expansion of export opportunities, development of modern market infrastructure, and creation of new jobs [1]. This document emphasizes the need to implement regional development based on a comprehensive approach and to fully utilize existing potential.

At the same time, assessing regional economic development solely through individual indicators—such as the volume of industrial output, the amount of investment, or the level of technological adoption—does not yield comprehensive results. Economic growth of a region is the outcome of the interaction of multiple factors over a certain period of time; therefore, a comprehensive analysis of development, involving the joint examination of internal and external factors, is required. Demographic conditions, the structure of labor resources, the investment climate, diversification of production sectors, and the development of the services sector constitute integral components of regional economic potential.

From this perspective, studying the economic potential of Namangan region makes it possible to identify existing opportunities, assess the level of development across sectors, clarify the factors influencing economic processes, and develop proposals to address existing challenges. The region's demographic growth rates, expansion of production sectors, development of small business and entrepreneurship, as well as changes in export–import activities, necessitate an in-depth analysis of regional economic potential.

This study is aimed at analyzing the socio-economic development indicators of Namangan region on the basis of statistical data and at providing a scientific assessment of the region's existing potential and future development prospects.

REVIEW OF LITERATURE ON THE SUBJECT

German economist Alfred Weber, in his work "Theory of the Location of Industries," explains the location of industrial enterprises—namely, the reduction or increase of enterprise costs, transport costs, proximity to raw material sources, and the influence of labor—through a scientific model [2].

Economist August Lösch, in "The Economics of Location," substantiates the need for economic units—such as manufacturing enterprises, sellers, or supplying entities—to identify the most optimal location centers for their activities, while also taking into account the territorial distribution of consumers. In addition, A. Lösch provides a comprehensive interpretation of the concept of agglomeration, explaining the concentration of economic activities within a single territory through the interactions, cooperation, and interdependence of enterprises, industries, and the population [3].

Moreover, numerous Uzbek economists—A. Ortiqov [4], D. Jo'rayev, Sh. Hamroyev, J. Abdurahmonov, and R. Qodirov—have, in their studies, conducted in-depth analyses of regional development, resource utilization, population distribution, urban systems, regional development strategies, assessment of socio-economic development and potential of regions, economic development strategies, regional modernization, evaluation of the effectiveness of industrial zones, economic development of rural areas, and the spatial distribution of productive forces. Based on these analyses, they have proposed scientific solutions aimed at addressing and improving existing problems in the national economy.

The methodology of this study is aimed at assessing the economic potential of Namangan region based on a comprehensive and systemic approach, grounded in the integration of theoretical concepts, statistical data, and analytical methods. The object of the research is the socio-economic development processes of Namangan region, while the subject of the research comprises the factors shaping the region's economic potential—namely, gross regional product, industrial and agricultural output, investment volume, number of enterprises, export–import indicators, employment, and demographic dynamics. The main objective of the study is to assess the current state of Namangan region's economic potential on the basis of statistical indicators, identify intersectoral changes, and substantiate development opportunities. To achieve this objective, tasks such as systematizing economic indicators, analyzing changes over time, identifying interrelationships among factors, and assessing internal and external factors influencing economic processes were carried out.

The data base of the study consists of materials from the State Statistics Committee of the Republic of Uzbekistan, the Namangan Regional Department of Statistics, regional economic programs, and official regulatory and legal documents. Statistical data for the period 2019–2024 were selected, as this timeframe is significant for relatively fully reflecting the effects of the pandemic, economic recovery, and changes in investment activity. A set of economic and statistical methods was applied in the analysis: horizontal analysis was used to determine annual growth rates of indicators, vertical analysis to assess the sectoral structure of gross regional product, comparative analysis to compare indicators with each other, and trend analysis to identify dynamic patterns. Graphs and diagrams were employed to visually analyze indicators such as demographic processes, investment volumes, and export–import dynamics.

In addition, the study relies on A. Weber's model of industrial location, A. Lösch's theory of regional economic development and agglomeration, as well as the scientific works of domestic economists on regional

development as its theoretical foundation. This approach made it possible to theoretically substantiate factors such as territorial location, resource utilization, spatial distribution of production, and infrastructure development that influence the formation of Namangan region's economy.

RESEARCH METHODOLOGY

During the research process, the factors influencing economic growth were assessed in terms of their interrelationships: the growth of gross regional product was analyzed in connection with investment volumes, production activity, and the number of enterprises, while employment levels were examined in relation to industrialization and agricultural efficiency. In addition, factors such as the export–import balance, technological modernization, demographic pressure, and the condition of the labor market were studied as integral components of economic processes.

The study identified several limitations, including insufficient statistical data for certain years, the incomplete reflection of real economic conditions during the pandemic period, and the limited availability of detailed open data for some sectors. At the same time, these limitations were taken into account in the interpretation of the research results, and, in order to ensure the reliability of the analysis, the most accurate possible statistical approach was applied within the scope of available official sources.

ANALYSIS AND RESULTS

Assessing the economic potential of regions requires the identification and elimination of existing problems, as well as the implementation of measures aimed at strengthening regions economically. In the process of economic assessment, it is necessary to systematically analyze changes in various internal and external factors. Therefore, regional economic development, improvement of living standards, attraction and effective organization of domestic and foreign investments, and expansion of production volumes through the introduction of new equipment and technologies are of critical importance. At the same time, the possibility of increasing regional economic development solely through the isolated influence of individual factors is limited; ensuring regional economic growth requires a comprehensive examination of all influencing factors.

Namangan region is geographically located in the northwestern part of the Fergana Valley. The total area of the region is 30.3 thousand km². According to statistical data, as of January 1, 2025, the population of the region amounted to 3,131.7 thousand people (Table 1) [5].

Table 1. Main macroeconomic indicators of Namangan region by years[2]

Indicators	2019	2020	2021	2022	2023	2024
Gross Regional Product (GRP), bln soums	29,384.4	34,169.1	41,993.6	50,668.2	61,074.9	71,869.1
GRP per capita, soums	10,673,980.1	12,156,361.2	14,644,673.0	17,286,411.2	20,375,279.4	23,439,907.4
Industrial output, bln soums	8,818.1	11,011.9	14,695.1	18,120.5	21,906.8	31,696.2
Agricultural output, bln soums	15,509.0	17,913.1	21,596.0	25,157.7	30,015.6	32,497.2
Unemployment rate, %	9.1	10.6	9.7	8.9	7.0	–
Average monthly wage, soums	1,778,602.4	2,057,542.1	2,289,175.7	2,769,228.8	4,067,840.63	3,755,158.78
Number of enterprises	22,353	26,568	31,815	34,600	38,374	40,820

In 2019, the gross regional product of Namangan region amounted to 29,384.4 billion soums. The COVID-19 period caused a decline in gross domestic product and led to economic disruption not only in Namangan region but also across countries worldwide. As a result, the volume of GRP in the region decreased during this period. However, following the COVID-19 pandemic, economic recovery was observed in the regional economy, and the gross regional product began to grow gradually. By 2024, the GRP of Namangan region reached 71,869.1

2 Source: Author's compilation based on data from the Namangan Regional Department of the State Statistics Committee of the Republic of Uzbekistan

billion soums, which represents an increase of nearly 2.5 times compared to 2019. This growth is primarily attributed to the development of small business and the increase in investments in fixed capital aimed at regional development.

Improving the welfare of the population residing in the region, creating new jobs, and increasing real incomes are also considered important socio-economic objectives (Figure 1).

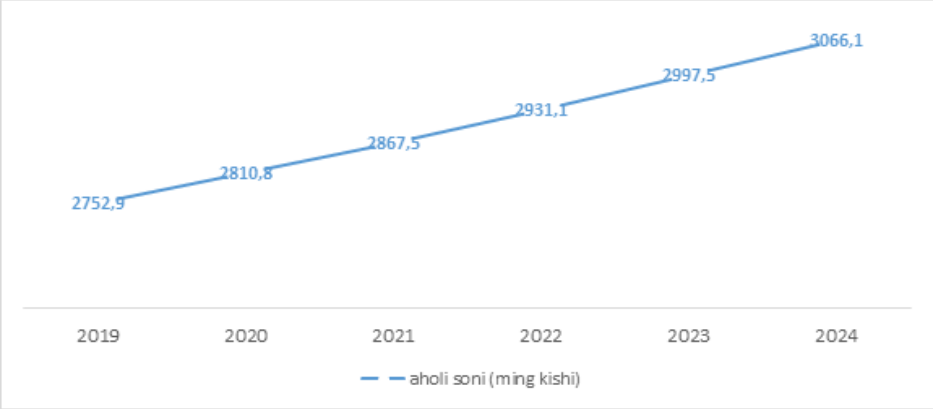

Figure 1. Population Growth Dynamics in Namangan Region[3]

As can be seen from the above graph, the population of Namangan region has been growing at a rapid pace. In 2019, the population of the region amounted to 2,752.9 thousand people, while by 2024 this figure had reached 3,066.1 thousand, representing an increase of 11.3% compared to 2019. Population growth in the region leads to the formation of a large labor market. Under such conditions, it is considered necessary for regional authorities to implement the following key tasks:

- improving production capacities in the region;
- establishing industrial enterprises through investments;
- creating new jobs;
- increasing export volumes;
- identifying ways to raise household incomes;
- enhancing overall living standards of the population.

As noted above, population growth also results in an increase in the volume of labor resources. The structure of labor resources includes men and women of working age (respectively 16–60 and 16–55 years), individuals older than working age who are employed, as well as individuals younger than working age who are employed (from the age of 14) (Figure 2).

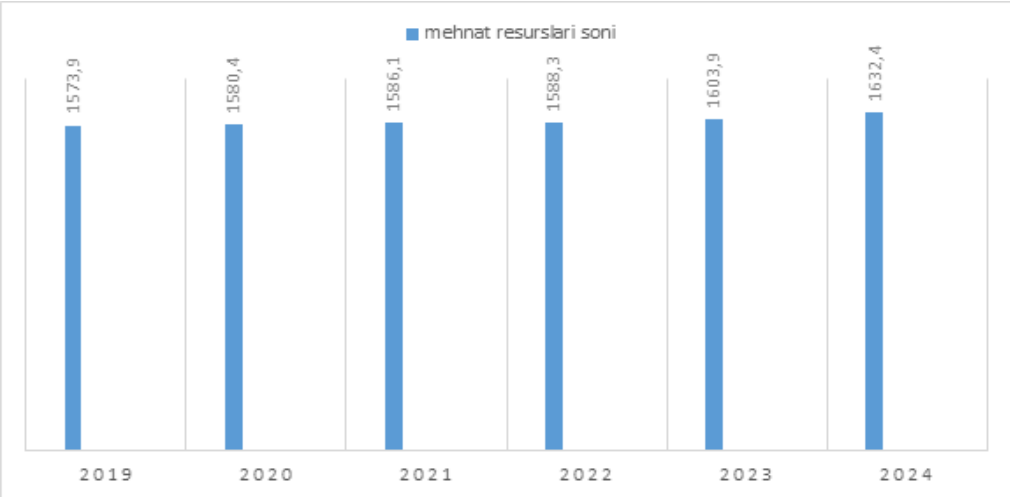

Figure 2. Number of Labor Resources in Namangan Region[4]

3 Source: Author's compilation based on data from the Namangan Regional Department of the State Statistics Committee of the Republic of Uzbekistan

4 Source: Author's compilation based on data from the Namangan Regional Department of the State Statistics Committee of the Republic of Uzbekistan

In 2019, the number of labor resources amounted to 1,573.9 thousand people, while by 2024 this figure had increased by 3.7% compared to 2019, reaching 1,632.4 thousand people.

In order to ensure the effective employment of a large labor force, increase incomes, and improve living standards, it is necessary to expand the number of industrial enterprises operating on the basis of innovative technologies in the region and to create new jobs. In addition, measures should be taken to expand educational coverage and introduce dual education systems to enhance the knowledge, skills, and experience of the workforce. In today's competitive market economy, education based solely on theoretical training (secondary specialized and higher education) is becoming an increasingly ineffective approach. Within the framework of the dual education system, the integration of theoretical knowledge with practical training enables the workforce to acquire skills and experience more quickly and efficiently, thereby contributing to increased economic efficiency (Figure 3).

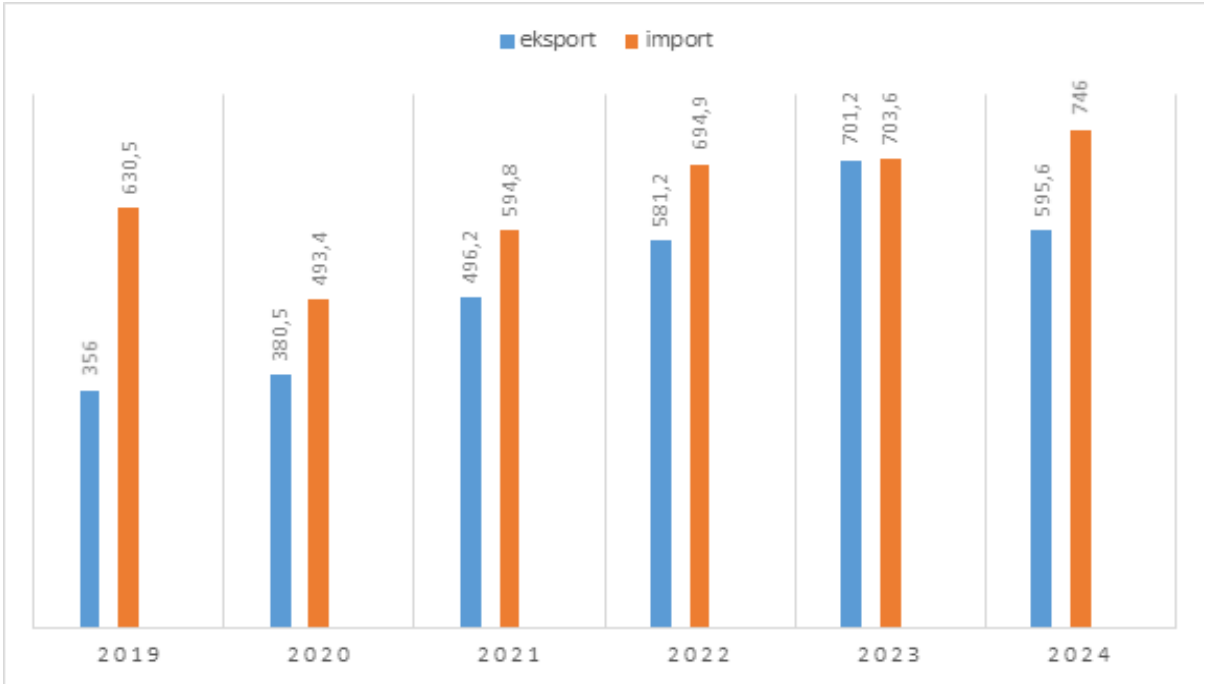

Figure 3. Export and Import Volumes in Namangan Region during 2019–2024[5]

The issue of increasing the region's export potential remains one of the most pressing challenges. At the same time, it should be noted that the region possesses substantial agricultural land resources, significant production capacity, and a broad range of opportunities created for enterprises.

In Namangan region, the development of the service and trade sectors makes it possible to increase revenues to the regional budget, as these sectors allow relatively high returns to be generated with comparatively lower capital investment.

In addition, the volume of service imports amounted to 2.8 thousand US dollars, or 0.01% of total imports, showing no significant change compared to the corresponding period of 2019 [6]. The main components of service imports were tourism, transport, and construction services.

Under the conditions of the COVID-19 pandemic, the introduction of quarantine measures in the regions led to a sharp decline in production levels, which in turn resulted in a reduction in regional export volumes. During this period, the growth in import volumes was driven by purchases of machinery and equipment for the healthcare system and other sectors, which accounted for 50.9%, while the purchase of chemical products and related goods accounted for 18.6%.

In 2019, export volumes amounted to 356 million US dollars, while imports totaled 630.5 million US dollars. Overall, during the period 2019–2024, both export and import volumes demonstrated a simultaneous upward trend; however, the share of imports consistently exceeded that of exports. By 2024, exports had increased by nearly 60% compared to 2019, reaching 595.6 million US dollars, while imports had grown by 84.5%.

During 2019–2020, the tightening of quarantine measures and the temporary suspension of production activities led to an increase in unemployment. In this period, the unemployment rate in the region amounted

5 Source: Author's compilation based on data from the Namangan Regional Department of the State Statistics Committee of the Republic of Uzbekistan

to 9.1% and 10.6%, respectively. Following the lifting of quarantine restrictions, employment opportunities for the economically active population expanded, making it possible to gradually reduce the unemployment rate in subsequent years (Figure 4).

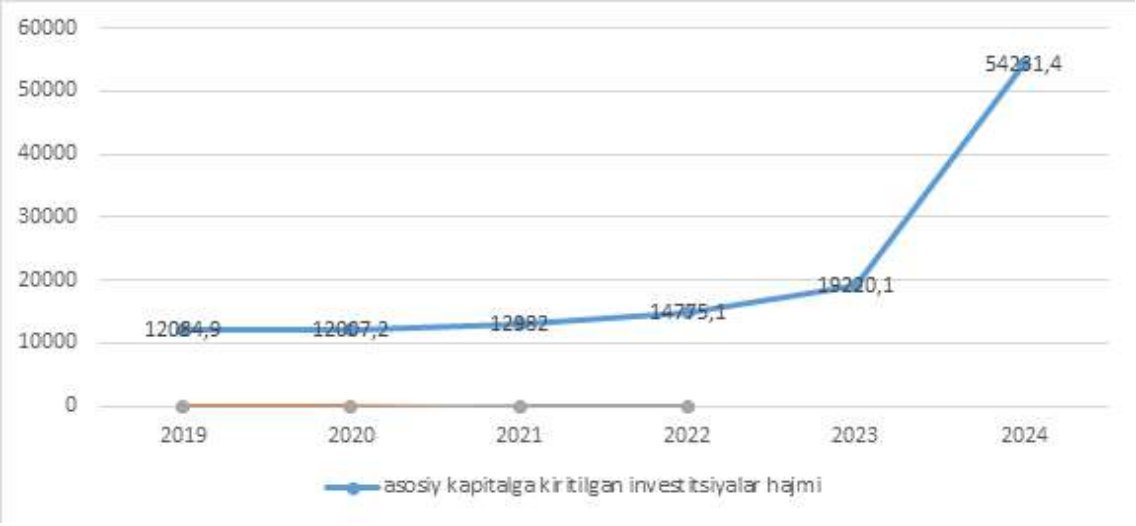

Figure 4. Volume of Investments in Fixed Capital (billion soums)[6]

An increase in the volume of investments in fixed capital signifies the expansion of production capacities, intensified technical modernization, and the growth of enterprise assets within the economy. During 2019–2022, the volume of investments in fixed capital remained relatively stable. In 2019, investments in fixed capital amounted to 12,084.9 billion soums, while by 2024 this indicator had increased by nearly 4.5 times, reaching 54,231.4 billion soums. The growth in fixed capital investments contributes to the establishment of new industrial enterprises in the region or the expansion of asset volumes at existing enterprises. As a result, opportunities emerge to alleviate the unemployment problem in the region.

In 2019, 22,353 enterprises were operating in the region, whereas by 2024 this number had risen to 40,820 enterprises. Over six years, the number of enterprises nearly doubled. The region also has high potential in agricultural production. In 2019, the total value of agricultural output amounted to 15,509.0 billion soums, and this indicator increased steadily over the years. By 2024, it had nearly doubled, reaching 32,497.2 billion soums.

Over time, the increase in the number of production enterprises, along with the development of the region's leading sectors—agriculture and industry—and the resolution of existing challenges within these sectors, has enabled the creation of new jobs and an increase in wages. In 2019, the average wage amounted to 1,778,602.4 soums, while by 2024 this figure had increased by 2.1 times, reaching 3,755,158.78 soums.

CONCLUSIONS AND SUGGESTIONS

In assessing the economic potential of a region, the development of the industrial, agricultural, service, and trade sectors is of particular importance. Enhancing efficiency in these sectors is achieved through the introduction of modern equipment and technologies into production processes, modernization of existing enterprises, rational use of resources, and the broad application of innovative approaches. Technological upgrades within these sectors increase economic efficiency and contribute to the region's overall economic growth.

The study results demonstrate that attracting investments and directing them toward fixed capital is a crucial factor in ensuring sustainable regional economic development. Increased investments in fixed capital enable the expansion of production capacities, the establishment of new enterprises, the growth of assets at existing enterprises, and technical and technological modernization. This process directly contributes to the growth of the region's gross domestic product.

The growing number of industrial enterprises leads to greater diversification of the regional economy, increased demand in the labor market, and a reduction in unemployment. Ensuring employment in line with professional qualifications, rising wages, and increasing real incomes not only strengthens economic stability but also improves the overall standard of living of the population.

6 Source: Author's compilation based on data from the Namangan Regional Department of the State Statistics Committee of the Republic of Uzbekistan

Overall, sectoral economic growth, intensified investment activity, increased export potential, a rising number of enterprises, and positive changes in household incomes in Namangan region indicate a steady increase in the region's economic potential. To sustain this process in the future, it is necessary to modernize key sectors, widely introduce innovative technologies, diversify exports, and develop comprehensive measures aimed at further increasing employment.

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DIRECTIONS FOR DEVELOPING INVESTMENT AND EXPORT IN REMOTE SERVICE ENTERPRISES

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Abstract: The scientific significance of this article is to identify the patterns of influence of remote service enterprises on investment processes in the context of digital transformation, as well as to identify mechanisms for stimulating innovation. The practical value of the work is to develop recommendations for business and government on the effective use of digital technologies in attracting investments and increasing the sustainability of the service economy.

Key words: digital transformation, innovation and investment activities, service sector, digital economy, fintech, artificial intelligence, big data, public-private partnerships, sustainable development.

Annotatsiya: Ushbu maqolaning ilmiy ahamiyati raqamli transformatsiya sharoitida masofaviy xizmat ko‘rsatish sohasi korxonalarining investitsiya jarayonlariga ta’sir etuvchi qonuniyatlarni aniqlash, shuningdek innovatsiyalarni rag‘batlantirish mexanizmlarini belgilashdan iborat. Ishning amaliy qiymati biznes va davlat boshqaruvi subyektlari uchun investitsiyalarni jalb etish hamda xizmat ko‘rsatish sohasi iqtisodiyotining barqarorligini oshirishda raqamli texnologiyalardan samarali foydalanish bo‘yicha amaliy tavsiyalar ishlab chiqilishi bilan izohlanadi.

Kalit so‘zlar: raqamli transformatsiya, innovatsion va investitsion faoliyat, xizmat ko‘rsatish sohasi, raqamli iqtisodiyot, fintech, sun’iy intellekt, katta ma’lumotlar (Big Data), davlat-xususiy sheriklik, barqaror rivojlanish.

Аннотация: Научная значимость данной статьи заключается в выявлении закономерностей влияния предприятий, предоставляющих удаленные услуги, на инвестиционные процессы в контексте цифровой трансформации, а также в определении механизмов стимулирования инноваций. Практическая ценность работы состоит в разработке рекомендаций для бизнеса и правительства по эффективному использованию цифровых технологий для привлечения инвестиций и повышения устойчивости экономики услуг.

Ключевые слова: цифровая трансформация, инновационная и инвестиционная деятельность, сектор услуг, цифровая экономика, финтех, искусственный интеллект, большие данные, государственно-частное партнерство, устойчивое развитие.

INTRODUCTION

In the context of accelerating global digitalization, companies in the remote service sector of Uzbekistan are faced with the need to deeply transform their innovation and investment strategies. Digital transformation is becoming a key factor in increasing competitiveness, reducing transaction costs, and accelerating innovation in segments such as financial services, logistics, education, healthcare, hospitality and tourism, and e-commerce. In 2023-2025, investments in digital services infrastructure in Uzbekistan increased by more than 32%, and

the share of online platforms in the total transaction volume reached 38%. Government programs and support from international financial institutions are creating favorable conditions for capital flows and the introduction of innovative technologies.

Particular attention is being paid to the development of artificial intelligence, big data, cloud services and fintech solutions. These technologies allow service enterprises to increase productivity, personalize customer experience and create new business models. The development of digital financial instruments such as crowdfunding, venture capital and public-private partnerships is playing an important role in ensuring the rapid modernization of service industries.

REVIEW OF LITERATURE ON THE SUBJECT

The Decree of the President of the Republic of Uzbekistan "On Additional Measures to Support the Training of Qualified Specialists in the Field of Digitalization", No. PQ-51, dated February-1, 2024, was adopted to ensure the implementation of the law and to support youth IT services, as well as to organize assistance for non-governmental educational organizations that train specialists for modern professions with high demand in the export sector. Starting from March-1, 2024, a one-time subsidy program was introduced for non-state educational organizations. Under this program, subsidies are provided in the amount of up to 75 times the base calculation amount when a graduate is employed by an organization exporting IT services, and up to 105 times the base calculation amount when a young graduate with a disability is employed by such an organization. Corresponding priorities and benefits were also established [1, 2].

The research of prominent scientists in the field of economic informatics and automated control systems, in particular G'ulomov S.S., is devoted to the issues of increasing the efficiency of the use and implementation of information and communication technologies in various sectors of the national economy [3].

The scientific works of Begalov B.A. cover the formation of information and communication technologies, their technological foundations, the development of the digital economy in the world and in Uzbekistan, as well as issues related to the introduction of ICT in enterprises. In turn, Odilov Sh.G'. proposed approaches and recommendations for improving company logistics processes based on the application of information and communication technologies [3, 4].

RESEARCH METHODOLOGY

The article uses monographic, expert and systematic analysis methods. The following methods were used: system analysis, factor analysis, and the views of leading scientists on improving the efficiency of remote service provision through the use of digital technologies.

ANALYSIS AND RESULTS

636 companies in January-May 2025IT Park Uzbekistan received the status of resident. This indicates a steady growth in interest in the country as a new global IT hub. 369 of them were registered in Tashkent and 267 in the regions, which indicates the ongoing digitization and technological development throughout the country.

The high share of export-oriented companies is particularly noteworthy - 284 residents plan to provide services abroad, 117 of which are foreign companies. Export-oriented companies in the capital have targeted exports of more than $46 million, while companies in the regions have targeted exports of more than $31 million. This data highlights the contribution of the IT sector to the country's foreign exchange earnings and the development of the digital economy.

Resident companies are actively working in four main areas:

IT services (142 companies, of which 72 are foreign);

BPO (87 companies, including 19 foreign);

Service services (33 companies, 16 of them foreign);

Game development and creative industries (22 companies, 10 of which are foreign).

In May 2025, 116 new companies were registered in the IT Park, bringing the total number of residents to 2,846. 51 export-oriented companies, 22 of which are companies with foreign capital, received the status of IT Park residents. The companies were established in countries such as the USA, Japan, Korea, Great Britain, France, Jordan, Romania, Spain, Iran and Pakistan. Their structure of activity includes:

23 companies provide BPO and other services;

17 are is working on creating IT products;

7 one specializes in IT services;

4 are developing in the creative industries.

In May, 17 companies received export-oriented resident status at the IT Park regional offices, 7 of which are companies with foreign capital. They are expected to create more than 235 jobs and ensure exports of more than $2.6 million.

Among the new residents of the IT Park with foreign capital are technology companies providing export services in the fields of artificial intelligence, engineering, BPO and EdTech. Their geography of activity covers the regions of Europe, the Middle East, Asia and Australia, including:

"OSYSTEMS" (Spain, Jordan) it is implementing its own program to develop, train, and deploy autonomous artificial intelligence models specializing in data analysis for the Jordanian, Qatari, and US markets.

"FORTIS INSTRUMENTS SOUTH" (France) provides engineering services in the field of radiation monitoring, providing a high level of technological expertise for the French market.

"HUCORP GLOBAL" (Korea) is engaged in the localization of educational content and its export to Korea, contributing to the development of the EdTech sector internationally.

"EUROANSWER" (Romania) provides comprehensive BPO services for clients in Western Europe, including technical support and customer service for the German, French, Spanish, and Italian markets.

UNITLAB AI (USA) offers a data annotation platform equipped with its own AI-based automatic annotation models and workflow management tools. The company is engaged in outsourcing services to Germany, Australia, and France.

Data for the first five months of 2025 show that Uzbekistan is strengthening its position on the global IT map as a country with a favorable ecosystem for starting and expanding a business. The growth of exporters and foreign capital in the IT Park residents reflects the confidence of international investors and companies. The steady expansion into regions and the sophistication of the range of services provided indicate that the country's IT market has reached a new level of maturity.

Interest in Uzbekistan among foreign entrepreneurs remains stable: since the beginning of the year, 164 companies with foreign capital have joined the ranks of IT Park residents. In total, the geography of residents covers 61 countries, including new destinations such as Jordan, Hong Kong, Indonesia, Liechtenstein, New Zealand and Norway.

The growth rates of companies from a number of countries are particularly noteworthy: in 2025, the number of Japanese residents doubled, those from China increased by 71 percent, those from Turkey by 133 percent, and those from Azerbaijan by 67 percent. These indicators clearly confirm the attractiveness of the local IT market for international business.

There is also a growing share of BPO and service companies that are starting to provide more complex and high-profit services, such as consulting on training, business analysis, technical documentation, and statistical data preparation. This indicates an increasing level of professionalism among Uzbek teams.

Uzbekistan IT services the number of exporters increased by 70% in the first nine months of this year. By the end of September, 936 enterprises within the IT Park exported digital services to 78 countries, a significant increase compared to 58 countries last year.

The growth in export activity is significant, with more than a third of IT Park residents earning income from international trade. Among the new exporters, just over half are engaged in the provision of IT services, such as software development, modification and technical support. In addition, 190 companies operate in outsourcing services, and 21 enterprises operate in the creative industry and GameDev sector.

Regional developments are also noteworthy: 191 exporting companies have started operating across the country. The volume of IT services provided to foreign countries has increased by 374%. Tashkent region leads with 32 enterprises, followed by Samarkand with 29 and Jizzakh with 17.

In the third quarter alone, 84 joint ventures and a total of more than 200 IT companies with foreign participation were established. These enterprises were founded by investors from 52 countries, including the USA, Great Britain, Germany, France, China, Japan, the UAE, India and Singapore.

The geography of Uzbekistan exports of digital products and services is notable for covering 78 countries. North America remains the largest market - 45% of foreign revenues fall on this region. The CIS countries and the Asia-Pacific region account for 27%, the share of European markets is 21%, and the Middle East and North Africa countries are 6%.

In mid-October, President Shavkat Mirziyoyev announced new incentives for export-oriented IT companies founded by foreign founders. The reforms include a reduction in income tax and corporate tax rates to 5%, aimed at creating a more favorable environment for international business.

CONCLUSIONS AND SUGGESTIONS

In conclusion, we can note that supporting startups gives an additional impetus to the development of the creative economy: this year, $50 million has been allocated for their financing. These funds will be directed to the development of youth initiatives and the attraction of compatriots working in international companies.

The volume of IT services is expected to increase by 30% to 80 trillion soums, and exports will exceed $1 billion. Digitalization of regions and industries will remain an important direction.

The specific features and specific aspects of the development of the field of remote services were studied, the volume of services provided by types of economic activity in our country and trends in their growth rates were analyzed. Reforms aimed at the accelerated development of these sectors were also studied, and proposals were developed for further development of the service sector based on innovative tools and methods and increasing economic efficiency in the sector.

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УДК: 331.2:332.1

SPECIFIC FEATURES OF ENTREPRENEURSHIP IN INCREASING THE INCOME OF THE POPULATION IN THE REGION

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Abstract: The article examines the theoretical and practical aspects of entrepreneurship as a key factor in increasing household incomes at the regional level. It analyzes the historical evolution of entrepreneurship and its modern forms, including services, trade, tourism, logistics, agricultural services, and financial services. Special attention is paid to the role of entrepreneurship in job creation, income generation, poverty reduction, and improving living standards. The study substantiates entrepreneurship as an effective instrument of regional socio-economic development and sustainable income growth for the population.

Key words: entrepreneurship, service sector, trade, tourism, logistics, agricultural services, financial services, employment, household income.

Annotatsiya: Maqolada hududlar kesimida aholining daromadlarini oshirishda tadbirkorlik faoliyatining o‘rni va ahamiyati ilmiy-nazariy hamda amaliy jihatdan tahlil qilingan. Tadbirkorlikning shakllanish va rivojlanish bosqichlari, uning zamonaviy yo‘nalishlari, jumladan xizmatlar sohasi, savdo, turizm, logistika, agroxizmatlar va moliyaviy xizmatlar faoliyati yoritib berilgan. Shuningdek, tadbirkorlikning bandlikni ta’minlash, barqaror daromad manbalarini shakllantirish hamda aholi farovonligini oshirishdagi roli asoslab berilgan. Tadqiqot natijalari tadbirkorlikning hududiy ijtimoiy-iqtisodiy rivojlanishdagi strategik ahamiyatini ko‘rsatadi.

Kalit so‘zlar: tadbirkorlik, xizmatlar sohasi, savdo, turizm, logistika, agroxizmatlar, moliyaviy xizmatlar, bandlik, aholi daromadlari.

Аннотация: В статье рассматриваются теоретические и практические аспекты развития предпринимательства как одного из ключевых факторов повышения доходов населения в региональном разрезе. Раскрывается эволюция предпринимательской деятельности, ее современные формы и направления, включая сферу услуг, торговлю, туризм, логистику, аграрные и финансовые услуги. Особое внимание уделяется роли предпринимательства в обеспечении занятости, формировании устойчивых источников доходов и снижении уровня бедности. Обосновывается значение предпринимательской активности как инструмента социально-экономического развития регионов и повышения уровня жизни населения.

Ключевые слова: предпринимательство, сфера услуг, торговля, туризм, логистика, агроуслуги, финансовые услуги, занятость, доходы населения.

INTRODUCTION

The development of entrepreneurship in the region has deep historical roots and has evolved in successive stages. Undoubtedly, the development of entrepreneurship is a key factor in increasing the income of the population, as it contributes to the creation of new jobs, strengthens economic activity, and expands the financial opportunities available to households. The issue of identifying effective directions for increasing population incomes in the region is one of the most important areas of economic research and is examined from various perspectives, including labor economics, social policy, regional economic development, poverty reduction, and the impact of government programs.

REVIEW OF LITERATURE ON THE SUBJECT

When referring to the theoretical foundations and general approaches to this topic, classical economic works by A. Smith, D. Ricardo, and J.B. Say present ideas on increasing population incomes through productivity growth and the development of production. The works of other scholars also describe the theoretical foundations of income formation through wages, capital, and labor relations. In the studies of J.M. Keynes, ways to increase population incomes are substantiated through active government participation in the economy and the provision of full employment. M. Friedman and representatives of the monetarist school examined the impact of economic growth and monetary policy on population incomes.

Among foreign researchers, S. Kuznets developed the Kuznets law, which defines the relationship between income distribution and economic growth. In 2014, T. Piketty substantiated the impact of unequal income and wealth distribution on economic development. Economist J. Stiglitz also identified directions of economic policy and measures aimed at reducing inequality and increasing incomes. Today, World Bank reports are devoted to ways of increasing population incomes through employment expansion, support for small businesses, and poverty reduction.

In our country, increasing population incomes, reducing poverty, and supporting entrepreneurship are defined as priority objectives of state policy, with a clear linkage ensured between income growth dynamics and government programs. Among Uzbek scholars, A. Abdullaev, M. Tozhiboev, Sh. Tursunov, B. Khamdamov, and others have conducted research in the fields of labor markets, employment, income distribution, and service sector development. The literature review shows that pathways for increasing population incomes are closely linked to labor market development, support for small businesses and entrepreneurship, strengthening social policy, inflation regulation, and the expansion of innovative service sectors. In international literature, the main emphasis is placed on the issue of income inequality and its reduction, whereas studies in Uzbekistan focus on increasing population incomes through poverty reduction, government programs, and regional development.

RESEARCH METHODOLOGY

The role and specific features of entrepreneurship in increasing regional population incomes are examined using methods of economic analysis, comparison, and grouping, which make it possible to identify opportunities for income growth within the republic. This process includes comparing achieved results with international experience, as well as selecting prospective pathways aimed at expanding income-growth opportunities through the further development of entrepreneurship.

ANALYSIS AND RESULTS

In the process of transitioning to a market economy, entrepreneurial activity is one of the main drivers of economic growth. The development of entrepreneurship not only creates new jobs but also increases employment levels, expands income sources, and strengthens socio-economic stability in the regions. The economic reforms currently being implemented in Uzbekistan—particularly policies aimed at supporting small businesses and private entrepreneurship—serve as key factors in improving the welfare of the population in the regions.

The impact of entrepreneurial development on population incomes is primarily manifested through employment expansion and income growth. Entrepreneurship is the main source of new jobs, and each new small business project creates, on average, between 3 and 10 permanent jobs. Increased employment among women and youth significantly raises household incomes. As a result, labor incomes grow, consumer opportunities expand, and poverty levels decline.

In addition, entrepreneurship ensures the efficient use of local resources by integrating them into economic circulation, including agricultural raw materials, mineral resources, tourism potential, and handicraft traditions. This contributes to the creation of new products, the development of new markets, the formation of value-added chains, and income growth. [1]

The development of market infrastructure leads to the formation of banking, logistics, and marketing service systems, modern shopping centers, business centers, transport networks, and other facilities. This increases the volume of services in the region, promotes employment diversification, and stabilizes incomes.

The main directions for the development of this sector include:

1. Support for small businesses and private entrepreneurship: provision of tax incentives, loans, and subsidies; reduction of administrative barriers; simplification of licensing and permitting procedures; and provision of financial and legal consulting services to entrepreneurs.
2. Development of entrepreneurial infrastructure: establishment of innovation centers, business incubators, and technoparks; improvement of logistics and transport infrastructure; expansion of trade networks; and creation of digital platforms for the development of e-commerce.

3. Employment promotion and job creation: involvement of youth, women, and low-income households in entrepreneurship; establishment of small enterprises for agricultural processing and service delivery; and development of business skills through vocational training.

4. Use of innovation and the digital economy: creation of conditions for online services and startups; promotion of local products to international markets through digital platforms; and development of production and services based on new technologies.

5. Use of international experience: attraction of international grants and investments; adaptation of cluster systems widely used in many countries; and expansion of public-private partnership practices.

6. Social impact: growth of real population incomes, improvement in living standards, poverty reduction, increased local budget revenues, and their allocation to infrastructure development. [2]

The above analysis demonstrates that stimulating entrepreneurship is one of the most effective ways to increase employment, raise population incomes, and achieve social stability. In the context of the global economy, alongside traditional forms of entrepreneurship (trade, services, manufacturing), new modern forms based on technology and innovation are developing rapidly.

Modern forms of entrepreneurship include:

1. IT startups and digital entrepreneurship
2. Digital entrepreneurship
3. Freelancing and the gig economy
4. Crowdfunding and crowdsourcing
5. Fintech entrepreneurship
6. Green entrepreneurship
7. Innovative services and startup incubators
8. Social entrepreneurship
9. Agribusiness and agri-startups
10. Freelancing and remote services

Economic efficiency and population incomes also increase through the development of local production and the expansion of export potential. For example, the construction of modern greenhouses in the Kashkadarya region has created new jobs and significantly increased rural incomes. Preferential lending to small businesses by commercial banks stimulates entrepreneurial activity. The growth of enterprises in the light and food industries also has a positive impact on employment and population incomes. [3]

We consider it appropriate to propose the following recommendations:

• to strengthen cooperation between regional authorities and the private sector;

• to increase the volume of financial resources allocated to the development of small and medium-sized businesses;

• to expand programs for professional development and the introduction of innovative technologies in the field of entrepreneurship.

Increasing population incomes through the development of entrepreneurship is one of the key factors in achieving economic stability and social well-being in the regions. It is particularly important to examine the socio-economic essence of this process using the example of the Kashkadarya region.

An analysis of the dynamics of entrepreneurial development and population income growth in the Kashkadarya region shows that between 2020 and 2024 the number of entrepreneurial entities increased from 32.5 thousand to 46.5 thousand. During the same period, the number of newly created jobs rose from 18.2 thousand to 29.0 thousand. These indicators demonstrate the significant social role of entrepreneurship in ensuring employment and reducing unemployment. Average population incomes also increased markedly, from 2.3 million soums in 2020 to 4.2 million soums in 2024. The unemployment rate declined from 9.8% to 7.0%. Data analysis reveals a direct relationship between the growth in the number of entrepreneurial entities, job creation, and rising population incomes. [4]

Statistical data for Uzbekistan as a whole also confirm this trend: in 2024, the share of small business and private entrepreneurship in GDP amounted to approximately 55%. More than 74% of the employed population works in entrepreneurship and services. In 2023 alone, over 500 thousand new jobs were created, a significant proportion of which were in small business and the service sector. The incomes of households engaged in entrepreneurial activity are 1.5–2 times higher than those of other population groups. [5]

In rural areas, preferential loans within family entrepreneurship programs contribute to the development of livestock breeding, poultry farming, horticulture, and service activities. Programs supporting youth and women's entrepreneurship have enabled hundreds of thousands of young people to start their own businesses. The "Every Family Is an Entrepreneur" program has proven particularly effective.

International experience also illustrates this pattern: in Germany, small businesses account for 90% of exporters, making them a crucial factor in income growth and employment. In South Korea, startups and innovative entrepreneurship serve as the engines of economic growth.

Thus, supporting entrepreneurship and developing its infrastructure are key factors in increasing population incomes in the regions. The main indicators include a 55% share of small business in GDP, 74% employment in small business, and 500 thousand new jobs created in 2023. [5]

CONCLUSIONS AND SUGGESTIONS

In conclusion, it can be stated that digital, innovative, and social entrepreneurship represent the most modern directions in the development of this sector. They not only generate financial benefits but also stimulate broader socio-economic changes. Entrepreneurship creates new jobs and forms sources of higher incomes.

As a result of entrepreneurial development, the following outcomes are expected:

- a 20–30% increase in employment;
- a 1.5–2 times increase in incomes from family entrepreneurship;
- a significant reduction in poverty levels;
- a sharp increase in the share of services in gross regional product.

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KEY FACTORS OF ATTRACTING INVESTMENT THROUGH SUBSIDIES AND INVESTMENTS TO INCREASE AGRICULTURAL CROP PRODUCTION IN UZBEKISTAN

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Abstract: This article analyzes the key factors of the subsidy and investment system in increasing agricultural crop production in Uzbekistan. It identifies that population growth, the need to ensure food security, and the limited availability of land and water resources intensify the demand for innovative agricultural technologies. The study evaluates the digitalization of subsidy mechanisms, the implementation of a proactive payment system, and the economic efficiency of investments directed toward the agricultural sector. It also examines production expansion trends based on vertical farming, precision agriculture, water-saving irrigation technologies, and high-yield crop varieties. The results show that improving the agricultural subsidy system and strengthening investment flows are strategic factors for ensuring economic sustainability in Uzbekistan's agricultural sector.

Key words: agriculture, subsidy, investment, vertical farming, irrigation technologies, innovation, food security, agrosubsidy, Uzbekistan's agrarian policy.

Annotatsiya: Ushbu maqolada O‘zbekistonda qishloq xo‘jaligi ekinlarini yetishtirish hajmini oshirishda subsidiya va investitsiyalar tizimining asosiy omillari tahlil qilingan. Aholi sonining o‘sishi, oziq-ovqat xavfsizligini ta’minlash zaruriyati hamda yer va suv resurslarining cheklanganligi innovatsion agrar texnologiyalarga bo‘lgan ehtiyojni kuchaytirayotgani aniqlangan. Tadqiqotda subsidiya mexanizmlarining raqamlashtirilishi, proaktiv to‘lov tizimining joriy etilishi va qishloq xo‘jaligiga yo‘naltirilayotgan investitsiyalarning iqtisodiy samaradorligi baholangan. Shuningdek, vertikal dehqonchilik, aniq qishloq xo‘jaligi, suvni tejaydigan sug‘orish texnologiyalari hamda yuqori hosildor navlar asosida ishlab chiqarish hajmining kengayish tendensiyalari o‘rganilgan. Olingan natijalar O‘zbekistonda agrar sohada subsidiyalarni takomillashtirish va investitsiya oqimini kuchaytirish iqtisodiy barqarorlikni ta’minlashda strategik omil ekanini ko‘rsatadi.

Kalit so‘zlar: qishloq xo‘jaligi, subsidiya, investitsiya, vertikal dehqonchilik, sug‘orish texnologiyalari, innovatsiya, oziq-ovqat xavfsizligi, agrosubsidiya, O‘zbekiston agrar siyosati.

Аннотация: В данной статье проанализированы основные факторы системы субсидий и инвестиций в повышении объёмов производства сельскохозяйственных культур в Узбекистане. Установлено, что рост численности населения, необходимость обеспечения продовольственной безопасности, а также ограниченность земельных и водных ресурсов усиливают потребность в инновационных аграрных технологиях. В исследовании оценены цифровизация механизмов субсидирования, внедрение проактивной системы платежей и экономическая эффективность инвестиций, направляемых в сельское хозяйство. Также изучены тенденции расширения производства на основе вертикального земледелия, точного сельского хозяйства, водосберегающих ирригационных технологий и высокоурожайных сортов. Результаты показывают, что совершенствование системы аграрных субсидий и усиление инвестиционных потоков являются стратегическим фактором обеспечения экономической устойчивости аграрного сектора Узбекистана.

Ключевые слова: сельское хозяйство, субсидия, инвестиция, вертикальное земледелие, ирригационные технологии, инновации, продовольственная безопасность, агросубсидия, аграрная политика Узбекистана.

INTRODUCTION

In Uzbekistan, agriculture is widely recognized as one of the most stable and promising sectors for medium- and long-term investments and subsidies. State support and access to subsidies for agricultural producers are driven by the constant demand for food products, the continued growth of global consumption, and the rapid modernization of the sector itself. Investments in agriculture have always been significant and will remain so as population growth continues, as they provide entry into a sector that is essential for societal development.

Several factors make agricultural financing, agrarian subsidies, and investment particularly attractive for investors: Population growth and rising demand for food strengthen farmers' confidence and incentives, serving as decisive factors for the sustainable development of the agrarian sector.

According to data from the National Statistics Committee, as of 1 July 2025, the permanent population of Uzbekistan amounted to 37.9 million people.

REVIEW OF LITERATURE ON THE SUBJECT

Agriculture has long been recognized as a strategically important sector for ensuring food security, economic stability, and sustainable development, particularly in countries with growing populations and limited land resources. Classical economic theory emphasizes the fundamental role of agriculture in national development. Arthur Lewis, in his dual-sector model developed in 1954, highlighted agriculture as a critical foundation for labor absorption and capital accumulation in developing economies. This perspective remains relevant in contemporary analyses of agrarian transformation.

Modern research increasingly focuses on the role of technological innovation in enhancing agricultural productivity and resilience. Paul Collier and Stefan Dercon, in their work published in 2014, argue that agriculture in developing countries must shift from subsistence-oriented models toward investment-driven, technology-intensive systems in order to meet rising food demand and mitigate climate-related risks. Their findings underline the importance of state-supported investment frameworks and risk-sharing mechanisms.

The concept of precision agriculture has been extensively studied by John V. Stafford and Simon Blackmore, whose research in the early 2000s demonstrated that site-specific farm management significantly improves resource efficiency and yield stability. Later empirical studies by James Lowenberg-DeBoer confirmed that the adoption of GPS-based technologies, sensors, and data analytics reduces input waste and increases long-term farm profitability, particularly under conditions of land and water scarcity.

Vertical farming and controlled-environment agriculture have gained increasing attention as responses to urbanization, water shortages, and climate volatility. Dickson Despommier, in his seminal work published in 2010, conceptualized vertical farming as a viable solution for producing food closer to consumption centers while minimizing land use and water consumption. Subsequent studies by Leo Marcelis and colleagues demonstrated that controlled-environment systems significantly enhance crop yields and quality through optimized light, temperature, and nutrient management.

Soil fertility and sustainable land management remain central themes in agricultural economics and environmental studies. Rattan Lal's extensive research since the late 1990s has shown that soil degradation poses a major threat to global food security, while sustainable soil management practices improve both productivity and carbon sequestration. Lal emphasizes that long-term agricultural investment must incorporate soil health as a core performance indicator.

The role of high-yield and stress-resistant crop varieties has been addressed by Norman Borlaug and later by Prabhu Pingali. Borlaug's contributions to the Green Revolution demonstrated the transformative impact of improved crop genetics on food availability. Pingali's later analyses highlight that while high-yield varieties increase output, their effectiveness depends on complementary investments in irrigation, extension services, and institutional support.

From an institutional perspective, the importance of subsidies and state intervention in agriculture has been analyzed by Joseph Stiglitz and Jean-Paul Fitoussi, who argue that market failures in agriculture justify public support mechanisms, particularly in the presence of climate risk and price volatility. Reports by the Food and Agriculture Organization consistently confirm that well-targeted subsidies and investment incentives improve productivity and income stability without distorting markets when properly designed.

Investment risk and return characteristics in agriculture have been examined by Robert J. Shiller, who notes that agricultural assets often exhibit lower correlation with financial markets, providing diversification benefits for investors. However, Shiller also emphasizes the long payback periods and exposure to exogenous shocks, reinforcing the need for rigorous project evaluation and risk management.

Recent empirical studies by the World Bank and the OECD indicate that digitalization of subsidy systems and agricultural support programs reduces administrative inefficiencies and corruption risks. Research published

by the OECD in 2021 shows that digital platforms enhance transparency, improve targeting of beneficiaries, and strengthen investor confidence, particularly in emerging economies undergoing institutional reforms.

Overall, the literature suggests that agriculture remains an attractive sector for medium- and long-term investment when supported by effective state policies, technological innovation, and sound risk management. Scholars consistently emphasize that sustainable agricultural development requires an integrated approach combining financial incentives, modern technologies, institutional capacity, and environmental stewardship.

RESEARCH METHODOLOGY

The study is based on secondary data obtained from official statistical reports, government policy documents, and publications of international organizations related to agricultural development. Quantitative data were analyzed using descriptive statistics and comparative analysis, while qualitative information was examined through content analysis to identify key investment drivers, risks, and policy impacts on the agricultural sector.

ANALYSIS AND RESULTS

In Uzbekistan, the growing demand for food products implies an increasing need for agricultural producers to expand production. This applies to crop farming, livestock production, and storage solutions. The use of innovative technologies in the agricultural sector to enhance efficiency, productivity, sustainability, and profitability ensures stable long-term demand. Currently, the existing 52 types of subsidies are being reduced under a new system, the human factor is being minimized, and all processes are managed through the Agroportal platform. The Agrosubsidy information system is being integrated with databases from multiple government agencies. It is also envisaged that in 2026 subsidies totaling 1.3 trillion soums will be provided proactively by state authorities—without requiring applications from beneficiaries.

Given the limited availability of arable land, agriculture must rely on new technologies to increase productivity. Investment capital is primarily directed toward the following areas:

Vertical farming is the practice of growing crops in vertically and horizontally stacked layers. It often includes controlled-environment agriculture aimed at optimizing plant growth, as well as soilless farming techniques such as hydroponics (used in greenhouse farming), aquaponics (a system that integrates plant cultivation and fish farming in a closed-loop environment), and aeroponics (a method of growing plants in the air or mist environment without soil or aggregate media). Common structures used for vertical farming systems include buildings, shipping containers, underground tunnels, and abandoned mine shafts. Considering the critical importance of water for life, vertical farming appears to be a solution to the major challenges faced by many countries due to drought and drinking water scarcity. Many cities are adopting vertical farming to maximize the use of limited space. Moreover, vertical agriculture enables food production to be located closer to consumption centers or even directly within urban areas.

Precision farming, or precision agriculture, is an agricultural concept based on the existence of “within-field variability.” It focuses on applying the right input, in the right place, in the right way, and at the right time. This approach requires the use of modern technologies such as Global Positioning Systems (GPS), sensors, satellites, aerial imagery, and Geographic Information Systems (GIS) to assess and understand field variability. The collected data can be used to more accurately determine optimal planting density, calculate fertilizer and other input requirements, and forecast yields more precisely. This approach aims to avoid uniform practices regardless of local soil and climate conditions and helps better assess localized disease outbreaks or crop failures.

Soil fertility refers to the soil’s ability to supply plants with nutrients and moisture, provide sufficient air and heat to roots, and create favorable physical and chemical conditions for normal plant growth.

High-yield varieties are genetically improved crop varieties—such as rice, maize, and wheat—characterized by accelerated growth rates, increased proportions of usable plant components, or enhanced resistance to adverse conditions.

Promising investments also include technologies that promote the sustainable use of energy and water resources, such as thermal insulation, photovoltaic solar panels, geothermal heat pumps, energy-efficient boilers, and water-saving irrigation systems. These innovations significantly increase farm profitability and attract investors seeking high-growth opportunities in the agritech sector.

In Uzbekistan, medium- and long-term investments in agriculture are regarded as a national priority aimed at ensuring food security. As a result, investors benefit from:

- tax incentives;
- subsidies;
- grants;

• low-interest loans;
• reduced land lease costs.

State policy directly supports agricultural development, lowers entry barriers, and reduces investment risks.

Agriculture satisfies one of humanity's most fundamental needs—food. This inelastic demand makes the sector more resilient even during major economic downturns. However, not all agricultural investments are equally profitable, and proper project evaluation is critically important.

Advantages of investing in agriculture

• Stable demand for products. Food demand continues to grow year by year due to population growth and rising incomes.
• Rising agricultural commodity prices. Food price inflation often increases returns for investors.
• Positive impact on national economies. Agricultural projects create jobs, support rural areas, and strengthen food security.
• Lower competition compared to other industries. Many entrepreneurs avoid agriculture due to its complexity, creating opportunities for well-structured projects.

Disadvantages and risks

• Dependence on climate and seasonality. Weather conditions significantly affect yields and revenues.
• Long payback periods. Some agricultural projects yield returns more slowly than technology- or service-based investments.
• Market volatility. High yields may lead to lower market prices.
• Limited insurance coverage. Unexpected factors may affect production quality or market access.
• High depreciation of equipment. Machinery and storage systems require regular upgrades.
• Need for strong analytical capacity. Agricultural investments require thorough due diligence and reliable data, which are not always readily available.

Agriculture includes various segments—crop production, livestock farming, greenhouses, storage, agribusiness, equipment, irrigation, and others—each with its own economic characteristics.

A prudent approach to agricultural investment is based on a comprehensive assessment of financial capacity. All costs and expected revenues should be calculated in advance, including long-term projections that reflect future operational and market conditions. While small private investors may conduct basic financial calculations independently, business owners and larger investors are advised to engage professional accountants to ensure accuracy and reliability in financial planning.

Another essential principle is the creation of a financial safety buffer. Agricultural investments often involve borrowing, which significantly increases financial risk. Before committing to project financing, investors should maintain sufficient reserves to cover all operating and personal expenses for a period of three to six months. This buffer serves as protection against unexpected disruptions, price volatility, or delays in production and sales.

Clear investment objectives must also be defined at the outset. These objectives may include capital preservation, capital growth, generation of passive income, or portfolio diversification. Establishing precise goals allows investors to determine appropriate time horizons and expected rates of return, which in turn guide decision-making throughout the investment process.

Risk identification and assessment constitute another critical component of sound agricultural investment. Each project has a unique risk profile shaped by climatic conditions, market fluctuations, technological factors, and regulatory environments. Investors should conduct thorough risk analysis, carefully review financial statements, and, where necessary, seek guidance from investment advisors to mitigate potential losses and enhance project resilience.

Selecting an appropriate investment strategy is equally important. Investors generally choose between conservative, moderate, or aggressive strategies, each differing in terms of risk exposure and expected returns. The chosen strategy should be consistent with the investor's risk tolerance, financial resources, and long-term objectives to ensure sustainability and alignment with overall financial planning.

Finally, investors should compare available projects and select the most promising option based on a comprehensive set of criteria. These criteria typically include profitability, project scale, operational risks, technological maturity, land requirements, competitive environment, and export potential. A carefully selected agricultural project, grounded in thorough analysis and strategic planning, is capable of generating stable and sustainable long-term income.

Regarding opportunities in the agricultural sector, agriculture offers a wide range of investment directions—from cold storage and food processing to livestock farming, vertical agriculture, and renewable energy–powered solutions. As emphasized by the President, strengthening farmers' confidence and motivation is a decisive factor in ensuring the sustainable development of the agrarian sector. For this reason, support mechanisms

are being gradually expanded. The key priority is selecting the right project and structuring it properly. At every stage—from idea generation to implementation—comprehensive support can be provided.

CONCLUSIONS AND SUGGESTIONS

In Uzbekistan, subsidies and investments play a strategic role in increasing agricultural crop production. Population growth, stable demand, limited land resources, and state-provided incentive mechanisms significantly enhance the sector's investment attractiveness.

Prudent investment management, the widespread adoption of innovative technologies (such as vertical farming, precision agriculture, and water-saving irrigation), and a digitized subsidy system create a solid foundation for the sustainable development of the agricultural sector.

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RAQAMLI MARKETING VA INNOVATSION TEXNOLOGIYALAR ASOSIDA EKOTIZIM SAMARADORLIGINI OSHIRISH USULLARI

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Annotatsiya: Maqolada raqamli marketing va innovatsion texnologiyalar asosida ekotizim samaradorligini oshirish yo‘llari tahlil qilingan. Sun’iy intellekt, katta ma’lumotlar, IoT va blokcheyn texnologiyalari marketing jarayonlariga integratsiya qilingan holatlar empirik dalillar bilan asoslab berilgan. Kichik va o‘rta korxonalarda raqamli transformatsiya jarayonlari baholangan, asosiy muammolar aniqlangan va strategik tavsiyalar ishlab chiqilgan. Maqola bibliometrik va tarkibiy tahlil usullari orqali, xalqaro ilmiy manbalarga tayangan holda yozilgan. Marketing samaradorligini oshirishda texnologik yondashuvlarning o‘rni aniq ko‘rsatilgan.

Kalit so‘zlar: raqamli marketing, sun’iy intellekt, katta ma’lumotlar, IoT, blokcheyn, ekotizim samaradorligi, raqamli transformatsiya.

Abstract: This research article examines modern approaches to improving ecosystem efficiency through digital marketing and innovative technologies. The effects of artificial intelligence, big data, the Internet of Things (IoT), and blockchain on marketing practices are analyzed. Special focus is given to the role of small and medium-sized enterprises (SMEs) in the digital transformation process. Based on a review of academic literature, practical recommendations are proposed to support the integration of digital tools for sustainable business growth.

Key words: digital marketing, artificial intelligence, big data, blockchain, IoT, ecosystem, SMEs, digital transformation.

Аннотация: В данной научной статье рассматриваются современные подходы к повышению эффективности экосистемы с использованием цифрового маркетинга и инновационных технологий. Проанализировано влияние искусственного интеллекта, больших данных, интернета вещей (IoT) и блокчейна на маркетинговую деятельность компаний. Особое внимание уделено малым и средним предприятиям (МСП) в процессе цифровой трансформации. На основе анализа научной литературы предложены практические рекомендации по интеграции цифровых решений для устойчивого роста бизнеса.

Ключевые слова: цифровой маркетинг, искусственный интеллект, большие данные, блокчейн, интернет вещей, экосистема, МСП, цифровая трансформация.

KIRISH

Global raqamli transformatsiya jarayonlari korxonalarning tashkiliy tuzilmasi, operatsion faoliyati hamda mijozlar bilan o‘zaro munosabatlarini tubdan o‘zgartirmoqda. Ayniqsa, marketing faoliyati tobora ko‘p ishtirokchidan iborat, murakkab va raqamli integratsiyalashgan tizimlar orqali amalga oshirilmoqda. Shu nuqtai nazardan, marketing ekotizimi tushunchasi zamonaviy menejment va marketing strategiyalarida markaziy o‘ringa chiqmoqda. Ushbu yondashuv korxonani alohida subyekt sifatida emas, balki u bilan bog‘langan manfaatdor tomonlar – mijozlar, hamkorlar, texnologik provayderlar, davlat organlari va boshqa ishtirokchilar bilan birgalikda shakllanadigan ochiq tizim sifatida talqin etadi.

Marketing ekotizimining asosiy afzalligi turli aktyorlar o‘rtasidagi o‘zaro hamkorlik, resurslar almashinuvi va qiymatning birgalikda yaratilishiga asoslanganidadir. Bunday ekotizimlar o‘zgaruvchan bozor sharoitlariga tez va

moslashuvchan javob bera oladi, innovatsiyalarni qisqa muddatda joriy etish imkonini yaratadi hamda mijozlar tajribasini yanada chuqurroq anglashga xizmat qiladi. Ekotizim yondashuvi korxonalarga faqat mahsulot yoki xizmatni taklif etish bilan cheklanmasdan, balki mijozlar va jamiyat ehtiyojlariga kompleks va barqaror qiymat yetkazish imkonini beradi.

Shu bilan birga, marketing ekotizimlarini samarali boshqarish va ularning ishtirokchilari faoliyatini muvofiqlashtirish dolzarb masala bo‘lib qolmoqda. Xususan, sun’iy intellekt, katta hajmdagi ma’lumotlar tahlili, blokcheyn va boshqa ilg‘or texnologiyalar marketing faoliyatiga tobora chuqur kirib borar ekan, ularning ekotizim doirasida qanday integratsiyalanishi hamda qanday strategik mexanizmlar orqali boshqarilishi masalalari alohida ilmiy e’tiborni talab etmoqda. Bugungi kunda raqobat ustunligi faqat mahsulot yoki xizmat sifatiga emas, balki umumiy tajriba, tezkorlik, shaxsiylashtirish va omnikanallik asosida shakllanmoqda.

Ushbu tadqiqotning maqsadi raqamli transformatsiya sharoitida marketing ekotizimini boshqarish va ishtirokchilar o‘rtasidagi munosabatlarni muvofiqlashtirish mexanizmlarini chuqur o‘rganish, samarali strategiyalarni aniqlash hamda korxonalar uchun amaliy takliflar ishlab chiqishdan iboratdir. Tadqiqot doirasida marketing ekotizimining nazariy asoslari, institutsional va texnologik omillari, ishtirokchilarning roli, ularning o‘zaro aloqalari hamda zamonaviy boshqaruv vositalari tahlil qilinadi. Ayniqsa, sun’iy intellekt va omnikanallik yondashuvlarining ekotizim ichidagi funksional roliga alohida e’tibor qaratiladi.

Mazkur tadqiqot marketing ekotizimining zamonaviy modelini yanada chuqurroq anglashga xizmat qilish bilan birga, amaliyotda qo‘llash mumkin bo‘lgan boshqaruv mexanizmlarini ishlab chiqish uchun ilmiy asos yaratadi. Natijada korxonalar o‘z marketing strategiyalarini yangi bosqichga ko‘tarish, innovatsion va moslashuvchan tizimlarni shakllantirish imkoniyatiga ega bo‘ladi.

MAVZUGA OID ADABIYOTLAR SHARHI

Raqamli marketing ekotizimining nazariy asoslari: Marketing texnologiyalari ekotizimi tushunchasi ilmiy adabiyotlarda turli nuqtai nazarlardan yoritilgan. Nim, Pedada va Hewett raqamli marketing ekotizimlarini ko‘p millatli korxonalar (MNE)ning global ekspansiyasi uchun muhim omil sifatida ta’riflaydilar [3]. Ularning tadqiqotiga ko‘ra, marketing ekotizimlari xizmatlar, innovatsiyalar, yangi mahsulotlarni ishlab chiqish, kommunikatsiyalar hamda umumiy marketing strategiyasi sohalarida jadal rivojlanmoqda. Rangaswamy va Grokk raqamli marketingning 1990-yillardan buyon bosib o‘tgan yo‘lini tahlil qilib, statik interaksiyalardan dinamik, ma’lumotlarga asoslangan ekotizimlarga o‘tish jarayonini alohida ta’kidlaydilar [4].

Theodorakopoulos va Theodoropoulou katta hajmdagi ma’lumotlar analitikasining raqamli marketingdagi rolini tizimli tahlil qilib, ushbu texnologiya iste’molchilar xulq-atvorini chuqurroq tushunish imkonini berishini asoslab berganlar [5]. Ularning fikricha, katta ma’lumotlar massivlaridan samarali foydalanish orqali korxonalar marketing strategiyalarini individual iste’molchilarga moslashtirib, mijozlar qoniqishi va jalb etilganlik darajasini oshirishlari mumkin.

Sun’iy intellektning marketing samaradorligiga ta’siri: Sun’iy intellekt texnologiyalari marketing amaliyotida inqilobiy o‘zgarishlarni yuzaga keltirmoqda. Influencer Marketing Hub tadqiqotiga ko‘ra, marketologlarning 70,6 foizi sun’iy intellekt asosiy marketing vazifalarida insonlardan ustun kelishi mumkinligiga ishonadi [6]. Shu bilan birga, respondentlarning qariyb 60 foizi sun’iy intellekt texnologiyalarining ularning ish o‘rinlarini egallab olishi ehtimolidan xavotir bildirmoqda. Harvard Professional Development ma’lumotlariga ko‘ra, marketologlar sun’iy intellektdan takroriy vazifalarni avtomatlashtirish, qarorlar qabul qilish jarayonlarini qo‘llab-quvvatlash hamda mijozlar bilan samarali aloqa o‘rnatish uchun faol foydalanmoqda [7].

MDPI jurnalida chop etilgan tadqiqot sun’iy intellektning barqaror raqamli marketing strategiyalarini ishlab chiqishdagi rolini o‘rganib, SI texnologiyalari mijozlar xulq-atvorini tahlil qilish, shaxsiylashtirilgan xizmatlar ko‘rsatish, jarayonlarni avtomatlashtirish va biznes samaradorligini oshirish salohiyatiga ega ekanligini ko‘rsatdi [8]. Unilever, Amazon va boshqa yirik kompaniyalar sun’iy intellektdan innovatsiyalarni joriy etish, operatsion samaradorlikni oshirish va barqaror rivojlanish maqsadlariga erishish uchun muvaffaqiyatli foydalanib kelmoqda.

Blokcheyn va IoT texnologiyalarining marketing integratsiyasi: Blokcheyn texnologiyasi marketing sohasida yangi imkoniyatlar ochib bermoqda. ScienceDirect (2024) platformasida e’lon qilingan tadqiqotlarga ko‘ra, blokcheyn marketing aralashmasini takomillashtirish, marketing kanallarini markazlashtirishdan chiqarish, mijozlar ishonchi va sodiqligini oshirish hamda kanallararo bog‘lanishni kuchaytirish imkonini beradi [9]. MDPI jurnalida nashr etilgan tadqiqot esa IoT va blokcheyn texnologiyalarining integratsiyasini tahlil qilib, ularning arxitektura moslashuvi, ilovalar, xavfsizlik va miqyoslanish jihatlarini chuqur o‘rganadi [10].

Sensors jurnalida chop etilgan tadqiqot blokcheyn va IoT asosidagi ilovalarning Sanoat 4.0 va Jamiyat 5.0 konsepsiyalari uchun ahamiyatini yoritib beradi [11]. Sun’iy intellekt, IoT, robototexnika va kengaytirilgan reallik kabi ilg‘or texnologiyalar kundalik hayot, sog‘liqni saqlash va boshqa sohalarda keng qo‘llanilishi mumkinligi ta’kidlangan. Discover Internet of Things jurnalida esa blokcheyn texnologiyasining iqtisodiyot, sog‘liqni saqlash, axborot tizimlari, simsiz tarmoqlar hamda aqlli energiya tarmoqlarida qo‘llanilishi keng qamrovda tahlil qilingan [12].

KO‘K va kichik korxonalarda raqamli transformatsiya: Kichik va o‘rta korxonalar (KO‘K) raqamli transformatsiya jarayonida muhim o‘rinni egallaydi. Sustainability jurnalida chop etilgan tadqiqot raqamli marketingning KO‘Klar faoliyatiga ta’sirini o‘rganib, raqamli marketing ushbu korxonalar samaradorligi uchun hal qiluvchi omil ekanligini isbotladi [13]. Tadqiqot natijalari shuni ko‘rsatadiki, raqamli transformatsiya vositachiligida raqamli marketingni joriy etish kuchliroq iqtisodiy natijalarga va kengaytirilgan bozor mavqeiga olib keladi.

Cogent Business & Management jurnalida ijtimoiy tarmoqlar marketingini qo‘llashning KO‘Klar faoliyatiga ta’siri tahlil qilingan [14]. Tadqiqot natijalari ijtimoiy tarmoqlar marketingining strategik joriy etilishi KO‘Klar faoliyati samaradorligi bilan ijobiy bog‘liqligini tasdiqlaydi. Shuningdek, Technological Forecasting and Social Change jurnalida e’lon qilingan empirik tadqiqot raqamli marketing strategiyasi va KO‘Klar faoliyati o‘rtasidagi bog‘liqlikni chuqur tahlil qilgan [15].

TADQIQOT METODOLOGIYASI

Tadqiqot sifat va miqdoriy usullarning kombinatsiyasiga asoslangan kompleks yondashuv orqali amalga oshirildi. Asosiy tadqiqot usuli sifatida tizimli adabiyotlar sharhi (systematic literature review) qo‘llanildi. Tadqiqot doirasida Scopus, Web of Science, MDPI va boshqa yetakchi xalqaro ilmiy ma’lumotlar bazalarida 2017-2024-yillar oralig‘ida chop etilgan ilmiy maqolalar tanlab olindi.

Tadqiqot namunasi sifatida marketing texnologiyalari ekotizimi, raqamli transformatsiya, marketingda sun’iy intellekt, blokcheyn va IoT texnologiyalarining integratsiyasi, shuningdek kichik va o‘rta korxonalarda (KO‘K) raqamli marketing mavzulariga oid ilmiy maqolalar tanlab olindi. Maqolalarni tanlash va tahlil qilish jarayoni PRISMA protokoli asosida amalga oshirildi [5]. Dastlabki qidiruv natijasida 468 ta ilmiy maqola aniqlangan bo‘lib, ulardan 144 tasi belgilangan tanlov mezonlariga to‘liq javob bergan [1].

Tadqiqotda kontekst, xususiyatlar va metod (TCCM-Theory-Context-Characteristics-Method) modeli tahliliy ramka sifatida qo‘llanildi [1]. Ma’lumotlarni tahlil qilish jarayonida bibliometrik tahlil, tarkibiy tahlil hamda sifatli kontent tahlili usullaridan foydalanildi. Shuningdek, VOSviewer va RStudio Biblioshiny dasturiy vositalari yordamida ilmiy hamkorlik tarmoqlari, asosiy tadqiqot mavzulari va eng ta’sirli adabiyotlar aniqlandi [16].

Empirik ma’lumotlarni chuqur tahlil qilish maqsadida tuzilmaviy tenglamalar modellashtirish (SEM) hamda PLS-SEM usullari qo‘llanildi [13, 15].

Tadqiqotning asosiy cheklovlari sifatida quyidagilar e’tirof etiladi:

- tahlil faqat ingliz tilida chop etilgan ilmiy maqolalar bilan cheklanganligi;
- tadqiqotning muayyan vaqt oralig‘i (2017-2024-yillar) bilan chegaralanganligi;
- geografik qamrovning cheklanganligi.

TAHLIL VA NATIJALAR

Raqamli marketing texnologiyalari ekotizimining zamonaviy holati: Tadqiqot natijalari raqamli marketing texnologiyalari ekotizimi (MarTech ecosystem) ning jadal va tizimli ravishda rivojlanib borayotganligini ko‘rsatdi. Xususan, Scott Brinker tomonidan 2011-yilda shakllantirilgan marketing texnologiyalari (MarTech) landshaftida atigi 150 ta kompaniya faoliyat yuritgan bo‘lsa, 2024-yilga kelib ushbu ko‘rsatkich 14 106 taga yetdi, bu esa 9 304 foizlik o‘sishni anglatadi [17]. Mazkur holat MarTech ekotizimining nafaqat kengayib borayotganini, balki uning murakkablashuvi va fragmentatsiyalashuvi kuchayib borayotganini ham ko‘rsatadi.

Bunday keskin o‘sish raqamli marketing faoliyatida texnologik yechimlarning diversifikatsiyalashuvi, ixtisoslashuvi va funksional segmentatsiyasining chuqurlashayotganidan dalolat beradi. Natijada korxonalar oldida marketing texnologiyalarini tanlash, integratsiyalash va boshqarish bo‘yicha yangi strategik vazifalar paydo bo‘lmoqda.

Gartner tomonidan o‘tkazilgan tadqiqotlarga ko‘ra, 2024-yilda marketing byudjetlari o‘rtacha 15 foizga qisqargan va kompaniya umumiy daromadlaridagi ulushi 9,1 foizdan past darajaga tushgan [17]. Ushbu tendensiya marketing bo‘limlaridan cheklangan resurslar sharoitida yuqori samaradorlikka erishishni talab etmoqda. Aynan shu sharoitda sun’iy intellekt, ma’lumotlar analitikasi va avtomatlashtirish texnologiyalari marketing faoliyatining samaradorligini oshirishda hal qiluvchi vosita sifatida namoyon bo‘lmoqda.

Sun’iy intellektga asoslangan marketing texnologiyalari kontent yaratish, mijozlar xulq-atvorini prognozlash, personalizatsiya, omnikanallikni ta’minlash hamda qarorlar qabul qilish jarayonlarini optimallashtirish imkonini bermoqda. Bu esa marketing ekotizimining raqamli yetuklik darajasini oshirish va strategik moslashuvchanligini ta’minlashga xizmat qilmoqda.

Quyidagi 1-jadvalda raqamli marketing texnologiyalarining asosiy ko‘rsatkichlari umumlashtirilgan holda keltiriladi.

1-jadval. Raqamli marketing texnologiyalari samaradorligi ko‘rsatkichlari[1]

Ko‘rsatkich	Qiymat	Manba
AI asosida ROI o‘sishi	20-30%	McKinsey, 2024
Marketing avtomatlashtirish ROI	544%	Forrester, 2024
AI qo‘llaydigan marketologlar	88%	SurveyMonkey, 2024
AI ishonch darajasi	70.6%	Influencer Marketing Hub
Konversiya o‘sishi	14%	Amra and Elma, 2024
Unumdorlik o‘sishi (SI)	44%	Loopex Digital, 2025

Sun’iy intellekt va katta ma’lumotlar analitikasining marketing ekotizimiga ta’siri: Sun’iy intellekt (SI) zamonaviy marketing ekotizimida asosiy transformatsion kuchlardan biri sifatida namoyon bo‘lmoqda. O‘tkazilgan tahlillar natijalari shuni ko‘rsatadiki, sun’iy intellekt texnologiyalaridan foydalanuvchi marketing kampaniyalari an’anaviy yondashuvlarga nisbatan 20-30 foizga yuqori ROI ko‘rsatkichlariga ega [18]. Xususan, Netflix kompaniyasi SI asosida ishlab chiqilgan shaxsiylashtirilgan tavsiya tizimlari orqali har yili 1 milliard AQSh dollariga yaqin qo‘shimcha daromad olmoqda [18].

Shuningdek, so‘rov natijalariga ko‘ra, marketologlarning 49 foizi sun’iy intellektdan bozor tadqiqotlari va marketing analitikasi maqsadlarida foydalanmoqda. Bu esa raqobatchilar faoliyatini tahlil qilish va mijozlar xulq-atvori bo‘yicha chuqur insightlar olishga sarflanadigan vaqtni kunlardan soatlarga qisqartirish imkonini bermoqda.

Katta ma’lumotlar (Big Data) analitikasi esa iste’molchilar xulq-atvorini chuqur tushunish, modellashtirish va bashorat qilishda hal qiluvchi rol o‘ynamoqda. Theodorakopoulos va Theodoropoulou (2024) tadqiqotiga ko‘ra, katta ma’lumotlar texnologiyalaridan foydalanish marketing faoliyatining samaradorligini oshirish, mijozlar bilan o‘zaro aloqalarni shaxsiylashtirish hamda iste’molchilar afzalliklarini oldindan aniqlash imkonini beradi [5].

Empirik tadqiqotlar shuni ko‘rsatadiki, shaxsiylashtirilgan marketing strategiyalari sotuv hajmini o‘rtacha 10 foizga oshiradi, marketing xarajatlariga nisbatan olinadigan daromad (ROI) esa 5-8 barobarga ko‘payadi [19]. Bu holat sun’iy intellekt va katta ma’lumotlar analitikasining marketing ekotizimidagi strategik ahamiyatini yanada kuchaytiradi.

Quyidagi 1-rasmda sun’iy intellektga asoslangan marketing texnologiyalari ekotizimining asosiy komponentlari vizual tarzda aks ettirilgan.

1-rasm. Raqamli marketing texnologiyalari ekotizimi tuzilishi[2]

1 Manba: Turli tadqiqotlar asosida muallif tomonidan tuzildi [2], [6], [17], [18]
2 Manba: Muallif tomonidan ilmiy adabiyotlar asosida tuzildi [1], [3], [8]

KO‘K va kichik korxonalarda raqamli marketing samaradorligi: Kichik va o‘rta korxonalar (KO‘K) raqamli texnologiyalarni joriy etish jarayonida moliyaviy resurslarning cheklanganligi, texnologik infratuzilmaning yetarli darajada rivojlanmaganligi hamda malakali kadrlar tanqisligi kabi o‘ziga xos qiyinchiliklarga duch keladi. Shunga qaramay, ilmiy tadqiqotlar raqamli marketing KO‘Klar faoliyati samaradorligini oshirishda muhim omil ekanligini tasdiqlaydi.

Sustainability jurnalida chop etilgan tadqiqotda 190 ta marketing kompaniyasidan olingan ma’lumotlar tahlil qilinib, raqamli marketing strategiyalarini qo‘llash KO‘Klar uchun iqtisodiy samaradorlikni oshirish va bozor mavqeini kengaytirishda hal qiluvchi ahamiyatga ega ekanligi aniqlangan [13]. Tadqiqot natijalariga ko‘ra, raqamli transformatsiya bilan uyg‘unlashgan raqamli marketing faoliyati savdo hajmining o‘sishi, mijozlar bazasining kengayishi va raqobatbardoshlikning mustahkamlanishiga olib keladi.

Texnologiyani qabul qilish modeli (Technology Acceptance Model – TAM) nuqtai nazaridan, KO‘Klar tomonidan raqamli marketing vositalarining joriy etilishi, asosan, texnologiyaning qabul qilingan foydaliligi va foydalanish qulayligi darajasiga bog‘liqdir [13]. Cogent Business & Management jurnalida e’lon qilingan tadqiqot natijalari ijtimoiy tarmoqlar marketingining KO‘Klar faoliyatiga ijobiy ta’sir ko‘rsatishini tasdiqlab, bunda yuqori rahbariyatning qo‘llab-quvvatlashi hamda xodimlarning raqamli salohiyati texnologiyalarni qabul qilish jarayonini sezilarli darajada tezlashtirishini ko‘rsatdi [14].

Shuningdek, Asia Pacific Journal of Innovation and Entrepreneurship jurnalida chop etilgan tadqiqot rivojlanayotgan bozorlardagi KO‘Klarda raqamli marketingdan foydalanish va ularning faoliyat ko‘rsatkichlari o‘rtasidagi bog‘liqlikni empirik jihatdan tahlil qilgan [20]. Tadqiqot natijalari raqamli marketingni to‘g‘ri konseptualizatsiya qilish va tizimli ravishda qo‘llash KO‘Klar biznes boshqaruvi samaradorligiga ijobiy ta’sir ko‘rsatishini tasdiqladi. Bundan tashqari, tashqi muhitning dinamikligi raqamli marketing va KO‘Klar faoliyat natijalari o‘rtasidagi munosabatda ijobiy moderator rolini bajarishi aniqlangan.

Blokcheyn va IoT integratsiyasi natijalarining muhokamasi: Blokcheyn va Internet of Things (IoT) texnologiyalarining integratsiyasi marketing faoliyatida yangi strategik imkoniyatlarni yuzaga keltirmoqda. MDPI jurnalida chop etilgan tadqiqotga ko‘ra, IoT qurilmalari soni 2023-yilda 15,9 milliard donani tashkil etgan bo‘lib, 2030-yilga kelib ushbu ko‘rsatkich 32,1 milliarddan oshishi prognoz qilinmoqda [10]. Mazkur tendensiya marketing ekotizimlarida real vaqt rejimida katta hajmdagi ma’lumotlar shakllanishiga olib kelmoqda.

Blokcheyn texnologiyasining markazlashtirilmagan, o‘zgarmas va shaffof xususiyatlari IoT orqali yig‘iladigan ma’lumotlar uchun ishonchli xavfsizlik infratuzilmasini yaratadi. ScienceDirect jurnalida e’lon qilingan tadqiqotlarda blokcheynning marketing sohasidagi qo‘llanilishi tahlil qilinib, ushbu texnologiya marketing strategiyalarida tobora muhim ahamiyat kasb etayotgani ta’kidlangan [9]. Xususan, blokcheyn marketing aralashmasini takomillashtirish, marketing kanallarini markazlashtirishdan chiqarish, mijozlar ishonchi va sodiqligini oshirishda samarali vosita sifatida baholanadi.

Amaliy misol sifatida, Walmart kompaniyasining IBM bilan hamkorlikda amalga oshirgan blokcheyn loyihasi oziq-ovqat mahsulotlari kuzatuvchanligini ta’minlashda muvaffaqiyatli natijalarga erishganini ko‘rsatadi [21]. Ushbu loyiha ta’minot zanjirida shaffoflikni oshirib, iste’molchilar ishonchini mustahkamlashga xizmat qilgan.

XULOSA VA TAKLIFLAR

Tadqiqot natijalari raqamli marketing va innovatsion texnologiyalarning marketing ekotizimi samaradorligini oshirishda hal qiluvchi ahamiyatga ega ekanligini tasdiqladi. Sun’iy intellekt (SI), katta hajmdagi ma’lumotlar analitikasi (Big Data Analytics), blokcheyn va Internet of Things (IoT) texnologiyalarining integratsiyasi marketing amaliyotlarini tubdan transformatsiya qilmoqda. Ilmiy manbalarga ko‘ra, sun’iy intellektdan foydalanilgan marketing kampaniyalari an’anaviy yondashuvlarga nisbatan 20-30% yuqori ROI ko‘rsatkichlariga erishmoqda [2, 18]. Shuningdek, marketologlarning 88 foizi kundalik faoliyatida sun’iy intellekt texnologiyalaridan foydalanayotgani raqamli transformatsiya jarayonlarining keng qamrovli tus olayotganini ko‘rsatadi [17].

Katta ma’lumotlar analitikasi iste’molchilar xulq-atvorini chuqur tahlil qilish, ularning ehtiyoj va afzalliklarini aniqlash hamda kelgusidagi xarid xatti-harakatlarini bashorat qilish imkonini beradi. Shaxsiylashtirilgan marketing strategiyalari mijozlar qoniqishi va sodiqligini oshirishda muhim vosita hisoblanadi. Biroq, shaxsiylashtirishning uzoq muddatli istiqbolda mijozlar ishonchiga ko‘rsatadigan ta’sirini baholovchi longitudinal empirik tadqiqotlar yetarli emasligi ushbu yo‘nalishdagi ilmiy bo‘shliq sifatida qayd etilishi lozim [5].

Kichik va o‘rta korxonalar (KO‘K) uchun raqamli marketing strategiyalarini joriy etish alohida ahamiyat kasb etadi. Tadqiqot natijalari shuni ko‘rsatadiki, raqamli transformatsiya bilan uyg‘unlashgan raqamli marketing faoliyati KO‘Klar uchun kuchliroq iqtisodiy natijalarga olib keladi [13]. Shu bilan birga, yuqori rahbariyatning institutsional qo‘llab-quvvatlashi hamda xodimlarning raqamli salohiyati raqamli marketing strategiyalarini muvaffaqiyatli joriy etishning asosiy determinantlari sifatida namoyon bo‘ladi [14].

Mazkur ishda olib borilgan tavlillar natijasida quyidagi amaliy tavsiyalar ishlab chiqildi:

Birinchidan, korxonalar sun'iy intellekt texnologiyalariga investitsiya kiritishlari va ularni marketing strategiyalariga tizimli ravishda integratsiya qilishlari zarur. SI asosidagi analitika va avtomatlashtirish vositalari marketing jarayonlarining aniqligi va samaradorligini sezilarli darajada oshiradi.

Ikkinchidan, katta ma'lumotlar infratuzilmasini rivojlantirish hamda ma'lumotlar sifati va xavfsizligini ta'minlash muhimdir. To'liq, aniqligi yuqori va xolis ma'lumotlar sun'iy intellekt texnologiyalarining samarali joriy etilishi uchun zarur shart hisoblanadi [19].

Uchinchidan, xodimlarni raqamli marketing texnologiyalari bo'yicha muntazam o'qitish va ularning malakasini oshirish dasturlarini ishlab chiqish lozim. Raqamli marketing kompetensiyalari KO'Klarning xalqaro elektron tijorat bozorlarida muvaffaqiyatli faoliyat yuritishi uchun zarur bo'lsa-da, ular yagona hal qiluvchi omil emasligi ham inobatga olinishi kerak [16].

To'rtinchidan, davlat organlari tomonidan raqamli innovatsiyalarni rag'batlantirish, KO'Klarga moliyaviy va texnik ko'mak ko'rsatishga qaratilgan kompleks siyosat choralarini amalga oshirish maqsadga muvofiqdir [13].

Kelgusidagi tadqiqotlar sun'iy intellekt va blokcheyn texnologiyalarining marketing sohasiga uzoq muddatli ta'sirini empirik jihatdan o'rganishga, turli tarmoqlar va geografik hududlar kesimida qiyosiy tahlillar o'tkazishga hamda raqamli marketing texnologiyalarining axloqiy va institutsional jihatlarini chuqurroq tadqiq etishga qaratilishi lozim.

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WAYS TO IMPROVE THE STATISTICAL ASSESSMENT OF FRUIT AND VEGETABLE PRODUCTION PROCESSES AND EXPORT POTENTIAL IN THE REPUBLIC OF UZBEKISTAN

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Abstract: This article examines the current state, challenges, and development prospects of fruit and vegetable production and exports in the Republic of Uzbekistan. Using methods such as SWOT analysis, analysis and synthesis, and econometric modeling, the study identifies factors that influence production volume and export potential. On the basis of the empirical findings, practical recommendations are developed to optimize production, expand exports, and improve logistics infrastructure. The article is devoted to an in-depth examination of the economic importance of the fruit and vegetable sector and its position in international markets.

Key words: fruit and vegetable production, export, production volume, SWOT analysis, logistics, economic development, environmental challenges, Uzbekistan, agriculture, econometric model.

Annotatsiya: Ushbu maqolada O‘zbekiston Respublikasida meva-sabzavotchilik ishlab chiqarishi va eksportining hozirgi holati, mavjud muammolari hamda rivojlanish istiqbollari tahlil qilinadi. Tadqiqotda SWOT-tahlil, tahlil va sintez, shuningdek, ekonometrik modellashtirish kabi usullardan foydalanilgan bo‘lib, ishlab chiqarish hajmi va eksport salohiyatiga ta’sir etuvchi omillar aniqlangan. Olingan empirik natijalar asosida ishlab chiqarishni optimallashtirish, eksportni kengaytirish va logistika infratuzilmasini takomillashtirishga qaratilgan amaliy tavsiyalar ishlab chiqilgan. Maqola meva-sabzavotchilik tarmog‘ining iqtisodiy ahamiyati va uning xalqaro bozorlardagi o‘rnini chuqur tahlil qilishga bag‘ishlangan.

Kalit so‘zlar: meva-sabzavotchilik ishlab chiqarishi, eksport, ishlab chiqarish hajmi, SWOT-tahlil, logistika, iqtisodiy rivojlanish, ekologik muammolar, O‘zbekiston, qishloq xo‘jaligi, ekonometrik model.

Аннотация: В статье рассматриваются современное состояние, основные проблемы и перспективы развития производства и экспорта плодоовощной продукции в Республике Узбекистан. В исследовании использованы методы SWOT-анализа, анализа и синтеза, а также эконометрического моделирования, что позволило выявить факторы, влияющие на объёмы производства и экспортный потенциал отрасли. На основе полученных эмпирических результатов разработаны практические рекомендации, направленные на оптимизацию производства, расширение экспорта и совершенствование логистической инфраструктуры. Статья посвящена углублённому анализу экономической значимости плодоовощного сектора и его роли на международных рынках.

Ключевые слова: производство плодоовощной продукции, экспорт, объёмы производства, SWOT-анализ, логистика, экономическое развитие, экологические проблемы, Узбекистан, сельское хозяйство, эконометрическая модель.

INTRODUCTION

Global statistics show that in 2023 the size of the world fruit and vegetable market reached 3.6 trillion US dollars, reflecting a 5 percent increase over the last five years. This confirms the stable and high demand for such products. Integration of Uzbekistan into the international market in this sector provides not only economic benefits but also an opportunity to strengthen the national brand.

Against this background, the present article focuses on the statistical analysis of fruit and vegetable production in Uzbekistan, its current state, and development prospects. The main objective is to provide a detailed assessment of the role and importance of this sector in the national economy.

REVIEW OF LITERATURE ON THE SUBJECT

In recent years, a number of scholars have conducted research on fruit and vegetable production in the Republic of Uzbekistan, providing important insights into the development and prospects of the sector.

A. Abdullayev, in his study entitled “The Effectiveness of Using Innovative Technologies in Fruit and Vegetable Production,” examines the importance of introducing innovative technologies into Uzbekistan’s agriculture, particularly the fruit and vegetable subsector. The research analyzes the impact of drip irrigation, modern greenhouses, and automated monitoring systems on output volume and product quality. The results show that the use of these technologies increases yields on average by 20–25 percent and reduces water consumption by 35 percent. The author recommends expanding state subsidies and technological support programs to promote wider adoption of innovations.

In his scientific study “Development of Export Potential and Access to International Markets: The Case of the Fruit and Vegetable Sector,” O. Karimov analyzes how to enhance the competitiveness of Uzbekistan’s fruit and vegetable products in international markets. The findings show that export volumes are particularly high for grapes, tomatoes, and apples. However, deficiencies in international standards and certification systems were found to limit the export of certain products. The author provides strategic recommendations for improving logistics, aligning products with international standards, and entering new markets to promote Uzbekistan’s fruit and vegetable products abroad.

H. Haydarov, an expert and chief marketing specialist of the project “Technical Assistance for Fruit and Vegetable Marketing in Uzbekistan,” in his presentation on “Export of Fruit and Vegetable Products to the German Market,” notes that Uzbekistan mainly exports dried vegetables, carrots, melons, and raisins to Germany. In addition, there is demand in the European market for fresh cherries, apricots, and pears, as well as for products such as dried apricots, mung beans, and beans.

These studies serve as a scientific basis for more efficient organization of fruit and vegetable production and exports.

In their work “Sustainable Agricultural Practices in Central Asia: Opportunities and Challenges in Horticulture,” Johnson and Smith analyze the economic and environmental effects of efficient water use in fruit and vegetable production. Their results indicate that the adoption of drip irrigation technologies can increase production efficiency by 25 percent and reduce water consumption by 40 percent. The authors recommend introducing technological innovations to increase yields and reduce production costs.

Collectively, these studies examine in depth the processes of production, storage, processing, and export of fruit and vegetable products in Uzbekistan, and provide practical recommendations on the development prospects of the sector and ways to address existing problems.

RESEARCH METHODOLOGY

This article employs several scientific methods and approaches to analyze fruit and vegetable production in the Republic of Uzbekistan. These include SWOT analysis, analysis and synthesis, as well as econometric modeling. Each method contributes to a comprehensive examination of specific aspects of the sector.

SWOT Analysis. The SWOT method (strengths, weaknesses, opportunities, and threats) is used to identify the internal capabilities and constraints of the fruit and vegetable sector. Through this approach, the strategic position of Uzbekistan in fruit and vegetable production, the sector’s competitiveness, and its opportunities for integration into international markets are assessed. SWOT analysis is useful for identifying the sector’s strengths, the potential for efficient resource use, and existing threats and vulnerabilities in a competitive environment.

Analysis and Synthesis. This approach combines analytical and synthetic procedures. At the analytical stage, available statistical data, production processes, and market demand in the fruit and vegetable sector are examined in detail. At the synthesis stage, these data are integrated to develop recommendations aimed at improving production processes. This method makes it possible to consider the sector’s challenges and opportunities as a single system.

The combination of these methods plays an important role in improving the efficiency of the fruit and vegetable sector, increasing export potential, and designing strategies for sustainable development. As a result, scientifically grounded recommendations are derived for enhancing the sector’s competitiveness in domestic and foreign markets and for improving the management of production processes.

ANALYSIS AND RESULTS

It is well known that the natural and climatic conditions of Uzbekistan provide favorable opportunities for the sustainable development of agriculture, particularly fruit and vegetable production. During the transition to market relations, the President and the Government of the Republic of Uzbekistan have designated fruit and vegetable production as a priority sector. A significant portion of foreign currency earnings is generated through the export of horticultural products, highlighting the need for deep structural reforms and accelerated development in this area.

In recent years, several presidential decrees and government resolutions have been adopted, including Presidential Decree No. DP-5388[1] of 29 March 2018 “On additional measures for the accelerated development of horticulture in the Republic of Uzbekistan”; Presidential Decree No. DP-5853[2] of 23 October 2019 “On the approval of the Strategy for the development of agriculture of the Republic of Uzbekistan for 2020 — 2030”; Presidential Resolution No. RP-3978[3] of 17 October 2018 “On additional measures for increasing the efficiency of promoting horticultural products in foreign markets”; Presidential Resolution No. RP-4239 of 14 March 2019 “On measures to develop agricultural cooperation in the fruit and vegetable sector”; and Resolution of the Cabinet of Ministers No. 107[4] of 29 February 2024 “On measures to streamline the export of fruit and vegetable products in the republic.”

Overall, the economic reforms being implemented in the sector make it possible to address the following socio-economic issues. In the economic dimension, fruit and vegetable production accounts for 32.2 percent of total agricultural output (and 8.7 percent of the country’s gross domestic product) and serves as one of the main sources of income for rural populations. It directly influences the development of several industrial branches. Moreover, this sector occupies leading positions in the country’s agricultural exports.

In the social dimension, the sustainable development of fruit and vegetable production has a direct impact not only on the living standards of the rural population, but also on the overall social well-being of the entire nation.

Ultimately, the principal objective of these reforms is to ensure food security in the country, and the positive outcomes of the economic reforms implemented in all stages of New Uzbekistan’s development become clearly evident. These outcomes also reflect the gradual improvement in the population’s standard of living.

In this study, the fruit and vegetable production sector of the Republic of Uzbekistan was analyzed. Using SWOT analysis, analytical and synthetic methods, and econometric modeling, the research examined production indicators and the factors influencing export volumes.

The following table presents the internal strengths and limitations of Uzbekistan’s horticulture sector, together with the opportunities and threats arising from the external environment. The SWOT analysis serves as a foundation for defining strategic development directions and for ensuring the efficient utilization of existing resources (Table 1).

Table 1. SWOT Analysis of Uzbekistan’s Fruit and Vegetable Production Sector

Categories	Factors
Strengths	Favorable natural and climatic conditions; high-quality products; strategic geographical location
Weaknesses	Insufficient storage infrastructure; outdated technologies
Opportunities	Increasing export volumes to European and Asian markets; introduction of new technologies
Threats	Intensifying market competition; environmental changes.

The SWOT analysis shows that effective use of the sector’s strengths can increase export volumes. However, the existing weaknesses—such as outdated technologies—indicate the necessity of implementing innovative projects within the sector.

The following table reflects the changes in production volumes of major fruit and vegetable products in the Republic of Uzbekistan from 2021 to 2023. These production dynamics are closely related to the efficiency of resource utilization and the improvement of production technologies (Table 2).

1 https://lex.uz/ru/docs/6972755
2 https://lex.uz/docs/6971398
3 https://lex.uz/docs/7559479
4 https://lex.uz/uz/docs/7409091

Table 2. Dynamics of Fruit and Vegetable Production (2021–2023)

Year	Vegetables (thousand tons)	Fruits (thousand tons)	Berries (thousand tons)
2021	10,500	4,200	2,100
2022	11,200	4,500	2,250
2023	12,000	5,000	2,600

During 2021–2023, the production volume of fruit and vegetable products increased year by year. These changes can be explained by several important factors.

The growth in vegetable production. Vegetable output increased from 10,500 thousand tons in 2021 to 12,000 thousand tons in 2023, representing a 14.3 percent rise. This growth resulted from the expansion of land allocated for vegetable cultivation and the introduction of modern irrigation technologies. In addition, the successful implementation of land reclamation and restoration projects contributed to improved yields.

The growth in fruit production. The production volume of fruits increased from 4,200 thousand tons in 2021 to 5,000 thousand tons in 2023, reflecting a 19 percent rise. This was largely due to the establishment of new intensive orchards in Uzbekistan and the implementation of international certification programs. These programs enhanced product quality and enabled the cultivation of varieties tailored for export markets.

The growth in berry production. The production volume of berries rose from 2,100 thousand tons in 2021 to 2,600 thousand tons in 2023, an increase of 23.8 percent. This growth is associated with support programs for smallholder farms in rural areas and strategies aimed at accessing new export markets. Furthermore, the introduction of innovative technologies focused on producing goods that meet international standards also contributed to higher berry output.

Moreover, the introduction of innovative technologies aimed at producing goods that meet international standards has further contributed to the increase in berry production.

Technological innovations. One of the major drivers of production growth over the three-year period was the introduction of technological innovations and the increased level of mechanization in agriculture. In particular, the adoption of high-yield seed varieties, the use of biological fertilizers, and the application of environmentally friendly pest-control methods all contributed to increased production volumes.

State support. Government initiatives to provide financial and technical support to the agricultural sector—including subsidies and preferential loans—helped farmers expand their activities. At the same time, projects aimed at developing infrastructure for the export of agricultural products were implemented.

The introduction of modern technologies, high-quality seeds, and advanced irrigation methods has led to a significant increase in productivity. Rising international demand for Uzbek products encouraged farmers to expand production. Through land improvement and the establishment of intensive orchards, natural resources were used more efficiently. The adoption of innovative technologies that positively influence yields further stimulated production growth.

These results demonstrate the considerable potential for sustainable development of fruit and vegetable production in Uzbekistan. In the future, this growth can be sustained through entry into new markets and the diversification of production.

Our scientific analysis in this regard consists of the following points.

The importance of production volume. Production volume has a positive effect on export volume, which indicates the need to increase yields and expand the production of goods adapted to international market requirements.

The role of logistics infrastructure. A well-developed logistics network significantly enhances export efficiency. This is directly related to the ability to ensure rapid delivery and maintain product quality throughout the supply chain.

The model showed that production volume, logistics infrastructure, and environmental conditions exert a significant influence on export performance. In the future, the following measures should be considered:

– the development of modern logistics systems and the acceleration of export processes;
– improving environmental conditions by applying environmentally friendly pest-control methods and introducing water-saving technologies;
– the widespread adoption of new technologies to increase production volume.

Based on the modeling results, practical recommendations can be developed to optimize export volumes.

The following table presents the volume of fruit and vegetable products exported to Uzbekistan's main export markets during 2021–2023. These data demonstrate the relationship between strategic export development and international market demand (Table 3).

Table 3. Export Volumes of Fruit and Vegetable Products by Major Markets[5]

Year	Russia (million USD)	China (million USD)	Europe (million USD)	Uzbekistan's domestic production (thousand tons)
2021	400	250	100	10,500
2022	450	300	150	11,200
2023	500	350	200	12,000

Exports to the Russian market increased by 25 percent from 2021 to 2023, reaching 500 million USD. Russia remains Uzbekistan's primary export destination, largely due to geographic proximity and long-standing trade relations.

Exports to China rose from 250 million USD in 2021 to 350 million USD in 2023, an increase of 40 percent. This growth is explained by rising demand in the Chinese market for high-quality fruits and vegetables, as well as by strengthened efforts toward export diversification.

Exports to the European market grew from 100 million USD in 2021 to 200 million USD in 2023, effectively doubling over the period. This expansion is associated with the implementation of certification programs that meet European Union requirements and the broadening of international cooperation.

Uzbekistan's domestic production volume increased annually by 6–7 percent, reaching 12,000 thousand tons in 2023. When comparing domestic production growth with export market dynamics, it becomes clear that the main expansion has been directed toward the Russian and Chinese markets.

The doubling of export volume to Europe corresponds proportionally to the overall growth in production, indicating successful penetration into new markets.

Although Uzbekistan's production volume is high, the share of exports does not grow uniformly across the Russian, Chinese, and European markets. This discrepancy is explained by the relatively large share of domestic consumption and the limitations of the logistics infrastructure.

The high level of domestic production serves as a key factor for increasing export potential in the future.

To further expand exports to the Russian and Chinese markets, it is necessary to develop logistics chains and increase delivery speed.

To sustain growth in the European market, products must be prepared in accordance with international quality and environmental standards. Uzbekistan's large production capacity creates significant opportunities for enhancing export potential, which requires entering new markets and diversifying product offerings.

Participation in international exhibitions and effective product branding play an important role in increasing the share of exports.

This analysis clearly demonstrates Uzbekistan's current achievements in fruit and vegetable exports, as well as the opportunities that can be utilized in the future.

CONCLUSIONS AND SUGGESTIONS

The results of the analysis of fruit and vegetable production in the Republic of Uzbekistan show that this sector holds strategic importance as a key component of the national economy. During 2021–2023, the growth in production volume, expansion of export markets, and development of logistics infrastructure produced positive outcomes. However, several challenges and constraints remain, which hinder the sector's competitiveness and limit its ability to expand its share in international markets.

Growth in export volume. Although exports to Russia, China, and European markets have increased significantly, the share of exports relative to domestic production remains low.

Stability of domestic production. The volume of fruit and vegetable production continues to grow year by year, creating opportunities to enter new markets.

Environmental and logistical constraints. The deterioration of environmental conditions and the limitations of logistics infrastructure prevent full realization of export potential.

Based on the above, we propose the following recommendations:

1. Export diversification. It is necessary to develop strategies for entering new international markets, especially those in the Middle East and Southeast Asia. Certification and product branding systems should be organized in accordance with international requirements.

2. Development of logistics infrastructure. Modern logistics centers should be established to ensure fast and high-quality delivery of products. Expanding the cold-chain system is essential for preserving the quality of exported products.

5 Source:https://uz.kursiv.media/uz/2023-05-26/ozbekiston-meva-sabzavot-eksporti-karra-osmoqda/

3. Improving environmental sustainability. Water-saving technologies should be introduced, and environmentally friendly production methods should be widely applied. In agriculture, biological pest-control methods should be used instead of chemical agents.

4. Technological modernization. The widespread development of intensive orchards and modern agricultural technologies will help increase productivity. Introducing innovative seeds and fertilizers, as well as automating production processes, is also important.

5. Expanding financial support. Preferential loans and subsidies for farms should be continued. Export-oriented enterprises should be provided with tax and customs incentives.

6. Strengthening scientific research. Research programs should be implemented in cooperation with domestic and international scholars. Projects aimed at developing new varieties and producing goods tailored to export market requirements should be supported.

To fully utilize the existing potential of Uzbekistan's horticulture sector, a comprehensive strategy aimed at developing both export and domestic production is essential. If these recommendations are implemented, the country's agricultural sector may attain a leading position at both the regional and international levels.

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THE IMPACT OF DEGRADATION ON THE OPERATIONAL CHARACTERISTICS OF PHOTOVOLTAIC MODULES UNDER SHARPLY CONTINENTAL CLIMATIC CONDITIONS

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Abstract: In this paper, the degradation process of a crystalline silicon photovoltaic module SL100TU-18P (100 W), operated for 14 years under harsh continental climate conditions, is experimentally evaluated. The passport parameters of the module (Uoc, Isc, Umpp, Impp, and Pmax) are compared with the values measured under real operating conditions. The results show that high-intensity solar irradiance, sharp temperature fluctuations, high humidity, and increased dust concentration have a significant impact on the electrical characteristics of the module. In particular, a pronounced degradation is observed in the maximum power and current parameters. The experimental studies were conducted at the Heliopolygon of Tashkent State Technical University, and it was determined that the annual degradation rate of the module is significantly higher than the passport values specified under ideal conditions.

Key words: photovoltaic module, degradation, harsh continental climate, SL100TU-18P, I–U characteristics, maximum power (Pmax), short-circuit current (Isc), open-circuit voltage (Uoc), efficiency, temperature effect, solar radiation flux density, experimental measurements.

Annotatsiya: Ushbu maqolada keskin kontinental iqlim sharoitida 14 yil davomida ekspluatatsiya qilingan SL100TU-18P (100 Vt) kristalli kremniy fotoelektr modulining degradatsiya jarayoni eksperimental usulda baholandi. Modulning pasport parametrlari (Uoc, Isc, Umpp, Impp, Pmax) real ekspluatatsiya sharoitida o‘lchangan qiymatlar bilan solishtirildi. Olingan natijalar shuni ko‘rsatdiki, yuqori intensivlikdagi quyosh nurlanishi, issiq va sovuq haroratlarning keskin almashinuvi, namlik hamda changning yuqori darajasi modulning elektr parametrlariga sezilarli ta’sir ko‘rsatadi. Ayniqsa maksimal quvvat (Pmax) va tok ko‘rsatkichlarida yaqqol degradatsiya holatlari kuzatildi. Tajribalar Toshkent davlat texnika universiteti Geliopoligonida olib borildi hamda modulning yillik degradatsiya koeffitsiyenti ideal pasport qiymatlariga nisbatan ancha yuqori ekani aniqlandi.

Kalit so‘zlar: fotoelektr modul, degradatsiya, keskin kontinental iqlim, SL100TU-18P, I–U xarakteristika, maksimal quvvat (Pmax), qisqa tutashuv toki (Isc), salt yurish kuchlanishi (Uoc), samaradorlik, harorat ta’siri, quyosh nurlanishi oqim zichligi, eksperimental o‘lchov.

Аннотация: В данной статье экспериментально оценен процесс деградации кристаллического кремниевого фотоэлектрического модуля SL100TU-18P (100 Вт), эксплуатируемого в течение 14 лет в условиях резко континентального климата. Паспортные параметры модуля (Uoc, Isc, Umpp, Impp, Pmax) были сопоставлены с измеренными значениями в реальных условиях эксплуатации. Результаты показали, что высокая интенсивность солнечного излучения, резкие температурные колебания, повышенная влажность и высокая концентрация пыли оказывают существенное влияние на электрические параметры модуля. Наиболее выраженная деградация наблюдается по показателям максимальной мощности и тока. Экспериментальные исследования проводились на Гелиополигоне Ташкентского государственного технического университета, при этом установлено, что годовой коэффициент деградации модуля значительно превышает паспортные значения, полученные в идеальных условиях.

Ключевые слова: фотоэлектрический модуль, деградация, резко континентальный климат, SL100TU-18P, вольтамперная характеристика (I–U), максимальная мощность (Pmax), ток короткого замыкания (Isc), напряжение холостого хода (Uoc), эффективность, влияние температуры, плотность потока солнечного излучения, экспериментальные измерения.

INTRODUCTION

At present, among renewable energy sources, the share of photovoltaic (PV) technologies is increasing rapidly. In particular, in regions with a sharply continental climate, the use of solar energy plays a significant role in ensuring energy security, reducing the cost of electricity generation, and minimizing negative environmental impacts. However, in such areas, high ambient temperatures observed throughout the year, intense solar irradiance, wind, dust storms, and ultraviolet radiation have a considerable influence on the physicochemical condition of photovoltaic modules [1].

During long-term operation, degradation of photovoltaic modules inevitably occurs. Degradation refers to the gradual decline of a module's electrical parameters over time and is characterized by a reduction in key indicators such as short-circuit current (I_{sc}), open-circuit voltage (U_{oc}), maximum power (P_{max}), and overall efficiency (η). Under sharply continental climatic conditions, the rate of this process may be higher than in temperate climates. For example, elevated temperatures activate thermally induced defects within silicon cells caused by the combined effects of heat, solar radiation, and time, while leading to the yellowing of the encapsulant (EVA) layer [16]. In addition, dust storms contribute to increased optical losses [1–2–4].

Recent studies indicate that the annual degradation rate of photovoltaic modules is directly dependent on the type of technology—monocrystalline, polycrystalline, or thin-film—as well as on module design features and the climatic parameters of the installation area [1–5–11]. Scientific research confirms that factors such as high temperature cycling, low annual humidity, limited cloud cover, strong solar radiation, and increased UV radiation density in sharply continental climate zones can accelerate module aging and shorten their actual operational lifetime [5–6–15].

REVIEW OF LITERATURE ON THE SUBJECT

Photovoltaic (PV) module degradation has been extensively studied over the past decades, as it directly affects long-term energy yield, system reliability, and economic feasibility of solar power plants. One of the most comprehensive analytical overviews of PV degradation mechanisms and rates is provided by Jordan and Kurtz (2013), who synthesized global field data and demonstrated that degradation is a cumulative process influenced by climate, technology type, and operational conditions. Their findings established degradation rate analysis as a standard tool for assessing PV system performance over time.

Field-based experimental studies have significantly contributed to understanding real-world degradation behavior. Skoczek, Sample, and Dunlop (2009) investigated field-aged crystalline silicon modules and reported that current-related parameters, particularly short-circuit current and maximum power, exhibit more pronounced degradation compared to voltage parameters. This observation has been repeatedly confirmed in later studies and is considered characteristic of crystalline silicon technologies.

Climatic stress factors play a decisive role in accelerating degradation processes. Ndiaye et al. (2013) analyzed PV module performance in desert environments and identified high temperatures, dust deposition, and intense solar radiation as dominant degradation drivers. Similar conclusions were drawn by Bouaichi et al. (2019) in Morocco, where harsh climatic conditions caused early-stage degradation across different PV technologies, with crystalline silicon modules showing notable power losses. These findings are especially relevant for sharply continental climate zones, where thermal cycling and solar irradiance levels are high.

Temperature variability has been identified as a critical degradation factor in continental regions. Liang et al. (2021) demonstrated that frequent temperature fluctuations intensify thermomechanical stress in PV modules, leading to microcrack formation, encapsulant aging, and increased internal resistance. Long-term exposure studies further support this conclusion. Han et al. (2018) examined crystalline silicon modules exposed for over

30 years and confirmed that prolonged thermal and ultraviolet stress significantly reduces power output, even when voltage parameters remain relatively stable.

Encapsulant degradation, particularly EVA discoloration and loss of optical transmittance, is another key mechanism affecting PV performance. This aspect is highlighted in the works of Dyskin et al. (2025), who analyzed the temporal degradation of EVA transmittance and demonstrated its direct impact on photogeneration efficiency. Increased optical losses due to encapsulant aging have also been linked to reduced current generation in multiple field studies.

Regional investigations conducted in Uzbekistan provide valuable insights into PV module behavior under sharply continental climatic conditions. Yuldashev et al. (2025) performed a comparative analysis of polycrystalline PV modules and reported substantial reductions in current and power parameters after long-term operation. These results align with broader regional climate assessments provided by the World Meteorological Organization, which characterize Central Asia by high solar irradiance, low humidity, and significant temperature extremes—conditions known to exacerbate PV module degradation.

Comparative international studies from tropical and hot climates further reinforce these findings. Limmanee et al. (2016) and Aboagye et al. (2021) documented degradation trends in Southeast Asia and West Africa, respectively, emphasizing that current and power losses dominate long-term performance decline. Ndiaye et al. (2014, 2013) also proposed novel diagnostic approaches for identifying degradation mechanisms, highlighting the importance of in-situ measurements for accurate performance evaluation.

Finally, Sharma and Chandel (2013) provided a comprehensive review of performance degradation mechanisms and emphasized that long-term reliability of PV systems depends on effective mitigation strategies, including improved materials, thermal management, and protective coatings. From a broader energy systems perspective, Strebkov (2012) underscored the strategic importance of accounting for degradation effects in future solar energy development, particularly in regions with challenging climatic conditions.

Overall, the reviewed literature consistently demonstrates that sharply continental climatic conditions—characterized by high solar irradiance, temperature extremes, low humidity, and strong ultraviolet radiation—significantly accelerate degradation processes in photovoltaic modules. Current-related parameters and maximum power output are most affected, while voltage parameters remain comparatively stable. These findings provide a strong theoretical and empirical foundation for analyzing the degradation-induced changes in the operational characteristics of photovoltaic modules under sharply continental climate conditions.

RESEARCH METHODOLOGY

This study is based on experimental field measurements of a crystalline silicon photovoltaic module operated under sharply continental climatic conditions. Primary data were obtained through in-situ monitoring of electrical parameters and environmental variables and compared with datasheet values. The analysis employed descriptive statistics and comparative evaluation to identify degradation levels and assess climatic impacts on module performance.

ANALYSIS AND RESULTS

To evaluate the operational parameters of a 100 W SL100TU-18P photovoltaic module after 14 years of operation, field measurements were conducted on November 12 of the current year. During the measurements, solar irradiance, ambient temperature, open-circuit voltage (U_{oc}), short-circuit current (I_{sc}), voltage (U_{mpp}) and current (I_{mpp}) at the maximum power point, as well as maximum power output (P_{max}), were determined [7,8] (Figure 1; Table 1).

Figure 1. General view of the photovoltaic module (PV module)[1]

1 Source: Author's compilation.

Table 1. The main electrical parameters of the photovoltaic module (PVM) specified in the datasheet[2]

Short-circuit current (I_{sc})	Open-circuit voltage (U_{oc})	Current at the maximum power point (I_{mpp})	Voltage at the maximum power point (U_{mpp})	Maximum efficiency of the PVM
5,6 A	22,68 V	5.23 A	19,12 V	14,9%

According to the experimental results, the Uoc value during the day ranged between 19.6 and 19.8 V, indicating that voltage degradation of the module is minimal. This behavior is consistent with crystalline silicon modules, in which voltage tends to remain relatively stable over long periods of operation (Table 2).

Table 2. Experimental results[3]

No.	Time (min)	Solar irradiance (W/m²)	Ambient temperature (°C)	U_{oc} (V)	I_{sc} (A)	U_{mpp} (V)	I_{mpp} (A)	P_{mpp} (W)
1	11:00	685	14	19.8	3.28	13.5	2.43	33
2	11:10	701	14	19.8	3.28	13.2	2.56	34
3	11:20	714	14	19.7	3.18	13.1	2.45	32
4	11:30	701	14	19.6	2.95	13.1	2.40	31
5	11:40	693	15	19.6	2.72	14.2	2.00	28
6	11:50	686	15	19.6	2.70	14.4	1.97	28
7	12:00	691	15	19.6	2.87	14.4	2.00	29
8	12:10	680	16	19.6	2.78	14.2	1.96	28
9	12:20	683	17	19.6	2.86	14.4	2.00	29
10	12:30	682	17	19.6	3.03	13.1	2.37	31

However, the I_{sc} values exhibited significant variation within the range of 2.73–3.28 A. These changes are directly associated with fluctuations in solar irradiance between 680 and 714 W/m². Since short-circuit current is the most sensitive parameter to irradiance, even variations of 20–30 W/m² resulted in noticeable changes in current. After 14 years of operation, the reduction in Isc confirms a decline in photogeneration within the light-sensitive layer of the module and indicates probable thermally induced degradation processes.

During the experiment, P_{max} was recorded in the range of 28–34 W. Considering that the module is rated at 100 W according to its datasheet, this indicates a sharp reduction in power output under real operating conditions. This decline may be attributed to the following factors:

1. natural degradation of the photovoltaic layer,
2. yellowing of the EVA and protective layers,
3. elevated module temperature (although ambient temperature was around 14–17 °C, solar irradiance density was high),
4. aging of metallic contacts.

The I_{mpp} values ranged between 1.97–2.56 A and varied in direct correlation with $P_{max.}$ As solar irradiance density increased, I_{mpp} also rose; however, due to increased internal resistance of the module, the maximum power did not recover significantly. This behavior indicates long-term degradation accumulated within the internal components of the module (series contacts, shunt losses).

The experimental results obtained for the SL100TU-18P module reveal the following degradation characteristics: a reduction in maximum power exceeding 60–70%, which represents a very high level of degradation for such modules. Significant losses in current parameters, particularly decreases in I_{sc} and $I_{mpp,}$ indicate a reduced light absorption efficiency of the module. Voltage parameters remain relatively stable, which is typical for crystalline silicon modules. Increased sensitivity to solar irradiance density can be explained by thermal and ultraviolet aging effects.

Overall, these results confirm a substantial deterioration of the real operating parameters of PV modules that have been in long-term service under sharply continental climatic conditions.

2 Source: Author's compilation.
3 Source: Author's compilation.

CONCLUSIONS AND SUGGESTIONS

In the course of this study, experimental measurements of the operating parameters of a crystalline silicon photovoltaic module enabled a comprehensive assessment of the technical condition, degradation level, and the impact of sharply continental climatic conditions by comparing the actual performance parameters of the SL100TU-18P photovoltaic module after 14 years of operation with its datasheet specifications. According to the manufacturer's data, the module's short-circuit current should be I_{sc} = 5.6 A, open-circuit voltage U_{oc} = 22.68 V, current at the maximum power point I_{mpp} = 5.23 A, voltage at the maximum power point U_{mpp} = 19.12 V, and maximum power output 100 W, corresponding to an efficiency of 14.9%. However, the experimentally obtained results under real operating conditions revealed a significant reduction in these parameters. Specifically, during the measurements, I_{sc} ranged from 2.7 to 3.28 A, U_{oc} from 19.6 to 19.8 V, I_{mpp} from 1.97 to 2.56 A, U_{mpp} from 13.2 to 14.4 V, and P_{max} from 28 to 34 W.

These values indicate pronounced degradation in the most sensitive parameters of the module—namely I_{sc}, I_{mpp}, and P_{max}. The reduction in current-related parameters by approximately 40–55% can be attributed to long-term deterioration in light absorption, electron–hole pair generation, and increasing internal resistances within the module. The decline in maximum power by up to 60–70% reflects degradation processes in the photovoltaic layer induced by prolonged exposure to heat and ultraviolet radiation, yellowing of the EVA encapsulant, and intensified shunt-related losses.

Although voltage parameters (U_{oc} and U_{mpp}) remained relatively more stable, a decrease of about 10–15% nevertheless confirms the overall aging of the module. Climatic factors characteristic of sharply continental regions—such as high solar irradiance, elevated temperatures, low cloud cover, and low humidity—impose significant thermomechanical stress on the structural layers of the module during long-term operation, substantially weakening its operational performance.

Overall, the conducted experiment demonstrates that after 14 years of service, the SL100TU-18P module has experienced significant degradation in efficiency, current, and power parameters, resulting in a sharp reduction in actual energy generation capacity compared with the rated specifications. These findings underscore the necessity of implementing additional thermal management solutions, improved protective coatings, and structural reinforcement measures to maintain stable performance of photovoltaic modules operating under sharply continental climatic conditions throughout their service life.

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INTEGRATED NEW MEDIA OPERATION MODEL FOR INTELLIGENT TALENT ASSESSMENT PLATFORMS: THE PATH OF QR CODE ACTIVATION AND CONTENT-DRIVEN ENGAGEMENT

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Abstract: Against the backdrop of the digital economy, intelligent talent assessment platforms are shifting from a "tool-oriented" to an "operation-oriented" paradigm. Based on the pilot practice of a specific platform, this paper proposes and analyzes an integrated operational path of "new media content drainage + QR code activation." The research indicates that this path enhances users' perceived usefulness through storytelling content and significantly lowers the barrier to entry via the QR code mechanism, thereby markedly improving assessment activation and completion rates. The paper constructs an operational framework of "Content Reach -> QR Code Activation -> Online Assessment -> Report Interpretation -> Service Conversion," summarizing the model's advantages in replicability and its potential risks, such as channel dependency and data security. Finally, it provides concrete practical recommendations for platform providers, partner institutions, and career consultants.
Key words: Intelligent Talent Assessment; New Media Operations; QR Code Activation; Content Funneling; Career Education.

Annotatsiya: Raqamli iqtisod sharoitida intellektual islohotlarni baholash platformalari "vosita yo‘naltirilgan" paradigmasidan "operatsion yo‘naltirilgan" paradigmasiga o‘tmoqda. Ushbu maqola muayyan platformaning pilot amaliyotiga asoslanib, "yangi media kontent oqimi + QR kod aktivatsiyasi"ning integratsiyalashgan operatsion yo‘lini taklif qiladi va tahlil qiladi. Tadqiqot shuni ko‘rsatadiki, bu yo‘l foydalanuvchilarning idrok etilayotgan foydasini hikoya qilish asosidagi kontent orqali oshiradi va QR kod mexanizmi orqali kirish to‘siqini sezilarli darajada pasaytiradi, shu bilan baholash aktivatsiyasi va yakunlanish ko‘rsatkichlarini yaxshilaydi. Maqola "Kontent Yetkazish -> QR Kod Aktivatsiyasi -> Onlayn Baholash -> Hisobotni Izohlash -> Xizmatga O‘tkazish" operatsion strukturasini quradi, modelning takrorlanishidagi afzalliklarini va kanal bog‘liqligi va ma'lumotlar xavfsizligi kabi potentsial xavflarni umumlashtiradi. Yakunida, platforma ta'minlovchilari, hamkor muassasalar va karyera maslahatchilari uchun an'amviy amaliy tavsiyalar taqdim etiladi.
Kalit so‘zlar: Intellektual Islohotlarni Baholash; Yangi Media Operatsiyalari; QR Kod Aktivatsiyasi; Kontent Oqimi; Karyera Ta'limi.

Аннотация: В условиях цифровой экономики платформы интеллектуальной оценки талантов переходят от «инструментально-ориентированной» к «операционно-ориентированной» парадигме. На основе пилотной практики конкретной платформы в данной статье предлагается и анализируется интегрированный операционный путь «привлечения трафика через контент в новых медиа + активация QR-кодом». Исследование показывает, что этот путь повышает воспринимаемую полезность для пользователей через контент, основанный на историях, и значительно снижает порог входа за счет механизма QR-кода, тем самым заметно улучшая показатели активации и завершения оценки. В статье строится операционная框架 «Охват контентом -> Активация QR-кодом -> Онлайн-оценка -> Интерпретация отчета -> Конверсия в услугу», обобщаются преимущества модели в возможности репликации и ее потенциальные риски, такие как зависимость от канала и безопасность данных. В заключение представлены конкретные практические рекомендации для провайдеров платформ, партнерских учреждений и карьерных консультантов.
Ключевые слова: Интеллектуальная Оценка Талантов; Работа в Новых Медиа; Активация QR-кодом; Контентная Вовлеченность; Карьерное Образование.

1. INTRODUCTION

In the thriving platform economy, while intelligent talent assessment tools have become highly digitalized, their promotion often falls into the predicament of “advanced tools, but few users.” Concurrently, new media has become the main channel for young people to obtain career information [4,5]. How to efficiently reach and activate target users through these channels has become a critical challenge in both theory and practice.

In my own platform practice, I have to admit that what often determines the success or failure of a project is not the sophistication of the assessment model, but whether the users (students, teachers) are willing and able to easily complete that “first click” in a real-world scenario. This “last mile” implementation challenge is the focus of this research.

Based on this, this paper aims to answer three core questions: (1) How do new media content and the QR code mechanism synergize to form an efficient conversion path? (2) What are the advantages and limitations of this path in terms of activation rate and completion rate compared to traditional methods? (3) What are the key governance points for the successful implementation of this model? The contribution of this paper lies in organically connecting digital talent assessment research with new media operation practices and extracting a set of reusable operational frameworks.

2. LITERATURE REVIEW AND FRAMEWORK

Existing research reveals a threefold gap. Firstly, digital talent assessment studies often focus on tool validity and platform architecture [1], neglecting the operational mechanisms of “how to get users to actually use” the tools. Secondly, although the Technology Acceptance Model (TAM/UTAUT) clarifies the core role of perceived usefulness and ease of use [2,3], there is little systematic application of these principles in the design of new media operations. Furthermore, QR code marketing [6] and WeChat ecosystem research [7] demonstrate the effectiveness of connecting online and offline, but have not been deeply integrated with the talent assessment context.

In view of this, this paper constructs an integrated operational framework (See Figure 1), merging front-end new media content reach (enhancing perceived usefulness), the middle-stage one-click QR code activation (enhancing perceived ease of use), back-end report interpretation and services, and an underlying data feedback loop into a unified analytical perspective, providing a structural basis for subsequent analysis.

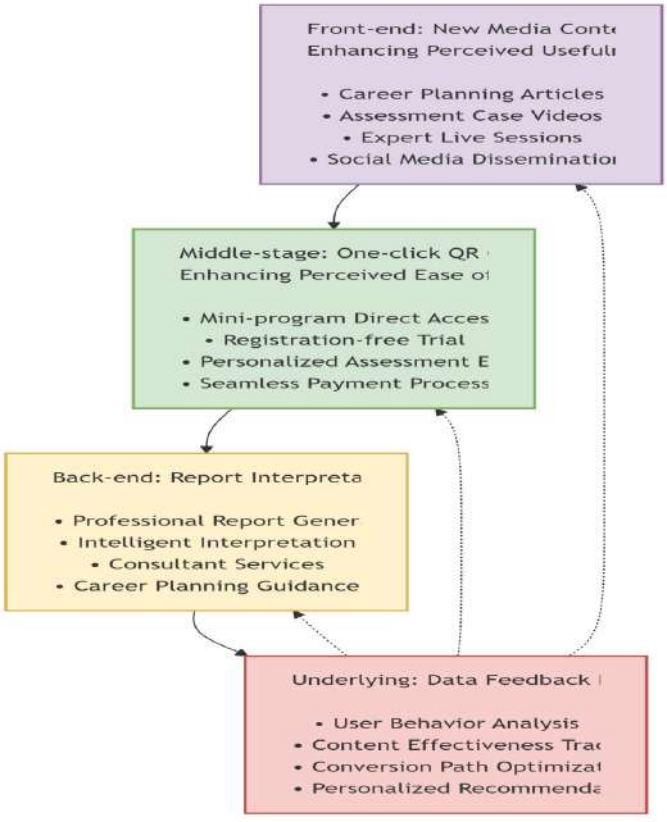

Figure 1. The Integrated Operational Framework of «New Media Content + QR Code Activation»

3. RESEARCH METHODOLOGY

This study adopts a case analysis approach, focusing on an intelligent assessment mini-program platform targeting students and early-career professionals. During the pilot run, the platform collaborated with schools, training institutions, and individual consultants to deploy three typical operational scenarios:

Video Channel Content Funneling + On-site Lecture Scanning: Career planning case studies were delivered via short videos, followed by QR code scanning during offline lectures.

Class/Community Push + E-poster Scanning: Electronic posters containing QR codes were distributed in class groups, allowing students to scan at their convenience.

Consultant One-on-One Distribution: Consultants sent personalized QR codes via WeChat before sessions, requiring clients to complete the assessment.

Data were sourced from anonymized backend records (e.g., scan counts, completion rates) and unstructured interviews with partner consultants. The analysis primarily employed descriptive and comparative methods.

4. ANALYSIS AND RESULTS

4.1 Content Strategy: From Information Push to Value Co-creation

The research found that simply pushing “assessment links” is ineffective. The successful strategy involved “storytelling”: presenting cases like “high school student Xiao Lin” through video channels, showcasing their confusion and enlightenment through interest and personality assessments, and visually displaying report charts and “next-step suggestions.” This essentially translates the abstract “usefulness of assessment” into a tangible value proposition for users, laying the psychological groundwork for subsequent behavioral conversion.

4.2 QR Code Activation: The Key to Simplifying Complex Operations

In this model, the QR code acts as a “behavioral folder.” Whether “scanning while listening” during a lecture or using printed cards for “delayed activation,” it simplifies the complex process of “searching-logging in-finding” into a single action of “scanning-clicking.” From a very practical point of view, whether a student completes the assessment often hinges on whether their phone displays an irrelevant video or a direct assessment page at that critical moment. Backend data indicated that in activities employing this mechanism, assessment completion rates stabilized in the 85%–95% range, significantly outperforming the traditional link distribution method.

4.3 From Assessment to Service: Building Trust and a Data Loop

Assessment completion is not the end goal. The platform enhanced report usability through structured reports (featuring a key findings summary on the first page) and actionable “next-step suggestions” (e.g., «suggest scheduling an in-depth consultation»). Follow-up interpretation by consultants further solidified trust. Preliminary data showed that most users found the reports «easy to understand» and «valuable for reference.” This practice initiated a “content-assessment-consultation” data feedback loop, providing a basis for continuous optimization.

4.4 Model Advantages, Risks, and Success Factors

Advantages include: 1) Significantly lowering the barrier to entry; 2) Building trust through front-loaded content; 3) Seamless integration with offline educational settings; 4) High replicability. Risks involve: 1) Dependence on a single channel (e.g., WeChat); 2) The challenge of balancing content engagement with professional depth; 3) Data privacy and security concerns arising from increased data flow. Success Factors depend on: the platform›s technical and data analytics capabilities, the willingness of partner institutions to engage with new media, and the consultants’ ability to transform a one-time assessment into an ongoing consulting action.

5. CONCLUSION AND RECOMMENDATIONS

This study confirms that the integrated path of “new media content funneling + QR code activation” effectively addresses the “difficult implementation” problem of intelligent talent assessment. It elevates new media from a mere “promotional channel” to a “tool for value delivery” and achieves ultimate simplification of the user path through QR codes.

Practical recommendations are as follows:

For Platform Providers: Establish cross-departmental teams integrating technology, content, and operations to continuously optimize the entire user experience path.

For Partner Institutions: Integrate assessment and new media content into the overall career education plan, creating multiple touchpoints.

For Career Consultants: Fully utilize backend data to transform a one-off assessment into a complete service cycle of “content-assessment-consultation-review.”

Research Limitations and Future Directions: This study is exploratory. Future research could conduct quantitative validation with larger samples, directly measuring user perceptions by incorporating TAM/UTAUT models, and explore adding intelligent recommendation functions based on user behavior to further enhance conversion and decision-making quality.

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METHODOLOGICAL FOUNDATIONS FOR SHAPING THE CREATIVE ACTIVITY OF YOUNGER PUPILS IN SOLVING MATHEMATICAL PROBLEMS

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Abstract: If education and training are considered necessary for young students to achieve many achievements and high goals in society, then creative thinking is considered important for the development of today's youth. Especially, the current development of scientific knowledge, the impact of creativity on the development of the individual, society and the state requires a deep study of this issue from a scientific and pedagogical point of view.

So, a primary school teacher can find the most effective way in any situation, any process and at any time and effectively organize the lesson process by putting it into practice, convenient, easy and efficient delivery can also be said to be a form of creativity.

The article discusses the methodological basis for the formation of the creative activity of primary school pupils aimed at the formation of creative activity by solving tasks related to the search for mathematical laws in the process of teaching mathematics, the tasks of searching patterns with geometrical content, which are actively working on the development of speech as well as visually illustrating new concepts.

Key words: primary school, mathematics, learning process, mathematical laws, problem solving, creativity, education.

Annotatsiya: Agar ta'lim va tarbiya yosh o‘quvchilarning jamiyatda ko‘plab yutuqlarga va yuksak maqsadlarga erishishi uchun zarur deb hisoblansa, unda ijodiy fikrlash bugungi yoshlarning rivojlanishi uchun muhim hisoblanadi. Ayniqsa, ilmiy bilimlarning hozirgi rivojlanishi, ijodkorlikning shaxs, jamiyat va davlat rivojlanishiga ta'siri bu masalani ilmiy va pedagogik nuqtai nazardan chuqur o‘rganishni talab qiladi.

Shunday qilib, boshlang‘ich sinf o‘qituvchisi har qanday vaziyatda, har qanday jarayonda va istalgan vaqtda eng samarali yo‘lni topib, dars jarayonini amaliyotga tatbiq etish orqali samarali tashkil qilishi mumkin, qulay, oson va samarali o‘qitish ham ijodkorlikning bir shakli deb aytish mumkin.

Maqolada matematika o‘qitish jarayonida matematik qonunlarni qidirish bilan bog‘liq vazifalarni hal qilish orqali ijodiy faoliyatni shakllantirishga qaratilgan boshlang‘ich sinf o‘quvchilarining ijodiy faoliyatini shakllantirishning metodologik asoslari, nutqni rivojlantirish ustida faol ish olib borayotgan, shuningdek, yangi tushunchalarni vizual tarzda tasvirlaydigan geometrik mazmunli naqshlarni qidirish vazifalari muhokama qilinadi.

Kalit so‘zlar: boshlang‘ich maktab, matematika, o‘quv jarayoni, matematik qonunlar, muammolarni yechish, ijodkorlik, ta'lim.

Аннотация: Если образование и обучение считаются необходимыми для достижения молодыми людьми многих успехов и высоких целей в обществе, то творческое мышление рассматривается как важный фактор развития современной молодежи. Особенно, учитывая современное развитие научных знаний, влияние творчества на развитие личности, общества и государства, этот вопрос требует глубокого изучения с научно-педагогической точки зрения. Таким образом, учитель начальной школы, находящий наиболее эффективный способ в любой ситуации, любом процессе и в любое время, а также эффективно организующий учебный процесс, благодаря его применению на практике, может также считаться удобной, легкой и эффективной подачей материала.

В статье рассматриваются методические основы формирования творческой деятельности учащихся начальной школы, направленные на развитие творческой активности путем решения задач, связанных с поиском математических законов в процессе обучения математике, задач поиска закономерностей с геометрическим содержанием, которые активно работают на развитие речи, а также визуально иллюстрируют новые понятия.

Ключевые слова: начальная школа, математика, учебный процесс, математические законы, решение задач, творчество, образование.

INTRODUCTION

The primary school teacher's first task is not to miss the sensitive period which is the most favorable for the formation of students' creative activity. Otherwise, what scientists-psychologists have termed as NUVERS will happen - irreversible fading of opportunities for effective development of abilities. At the same time, the improvement of reproductive thinking cannot be neglected either because it is "an important component of creative activity (especially at the initial and final stages of problem solving)". And yet the main value of education nowadays is the formation of creative personal qualities in a person, the need and opportunity to go beyond what is being studied, the ability to self-development, continuous self-education [1].

As a means of solving the problem of shaping the creative activity of younger pupils, we have chosen pattern finding tasks. This was done for the following reasons:

They are a logical continuation of the teaching of mathematics in kindergartens. The pre-school mathematics curriculum provides for work on tasks containing questions of the following kind: "What has changed in the second figure (picture) compared to the first one?", "How to continue the started row?", "Which figure out of three is superfluous?", etc:

- do not require a fundamental restructuring of the current programme;
- affect the development of patterns;
- have a significant impact on the development of analytical and synthetic activities, as confirmed by statistical processing of the experimental training data.

LITERATURE REVIEW

Until now, pattern finding tasks (whether general patterns or mathematical ones) have not been separately identified in the teaching and learning literature. For this reason, their definition has not been given either. These tasks are presented only as tests in some publications (first of all, by G.J. Eisenk). In our study we focus on the term "task", using a selection of definitions of this term which are presented in the work of G.I. Sarantsev [20].

"The most widespread is the definition of a task as a system (G.A. Ball, Y.M. Kolyagin, L.M. Friedman, A.F. Esaulov). Thus, Yu. M. Kolyagin suggests that by a task we understand a particular state of a "man - task situation" system, where the second component of the system is a set of elements interconnected through some properties of relations [5]. If the subject, who has come into contact with a situation, does not know at least one element, property or relation and has the need to establish the unknown elements, properties or relations of this situation, then the latter becomes a task for him. At the same time, the authors delineate in different ways the range of phenomena that belong to the scope of the concept of task. Some use the term "task" to denote objects belonging to the category of goals of actions of the subject, requirements imposed on the subject (A.N. Leontiev), others refer to the category of a situation including, along with the goal, the conditions in which it is to be achieved (L.L. Gurova, Y.M. Kolyagin [19], Y.N. Kulutkin, A.F. Esaulov, P.M. Erdniev, etc.), others refer to the category of a verbal formulation of this situation (L.M. Friedman). The most common is the use of the term "task" to refer to a situation that includes a goal and the conditions for achieving it [24].

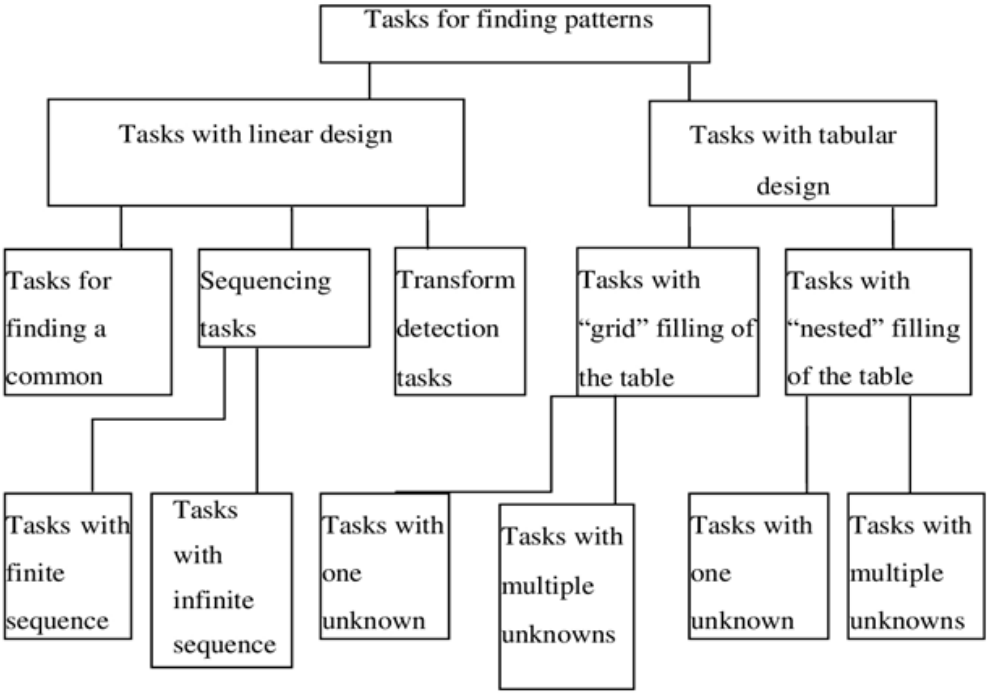
DISCUSSION

We will use the latter definition of a task as a situation involving a goal and a condition to achieve it in our work.

Thus, in our research, we understand pattern finding problems to be those whose solution is logically conditioned by the regularity of changing features.

The mathematical pattern finding problems include both arithmetical and geometrical problems.

An analysis of many works which at least mention pattern-finding tasks (although they are not named as such), allowed us to typify these tasks for younger pupils. Typification was made on the basis of the mutual arrangement of objects in the task condition (Scheme 1).



Scheme 1.

As we see, all problems in search of regularities are divided into two large groups - problems with linear construction and with tabular construction. When elements of a problem are arranged in one or more unconnected lines, we speak of problems with linear construction; when elements of a problem are arranged in the form of a table, we speak of problems with tabular construction [14].

But before describing specific pattern seeking tasks, it is necessary to talk about a learning task. According to A.N. Leontiev, by a learning task we mean a goal set in certain conditions, which can be achieved by implementing certain actions on the part of the learner and the instructor. The learning task is the main component of learning activity. On the one hand, it clarifies general learning objectives, specifies cognitive motives, and on the other hand, helps to make the process of activity itself meaningful. In the process of solving learning tasks, changes in the cognitive processes and personal qualities of the pupil take place.

There are different types of learning tasks: private, local, general and prospective. All types of learning tasks are interrelated in the learning process: solving local and private tasks is usually accompanied by solving general and prospective ones [14].

The following learning objectives are set for primary school students in our study. The prospective learning task is to develop analysis, synthesis, generalisation, comparison, abstraction, concretization. The general learning task is related to each individual type of pattern finding task, etc. Here are examples of tasks with geometric content belonging to each of the typing groups.

To solve this type of problem, the following scheme is proposed, which the students should follow:

Compare the figures of the condition (find what they have in common and what they have in common).

Formulate the common feature(s) that unite the condition figures.

Based on the feature(s) formulated, find a figure from the range of suggested answers that corresponds to them.

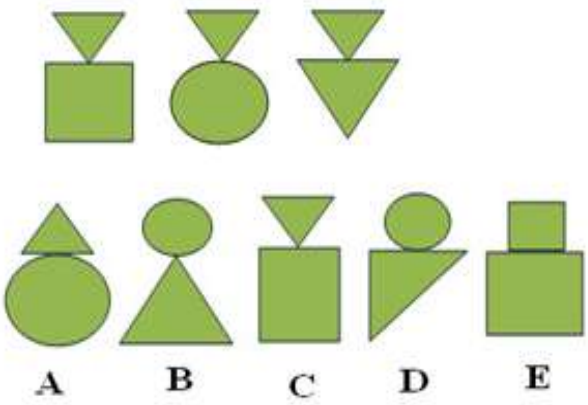
The peculiarity of this kind of problem is that a row with a choice of answers is obligatory for them. Otherwise, it is not possible to solve the problem.

RESULTS

All other groups can be either with or without a choice of answers. In both cases the problems are solvable. That is, the images that are offered as suggested answers are used only to confirm the answer found on the basis of analysis of the figures. Therefore, they should not be shown to children while searching for a solution to the problem. Otherwise, the attention is focused not on the solution of the problem, but on the choice of the figure they like. Sometimes the child's eyes get lost and he/she "chooses" at random.

During the geometric problem solving process, speech development is actively pursued and new concepts are vividly illustrated.

For example: Task No. 1



Teacher: Look carefully at the figures in the first row. What do they have in common? Which figure could continue the row?

Pupils: The shape under the letter C. There is a triangle there.

Teacher: The figure under B also has a triangle.

Pupils: The triangle must be on top.

Teacher: Under the letter A is a triangle on top.

Pupils: But the triangle is turned like this (represents an inverted triangle).

Teacher: So the top figure is a triangle with the base facing upwards.

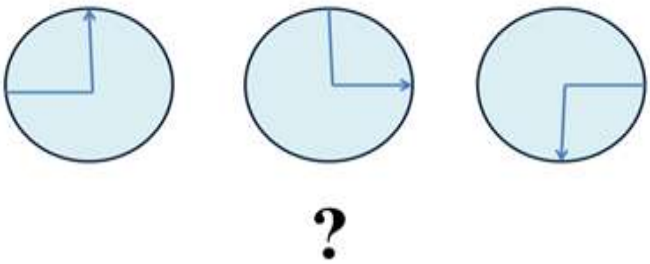
All sequence problems can have finite and infinite series. A finite series can be continued with one or more figures, an infinite series lasts as long as you like [14].

An example of a sequence problem with a finite number would be the following:

Task No. 2. Since in each subsequent figure one of the internal triangles is replaced by a circle, the next (and last) figure will be a figure consisting of four concentric circles. All triangles have been replaced by circles - so the row is complete.

Task No. 3.

The second-grade pupils find it very interesting when they solve the problem: “Continue the series



Teacher: How do the figures change one by one?

Pupils: The hands are turning.

Teacher: How do they turn?

Pupils: That’s it (show hands).

Teacher: Clockwise or anti-clockwise? Look carefully.

Pupils: Clockwise.

Teacher: By how much does it turn?

Pupils (thinking): For three hours.

The solution is given correctly. Et cetera.

The pattern problems are solved both orally and as a self-study exercise to reinforce the new material and to check what has been learned.

When comparing the instructions enclosed with the different types of tasks, it is clear that they are broadly similar. However, each of them has its own peculiarity. For example, when solving problems on finding common features, comparing figures in order to find common and different features, attention should be focused on common features, which are the basis for all tasks of the group. And when solving transformation problems first of all attention is paid to distinctions of figures, which is fundamental for this group of problems. And so on.

We have looked at the examples that make up the group of linear design problems. Let's move on to tabular construction [1].

As mentioned above, we will refer to tasks with tabular construction as those whose conditions are arranged in the form of a table.

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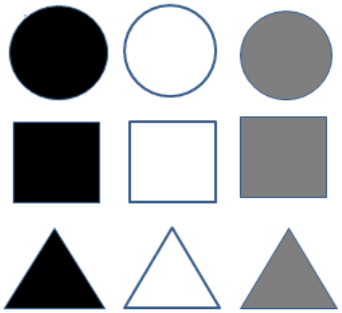
As mentioned above, we will refer to tasks with tabular construction as those whose conditions are arranged in the form of a table.

Let's look at an example of what a "grid" table is like.

Task No. 4.



The proposed problem identifies two features by which changes occur: shape changes vertically, colour changes horizontally. Horizontally the shape remains unchanged, the colour does not change vertically. Consequently, the condition of a problem with a "grid" table can be represented as a valid (conventional) tables, titling the columns and rows:

The solution to the problem comes down to "seeing" this table and filling in the empty cell according to the row and column names.

It is recommended to solve the grid problems using the following plan:

Compare the figures in the columns (find what they have in common and what they have in common).

Compare the figures in the lines (find what they have in common and what they have in common).

Formulate the feature by which the figures in the columns change.

Formulate the feature by which the figures in the lines change.

Use the features of the changes in the figures to fill in the empty cells in the table.

As with linear construction problems, tabular construction problems (and with 'grid' filling as well) may be offered with answer options [14].

Each time an answer is given (right or wrong), the teacher should ask the pupil to argue their choice, to prove that they are right. Why did he choose this figure and not the other one?

In gridded problems, there may be more than one blank cell (one question mark). The most important thing to watch out for in a grid problem is that one column and one row should be filled in completely each time. The maximum possible number of empty cells in a nine-cell table is four. However, it is advisable to give problems with several unknowns to the second grade at the earliest.

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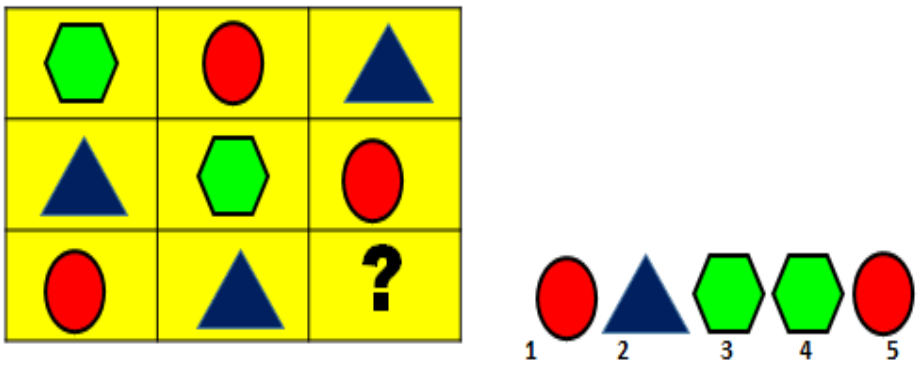
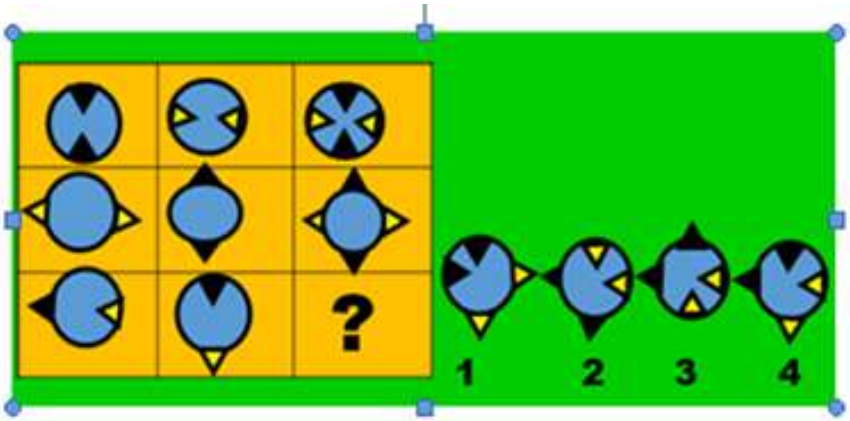
Task No. 5.



Of course, this task offers more opportunities to develop thinking than the one where only one figure is unknown.

The last group of all the variety of pattern-finding tasks is the "nested" table tasks. Let us also consider these problems with the help of a concrete example:

Task No. 6.



In contrast to the "grid" filling, in this problem all features (in our case three - the outer shape, the inner shape and the colour of the inner figure) change both horizontally and vertically. Each figure is, as it were, responsible for itself, forming a single "nest", but is of course in relationship to its neighbours both vertically and horizontally [10].

The following scheme is proposed to solve this type of problem:

Compare the figures in the table (find out what changes in the figures).

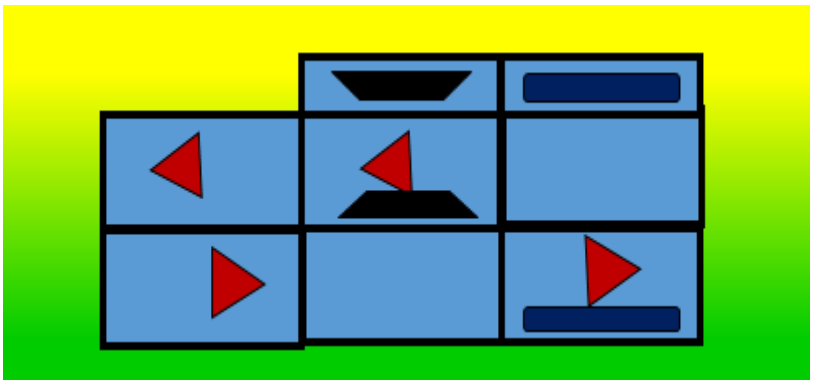
Formulate the characteristics by which the figures change.

3. Use the empty cells in the table to fill in the empty cells, one by one, according to the attributes.

For tasks with a "nested" table, answer options may also be provided. We will not dwell on this, as they are identical to those given above.

But problems of this type with several unknowns, unlike the "grid" ones, have their own peculiarity. It is necessary to add at least one more filled cell on one of the verticals and horizontals to the completely filled cells. Otherwise, it would be almost impossible for primary school pupils to solve the problem.

Task No. 7



We have considered all types of pattern finding tasks, which have been grouped together into appropriate groups.

CONCLUSION

However, it is often not possible to link the pattern finding problems to the topic being studied. This is mainly due to the small amount of geometric material taught in primary school. For this reason we offer you to work orally on patternfinding problems with geometric content. This will help to diversify this arithmetic-loaded stage of the lesson and will have an impact on the development of imaginative thinking.

So, we propose pattern finding tasks as a means to solve the problem of shaping the creative activity of younger pupils. Our study also provides a definition of these tasks [11].

The proposed typification of pattern finding tasks, made on the basis of the construction, allows one to navigate in the whole variety of these tasks and provides the possibility to use them in practical activities.

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SOLIDWORKS-BASED MODELING OF AN AIR-BLOWING SYSTEM TO ENSURE HIGH-QUALITY FIBER REMOVAL FROM SAW TEETH

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Abstract: This study presents the development and SolidWorks-based modeling of an air-blowing system designed to efficiently remove fibers from saw teeth. The effects of airflow direction, velocity, and pressure on fiber separation efficiency were analyzed. Aerodynamic characteristics of the structure, optimal geometric parameters, and methods for reducing process losses were determined. An improved design of the air-blowing system is proposed, enabling higher fiber extraction quality and increased overall technological process efficiency in industrial applications.

Key words: Saw teeth, fiber separation, air-blowing system, SolidWorks, modeling, aerodynamics, optimization, technological process.

Annotatsiya: Ushbu tadqiqotda arra tishlaridan tolalarni samarali ravishda olib tashlash uchun mo‘ljallangan havo puflash tizimining ishlab chiqilishi va SolidWorks asosidagi modellashtirilishi taqdim etiladi. Havo oqimi yo‘nalishi, tezligi va bosimining tolalarni ajratish samaradorligiga ta'siri tahlil qilindi. Tuzilmaning aerodinamik xususiyatlari, optimal geometrik parametrlar va jarayon yo‘qotishlarini kamaytirish usullari aniqlandi. Sanoat qo‘llanmalarida tolalarni yuqori sifatli ajratib olish va umumiy texnologik jarayonlar samaradorligini oshirish imkonini beruvchi havo puflash tizimining takomillashtirilgan dizayni taklif qilindi.

Kalit so‘zlar: Arra tishlari, tolalarni ajratish, havo puflash tizimi, SolidWorks, modellashtirish, aerodinamika, optimallashtirish, texnologik jarayon.

Аннотация: В данном исследовании представлена разработка и моделирование в SolidWorks системы обдува воздухом, предназначенной для эффективного удаления волокон с зубьев пилы. Проанализировано влияние направления, скорости и давления воздушного потока на эффективность отделения волокон. Определены аэродинамические характеристики конструкции, оптимальные геометрические параметры и методы снижения технологических потерь. Предложена улучшенная конструкция системы обдува воздухом, обеспечивающая более высокое качество извлечения волокон и повышение общей эффективности технологического процесса в промышленных условиях.

Ключевые слова: зубья пилы, отделение волокон, система обдува воздухом, SolidWorks, моделирование, аэродинамика, оптимизация, технологический процесс.

INTRODUCTION

Efficient removal of cotton fibers from saw teeth is a critical stage in the ginning process, directly influencing fiber quality, machine productivity, and the overall energy efficiency of the technological line. In traditional ginning systems, fiber accumulation on saw teeth leads to reduced operational stability, increased friction, higher power consumption, and accelerated wear of mechanical components. Ensuring continuous and high-quality fiber separation therefore requires reliable auxiliary mechanisms, among which air-blowing systems represent one of the most effective solutions.

Conventional mechanical cleaning methods often fail to maintain stable operation and may damage fiber structure due to intensive mechanical contact. In contrast, air-blowing (pneumatic assisted) systems rely on aerodynamic principles to safely detach fibers without compromising their physical properties. However, the

efficiency of such systems greatly depends on the correct selection of airflow direction, velocity, pressure distribution, and geometric configuration of the blowing channels. Many existing industrial designs suffer from non-optimal airflow alignment, uneven pressure distribution, and improper nozzle geometry, all of which limit fiber-removal performance.

Advances in computational modeling and 3D design technologies have opened new opportunities for optimizing pneumatic fiber-removal systems. SolidWorks, equipped with integrated CFD (Computational Fluid Dynamics) tools, allows for detailed simulation of airflow within complex geometries, enabling the analysis of pressure fields, velocity gradients, turbulence zones, and separation efficiency under various operating conditions. Such modeling significantly reduces the need for costly physical prototyping and accelerates the development of improved industrial designs.

The relevance of this study is driven by the increasing demand for higher fiber quality, reduced operational costs, and improved automation in modern ginning facilities. Effective fiber removal ensures stable machine operation, prolongs the service life of saw cylinders, decreases energy losses, and enhances the consistency of the final product. Furthermore, optimization of air-blowing systems contributes to cleaner working environments and greater technological reliability.

The present research aims to design and simulate an improved air-blowing system capable of efficiently detaching fibers from saw teeth using controlled airflow. By employing SolidWorks and CFD tools, the study evaluates the aerodynamic behavior of the system, identifies optimal structural parameters, and proposes a refined design suitable for industrial application. The simulated results serve as a scientific basis for developing a more efficient, energy-saving fiber-removal mechanism adaptable to modern ginning machines.

LITERATURE REVIEW ON THE TOPIC

The efficiency of fiber separation from saw teeth has long been a key research direction in cotton ginning technology. Early foundational studies by Knowlton and Van der Sluijs emphasized the mechanical behavior of fibers in saw-gin environments, highlighting how saw-tooth geometry, rotational speed, and fiber–metal interaction determine the degree of fiber entanglement and cleaning performance [1]. Their findings demonstrated that improper tooth geometry or insufficient cleaning mechanisms significantly increases fiber retention and reduces machine productivity.

Subsequent research has increasingly focused on pneumatic and aerodynamic methods for fiber removal. Khalfeev and Yuldashev investigated airflow-assisted separation in ginning systems, establishing theoretical principles for ejector-based cleaning mechanisms and identifying velocity thresholds required to detach fibers from saw surfaces [2]. Their experiments revealed that pneumatic cleaning not only reduces fiber damage but also stabilizes the cleaning process under varying operating loads. Similarly, Boykin and Baker analyzed airflow distribution in industrial gin environments and showed that optimized air-jet orientation can increase fiber-removal efficiency while lowering energy consumption [3].

Recent advancements in computational modeling have enabled more precise analysis of airflow behavior within ginning machinery. Islam and Jackson applied Computational Fluid Dynamics (CFD) to simulate air–fiber interactions in ginning ducts, demonstrating that detailed simulation can accurately predict turbulence levels, pressure drops, and airflow patterns that directly influence fiber behavior at the saw interface [4]. Their research validated CFD as a reliable tool for improving pneumatic system design. Parallel studies by Kerekes and Bennington on fiber suspensions in turbulent flows established fundamental insights into how aerodynamic forces act on fibrous particles—insights now widely applied in textile and ginning equipment optimization [5].

Within Uzbekistan's scientific community, several researchers have contributed significantly to the development of modernized ginning equipment. Azizov, Uzoqov, and Mirzakarimov conducted structural and aerodynamic analyses of saw-gin components, proposing new rib geometries, evaluating stress distributions in gin frames, and developing cost-efficient ginning machine variants [6–11]. Their studies highlight the necessity of integrating aerodynamic design with mechanical durability to create next-generation gins capable of handling variable cotton conditions. These works also emphasize that improved airflow systems can reduce fiber loss, improve quality, and extend equipment service life.

Overall, the literature indicates that achieving high-quality fiber removal requires a combination of optimized mechanical design and well-structured pneumatic cleaning systems. While traditional mechanical approaches remain widely used, modern ginning increasingly depends on precise airflow control, computational modeling, and geometry optimization. Despite significant progress, many existing systems still lack adequate airflow distribution and often fail to ensure consistent fiber removal. This gap underscores the relevance of the present study, which applies SolidWorks-based CFD modeling to develop an aerodynamically optimized air-blowing system designed specifically for effective fiber separation from saw teeth.

RESEARCH METHODOLOGY

In this study, the air-blowing system for fiber removal was modeled in SolidWorks to analyze airflow behavior around saw teeth. CFD (Flow Simulation) was used to evaluate velocity, pressure distribution, and airflow trajectories under different nozzle gaps and distances. Several geometric configurations were tested to identify the optimal airflow parameters ensuring efficient fiber detachment. Simulation results formed the basis for proposing an improved, energy-efficient air-blowing system design.

ANALYSIS AND RESULTS

At present, various mechanical and pneumatic methods are used in industrial enterprises to separate fibers and fine impurities. One of the most effective among them is the air-blowing (pneumatic cleaning) system, which operates based on aerodynamic principles. This system redirects the particle flow formed around the saw teeth into a safe direction through air pressure, ensuring continuous cleaning of the working zone. However, in many existing designs, insufficient airflow orientation, improper pressure distribution, or inaccurately selected geometric parameters lead to reduced operational efficiency.

Modern computer technologies—particularly 3D modeling and virtual simulation tools—provide extensive opportunities for addressing such technical challenges. SolidWorks software enables three-dimensional modeling of complex mechanical systems and facilitates the analysis of airflow movement, pressure distribution, turbulence intensity, flow velocity, and other key parameters. Utilizing these capabilities makes it possible to improve the air-blowing system, develop an optimal structural design, and enhance its operational performance.

The relevance of this research lies in the fact that high-quality fiber separation from saw teeth directly contributes to improved product quality, enhanced stability of the technological process, and reduced energy consumption. Moreover, it plays an important role in automating production and improving working conditions.

During cotton processing, fiber removal from saw teeth is typically carried out using various air-blowing devices; however, in many cases, they fail to fully perform their function—either due to insufficient airflow or improper airflow direction. To address this problem, we designed a new air-blowing and fiber-extraction system equipped with an automated airflow control mechanism.

During the 3D modeling stage, simulation makes it possible to avoid such errors. Let us examine how this process was carried out.

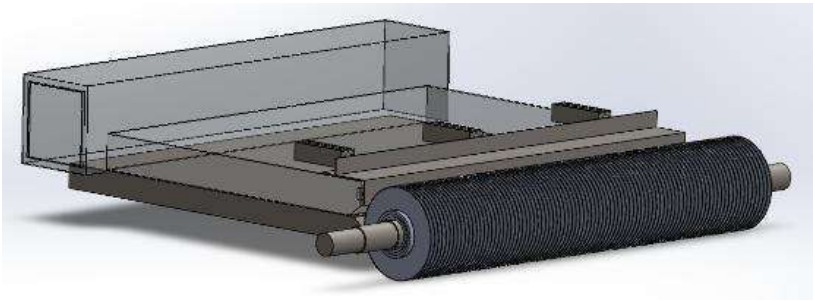

Figure 1. Automatically controlled air-blowing system

As a demonstration basis, let us take a simple model: in the SolidWorks add-ins tab, we enable the SolidWorks Flow Simulation add-in (if it is not already activated).

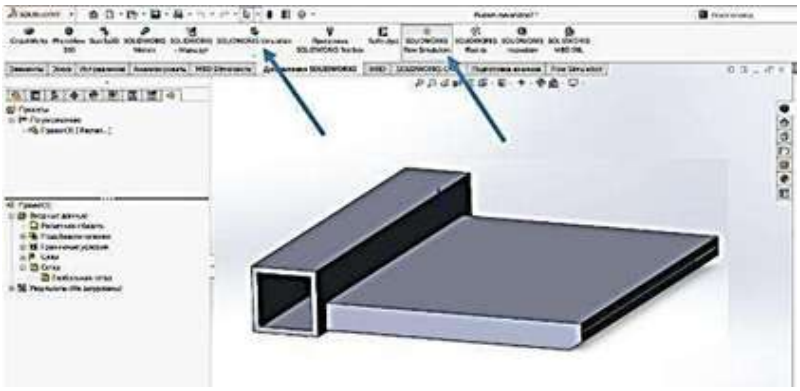

Figure 2. Automatically controlled air-blowing system

After that, a new tab with the necessary tools will appear.

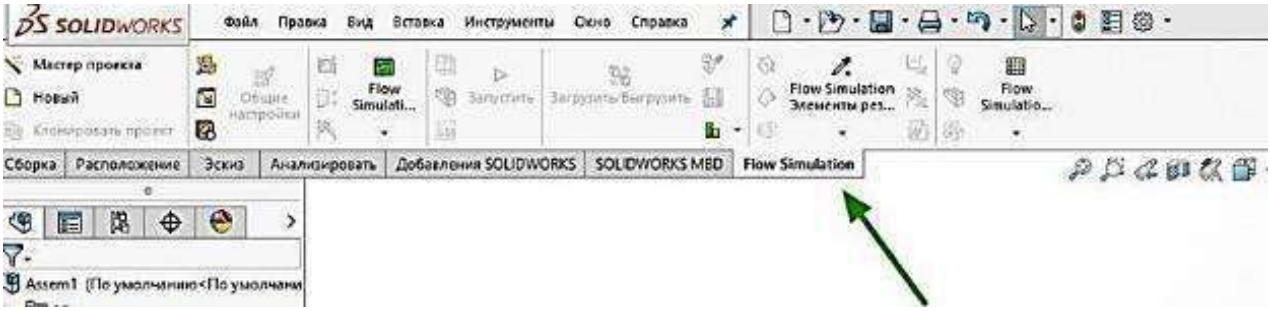

Figure 3. Automatically controlled air-blowing system

Let us create the air-blowing plane. The easiest way to do this is by placing a cover over the slots. We select the blowing plane (1) and confirm the selection (2).

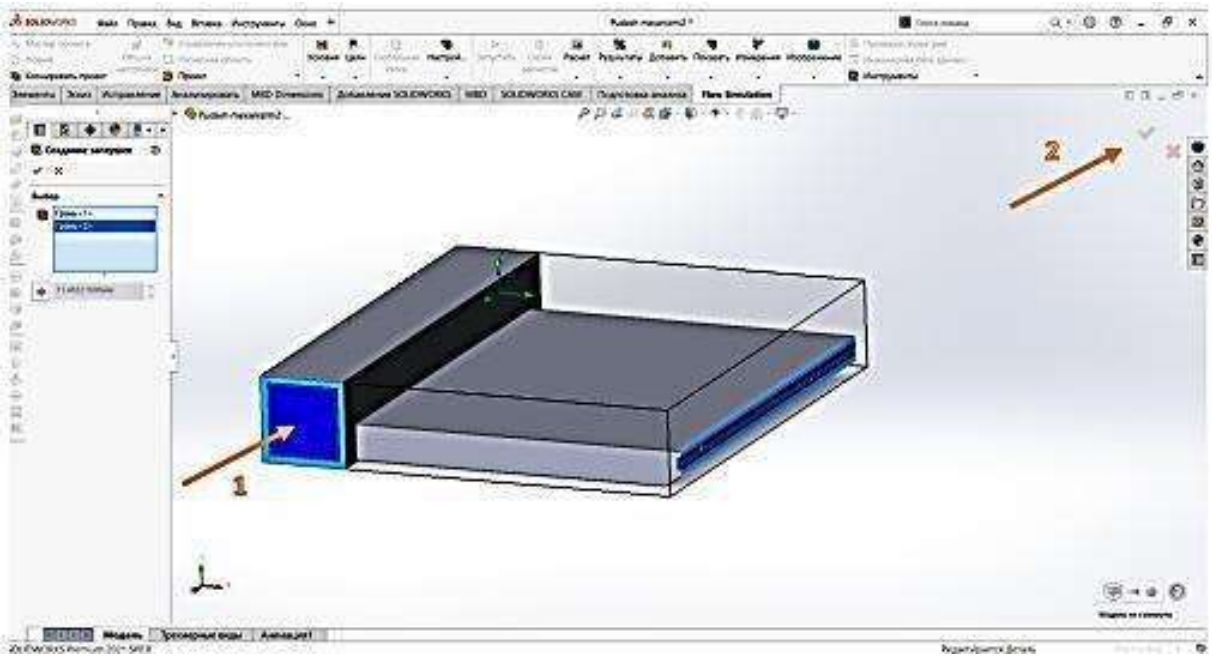

Figure 4. Automatically controlled air-blowing system

As a result, covers were created for the air inlet and air outlet slots.

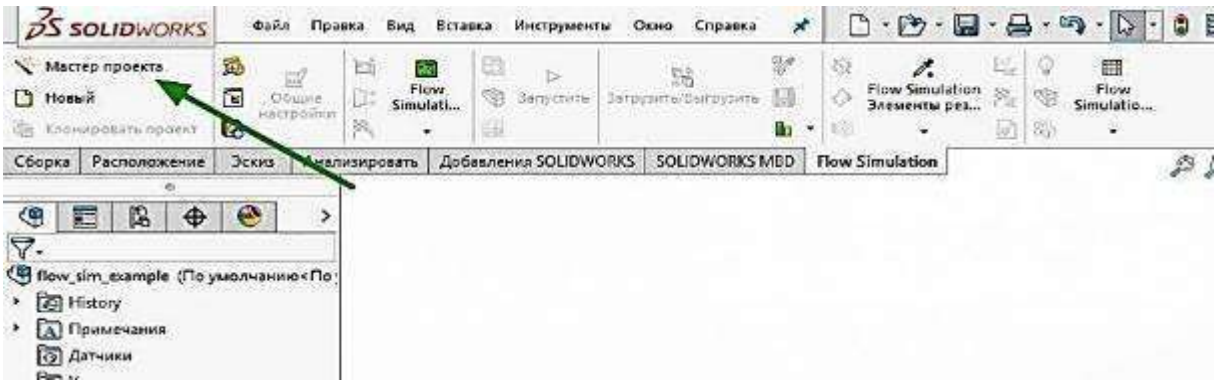

Figure 5. Automatically controlled air-blowing system

Using the “Master Project” button, we create the simulation project:

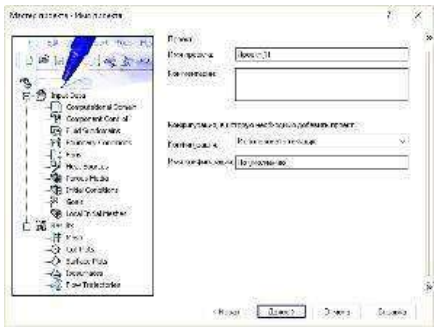

Figure 6. Project selection
The project name is useful only if the model contains multiple configurations. Otherwise, you may assign any name you wish.

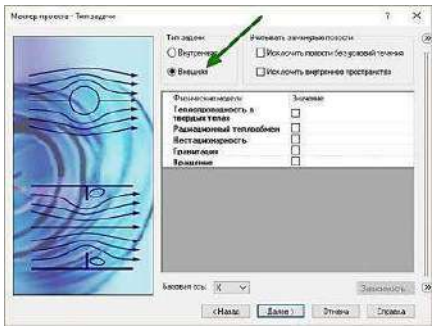

Figure 7. Selecting internal or external flow
The task type is set to internal flow, since the model is enclosed by covers on both sides. Additional physical models may be added if necessary, but using “ideal” conditions helps conserve computational resources.

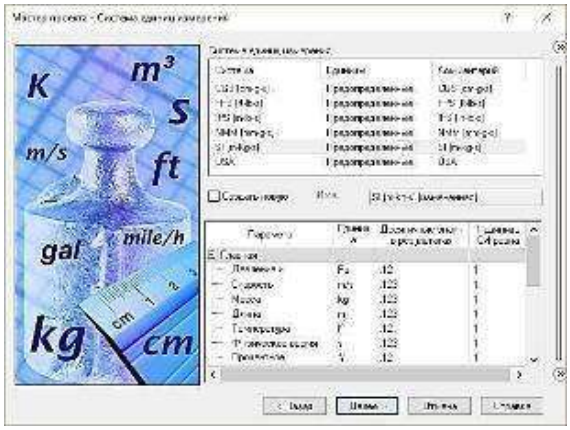

Figure 8. Selecting the AI calculation system

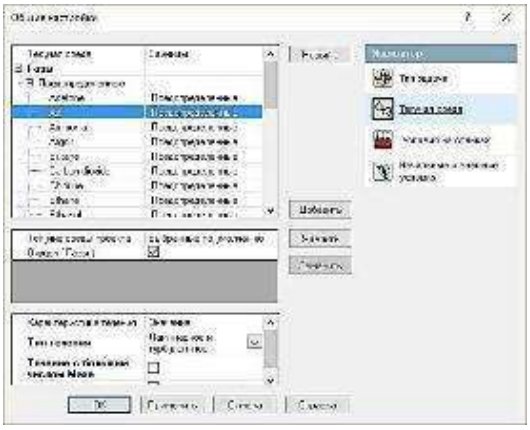

Figure 9. Selecting the air medium

By following the steps sequentially, an excessively large computational domain is generated. To reduce the simulation time, this domain must be trimmed.

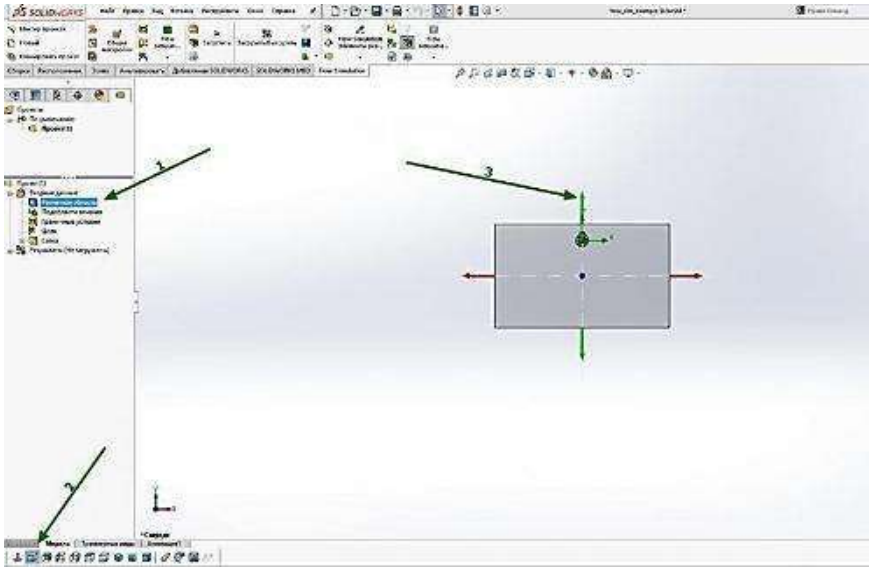

Figure 10. Limiting the computational domain

Select the “Computational Domain” (1), after which the dimension control arrows (2) will become highlighted. For convenience, you may switch viewing orientations (the control panel may differ, or you can open the view selector using the space bar). Adjust the arrows to reduce the domain to the required size (3).

Similarly, remove excess space on the opposite side.

In the air-blowing (“pudash”) zone, we leave slightly more space to observe how the airflow disperses externally.

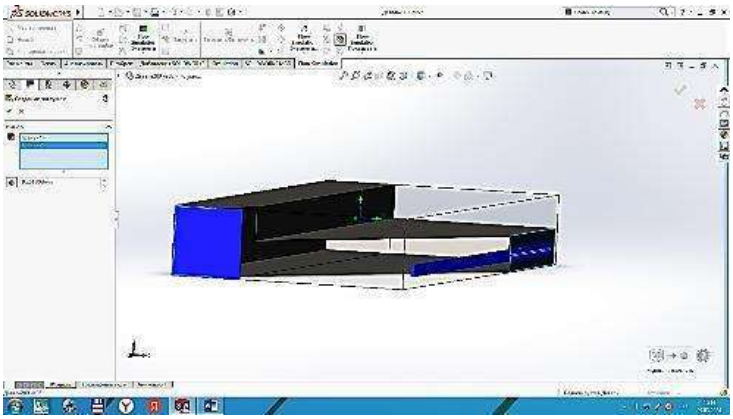

Figure 11. Closing openings and slots

We hide the computational domain from view. For convenience, we activate the section view of the model (1) and adjust it (2) to provide easy access to the inner surface of the cover (3).

Next, we select the inner surface of the cover (1), which performs the “air-blowing” function, and activate the fan feature on it (2).

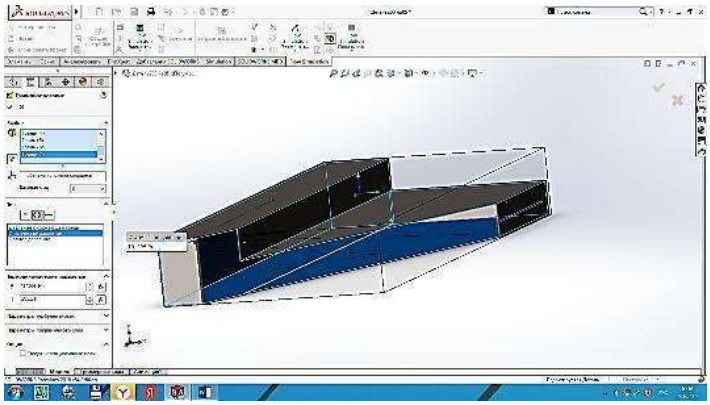

Figure 12. Selecting pressure for automatic calculation

We choose the airflow direction (1), select the type of fan (2), and apply the settings (3).

From the boundary conditions, we specify the static pressure for our design and set it to 101,325 Pascals.

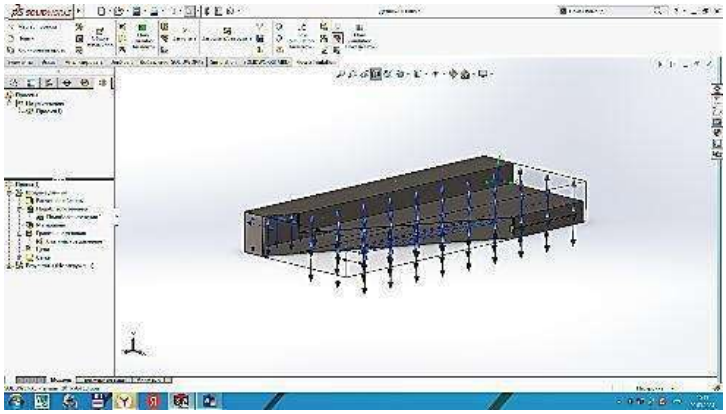

Figure 13. Pressure-affected surfaces

Next, we select the surfaces through which the airflow will move. As a result, the flow trajectories are generated, and green arrows appear on the model. After that, we specify the number of airflow particles—typically between 20 and 50—for both inlet and outlet flow visualization.

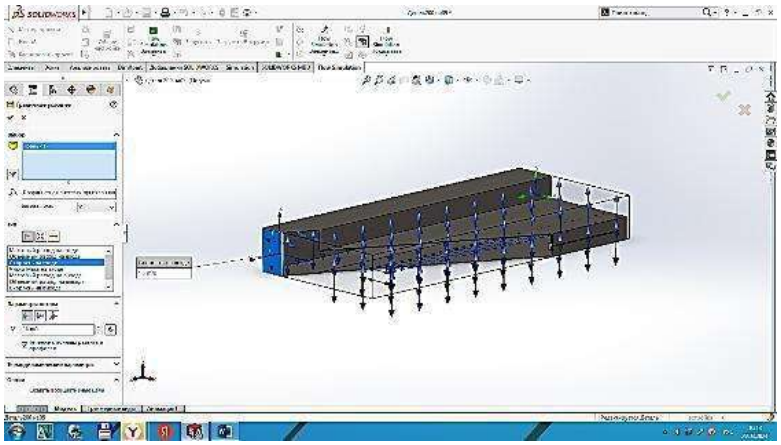

Figure 14. Setting the velocity at the inlet pipe

Next, we open the boundary conditions and assign the airflow velocity at the inlet pipe. Based on the performance characteristics of the VS-10 fan, we set the inlet velocity to 15 m/s. We also define the air outlet slot accordingly.

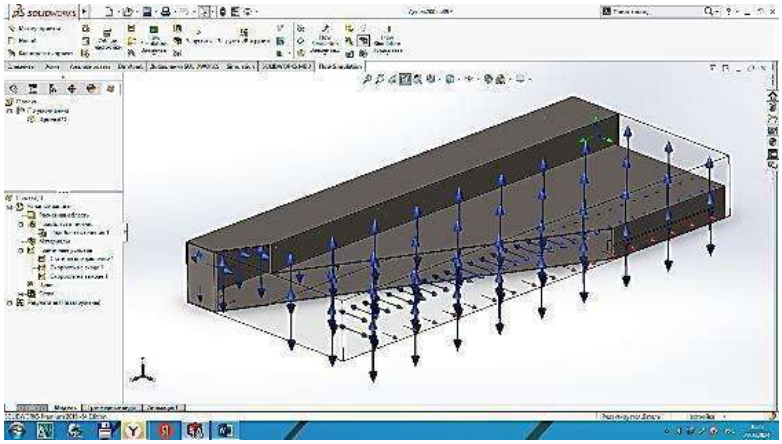

Figure 15. Airflow velocity direction

As a result, red arrows appear at the air inlet and outlet slots.
To run the simulation, we click the Start (Запустить) button located on the standard toolbar.

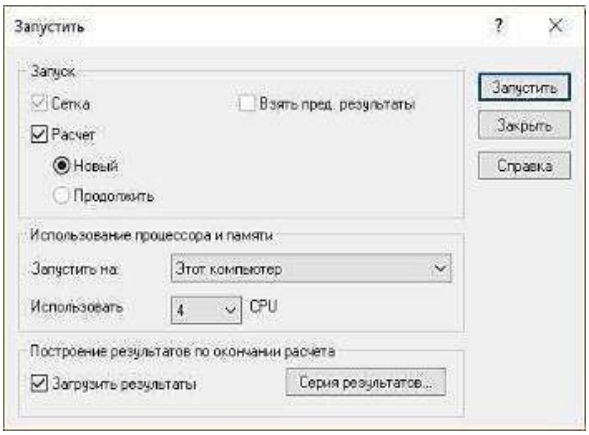

Figure 16. Starting the simulation We select the computer performance settings required for the calculation and then press the Start button to run the simulation.

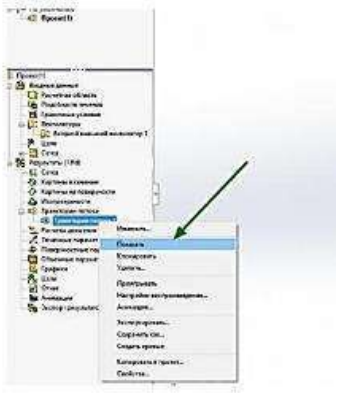

Figure 17. Displaying the contour plots After the simulation calculations are completed, the results appear in the Property Manager under the Results tab.

To visualize the airflow and velocities, we open the Results section in the Property Manager, select the Flow Trajectories option, and click Show to display them.

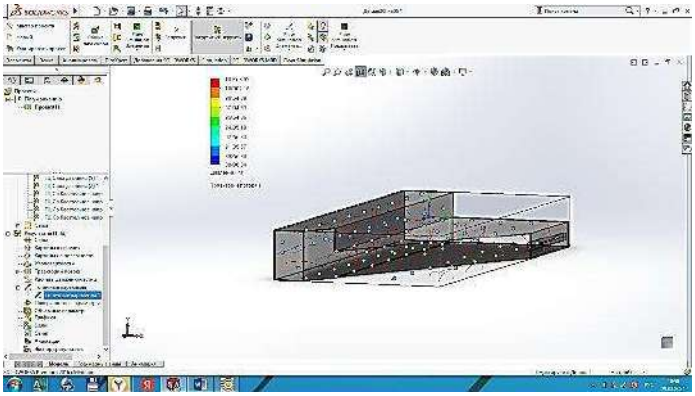

Figure 18. Pressure distribution and indicator diagram

A pressure contour and pressure distribution were obtained, as shown in the figure below.

The airflow contour at the outlet slot was also generated. Analysis of the contour and the corresponding color gradients revealed that the maximum airflow velocity at the outlet slot reaches 131 m/s, while the average exit velocity is approximately 120 m/s.

Based on these results, it was determined that the design parameters allow for the development of two independent air-blowing mechanisms.

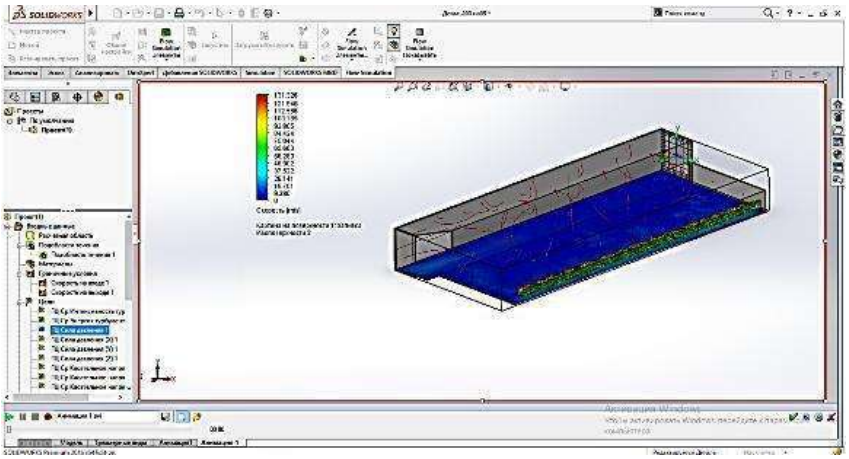

Figure 19. Airflow velocity contour at the outlet slot

As shown in the calculations, the method of compensating static pressure requires a more complex and extensive analysis compared to using a single main air duct along the entire system length. However, modern design and simulation tools make it possible to select the required parameters quickly and accurately.

After performing the simulation using the Flow Simulation module, the velocity plot indicates that the maximum airflow speed reaches 132 m/s, while the airflow exiting the slot in the air-blowing system averages around 120 m/s. This demonstrates that by adjusting the nozzle slot width through an actuator, it is possible to regulate airflow velocity and consequently improve the efficiency of fiber removal from saw teeth.

The developed three-dimensional model clearly confirms the effectiveness of the proposed design. The obtained results provide both theoretical and practical justification for constructing a functional prototype of the improved air-blowing mechanism.

CONCLUSION AND RECOMMENDATIONS

This study developed and analyzed an improved air-blowing (pudash) system designed to enhance fiber separation efficiency from saw teeth in cotton ginning machines. Using SolidWorks Flow Simulation, the airflow distribution, velocity profiles, and pressure gradients within the system were modeled and evaluated under different geometrical configurations.

Simulation results demonstrated that the optimized nozzle configuration generates a maximum airflow velocity of approximately 131–132 m/s, with a stable operating range near 120 m/s at the outlet slot—sufficient to ensure reliable fiber detachment from saw teeth. The improved aerodynamics reduce flow losses, stabilize pressure distribution, and minimize the risk of fiber re-adhesion.

The CFD-based approach confirmed that the proposed design significantly enhances operational performance compared to conventional air-blowing devices that frequently suffer from insufficient or poorly directed airflow. The validated 3D model provides a robust theoretical and practical foundation for fabricating a full-scale prototype.

Based on the findings of this study, the following recommendations are proposed:

- Manufacture a physical prototype using the optimized geometric parameters (slot width, nozzle curvature, airflow direction) identified in the simulations to validate performance under real operating conditions.
- Implement an actuator-based adjustable nozzle system to regulate slot width, allowing dynamic control of airflow velocity depending on cotton variety, moisture level, and ginning load.
- Conduct further analysis to examine energy consumption and fan efficiency, with the aim of reducing operational costs while maintaining high airflow velocity.
- Given that results show sufficient airflow capacity, consider integrating two synchronized air-blowing mechanisms for large-capacity gins to further enhance cleaning quality.
- Perform laboratory and industrial trials to compare actual fiber-removal performance with simulation predictions and quantify improvements in fiber quality, machine productivity, and residue reduction.
- Extend the model using turbulence models (k–ε, k–ω SST) or transient (time-dependent) simulations to better understand unsteady flow behavior and optimize the design further.
- Evaluate the suitability of different nozzle materials to improve system durability and reduce erosion caused by high-velocity airflow.

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THEORETICAL STUDY OF TEMPERATURE AND THERMAL PHENOMENA IN MECHANICAL CUTTING OF WHITE CAST IRON

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Abstract: The article is devoted to the theoretical study of temperature and heat phenomena during the mechanical cutting of white cast irons, the primary plastic deformation occurring in the shear plane, the amount of heat released in the conditional shear plane were analyzed. It is known that white cast irons have high hardness, strength and creep resistance, which greatly complicates the process of their mechanical processing. We theoretically studied the change in the temperature generated by friction on the front surface of the cutting tool during the mechanical processing of white cast irons depending on the type of white cast iron and the cutting speed.

Key words: mechanical energy, white cast iron, hard alloy, chip, wear, cutting speed, density, plastic deformation, physicochemical, tool blade, cutting tool, friction.

Annotatsiya: Maqola oq cho‘yanlarni mexanik kesib yo‘nish jarayonida harorat va issiqlik hodisalarini nazariy tadqiq etishga bag‘ishlangan bo‘lib, siljish tekisligida sodir bo‘ladigan birlamchi plastik deformatsiya hamda shartli siljish tekisligida ajralib chiqadigan issiqlik miqdori tahlil qilindi. Ma’lumki, oq cho‘yanlar yuqori qattiqlik, mustahkamlik va yeyilishga bardoshlik xususiyatlariga ega bo‘lib, bu holat ularni mexanik ishlov berish jarayonini o‘ta murakkablashtiradi. Tadqiqotda oq cho‘yanlarni mexanik ishlov berish jarayonida kesuvchi asbobning oldingi yuzasida ishqalanish natijasida hosil bo‘ladigan haroratning oq cho‘yan turlariga va kesish tezligiga bog‘liq holda o‘zgarishi nazariy jihatdan o‘rganildi.

Kalit so‘zlar: mexanik energiya, oq cho‘yan, qattiq qotishma, qirindi, yeyilish, kesish tezligi, zichlik, plastik deformatsiya, fizik-kimyoviy, asbob tig‘i, kesuvchi asbob, ishqalanish.

Аннотация: Статья посвящена теоретическому исследованию температурных и тепловых явлений при механической обработке резанием белых чугунов. Проведен анализ первичной пластической деформации, протекающей в плоскости сдвига, количества выделяющегося тепла в условной плоскости сдвига. Известно, что белые чугуны обладают высокой твердостью, прочностью и сопротивлением ползучести, что значительно затрудняет процесс их механической обработки. Теоретически исследовано изменение температуры, возникающей при трении на передней поверхности режущего инструмента при механической обработке белых чугунов, в зависимости от марки белого чугуна и скорости резания.

Ключевые слова: механическая энергия, белый чугун, твердый сплав, стружка, износ, скорость резания, плотность, пластическая деформация, физико-химические свойства, лезвие инструмента, режущий инструмент, трение.

INTRODUCTION

During mechanical cutting of metals, the cutting tool is subjected to active loads, elevated temperatures, and chemical interactions with the material being machined. This article is devoted to a theoretical study of temperature and thermal phenomena occurring during the mechanical cutting (machining) of white cast irons, based on a theoretical analysis of the mechanical cutting process of materials.

In mechanical cutting of metals, the generated heat is determined by the sum of the heat produced by primary plastic deformation occurring in the shear plane AB (Figure 1) and the frictional heat generated on the contact surfaces of the cutting tool's rake face (and the flank face in the case of constrained cutting processes) [1].

REVIEW OF LITERATURE ON THE SUBJECT

Theoretical and experimental studies of temperature and thermal phenomena in metal cutting have long occupied a central place in machining science, as thermal effects largely determine tool wear, surface quality, and process stability. Classical works in the field of materials cutting emphasize that heat generation during cutting is primarily associated with plastic deformation in the shear zone and friction at the tool–chip and tool–workpiece interfaces. In this context, Vereshchak and Kushner provide a comprehensive theoretical foundation for understanding cutting mechanics, heat generation sources, and their influence on tool performance. Their work systematically analyzes the interaction between cutting parameters, material properties, and thermal loads acting on the cutting tool, forming a methodological basis for subsequent studies on temperature fields in cutting processes.

Further development of cutting theory is closely related to the study of chip formation mechanisms and their dynamic behavior. Kozočkin's research on self-excited oscillatory mechanisms of chip formation highlights the complex nature of deformation and friction processes occurring during cutting. Although his work focuses primarily on chip instability, it also implicitly demonstrates the role of thermal effects, since temperature variations significantly affect material plasticity, friction conditions, and the stability of chip formation. These findings are especially relevant for hard-to-machine materials, such as white cast iron, where high cutting temperatures intensify tool wear and affect chip morphology.

A significant contribution to the theoretical analysis of thermal phenomena in cutting processes is made through computer modeling and optimization approaches. Pestretsov's учебное пособие on computer modeling of cutting processes presents modern methods for simulating heat generation, heat transfer, and temperature distribution in the cutting zone. The application of numerical modeling allows for a more detailed analysis of local temperature maxima in the shear plane and contact zones, which is difficult to achieve experimentally. Such approaches are particularly valuable for white cast iron, whose high hardness and resistance to plastic deformation lead to concentrated thermal loads in limited contact areas.

The concept of automated design of cutting processes, developed by Pestretsov, Altunin, Sokolov, and Odnolko, further advances the theoretical framework by integrating mechanical and thermal models into computer-aided process planning systems. Their work emphasizes the need to account for material thermophysical properties, cutting conditions, and tool geometry when predicting temperature levels and heat fluxes. This integrated approach is directly applicable to the theoretical study of temperature and thermal phenomena in the mechanical cutting of white cast iron, as it enables systematic evaluation of how cutting speed, material strength, and thermal conductivity influence frictional heating and overall temperature in the cutting zone.

Overall, the reviewed literature demonstrates that the theoretical study of thermal phenomena in cutting processes requires a combined analysis of mechanical energy dissipation, frictional interactions, and heat transfer mechanisms. Existing studies provide a solid scientific basis for analyzing temperature fields in metal cutting; however, the specific case of white cast iron, characterized by high hardness and low machinability, necessitates further focused theoretical investigations. This justifies the present study, which aims to deepen the understanding of temperature formation and thermal behavior during the mechanical cutting of white cast iron.

RESEARCH METHODOLOGY

According to A.D. Makarov and V.S. Mukhina, the amount of heat released in the conditional shear plane during the cutting process can be determined using the following formula [2]:

$$Q_{AB} = \frac{a_1 b_1 c_\rho \theta_A}{\operatorname{erf}\sqrt{\frac{\mathrm{Pe}B}{4}}}, \quad (1)$$

Here, θ_A – denotes the maximum temperature of the primary plastic deformation in the conditional shear plane (at point A of the cutting tool edge), °C.

The mechanical energy of plastic deformation in the conditional shear plane of the material being machined and in the adjacent regions is expressed by the following formula:

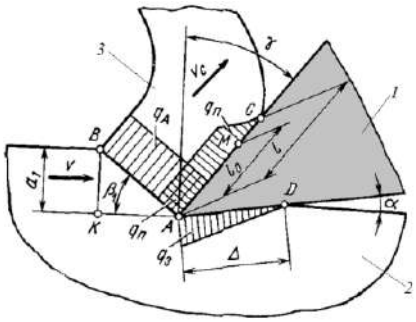
$$L_{AB} = R_c \cos\beta_1 v = \frac{\tau_p a_1 b_1 v}{B}, \quad (2)$$

Thus, using the equality of mechanical and thermal energies $L_{AB} = Q$, the maximum temperature at point A on the conditional shear plane can be expressed as follows:

$$\theta_A = \frac{\tau_p a_1 b_1 v}{c_\rho B} \operatorname{erf}\sqrt{\frac{\mathrm{Pe}B}{4}}, \quad (3)$$

According to equation (3), the maximum temperature in the conditional shear plane depends on the mechanical and thermal properties of the material being machined (λ, s, ρ, a), as well as on the degree of its deformation and the cutting conditions.

Mechanical cutting processes are characterized by the presence of three main rapidly moving planar heat sources, with width $AB = \frac{a_1}{\sin\beta_1}$, AC = l and lengths $AC = l$ and $AD = \Delta$, associated with the chip and the workpiece. The heat sources AS and AD are stationary relative to the cutting tool (Figure 1).



1 – cutting tool edge; 2 – workpiece being machined; 3 – chip being formed

Figure 1. Scheme of the distribution of heat release intensity on the contact surfaces of the cutting tool edge and in the shear plane [3]

The maximum heat release intensity q_A, q_n, and q_3 in the conditional shear plane AB and in the adjacent contact regions $AC = l$ and $AD = \Delta$ can be determined from the balance equation of mechanical and thermal energies.

According to equation (2), the amount of heat released over 1 second is expressed in J/s as follows:

$$Q_{AB} = q_A \frac{a_1 b_1}{\sin\beta_1}, \quad (4)$$

Since $L_{AB} = Q_{AB}$, we obtain:

$$q_A \frac{a_1 b_1}{\sin\beta_1} = \frac{\tau_p a_1 b_1 v \cos\beta_1}{\sin\beta_1}$$

After simplification, the final expression is:

$$q_A = \tau_p v \cos\beta_1. \quad (5)$$

Thus, the heat release intensity in the conditional shear plane AB increases with an increase in the strength τ_p of the material being machined and the cutting speed v, as well as with a decrease in the inclination angle of the conditional shear plane.

Analysis and results

The mechanical energy of friction in the contact region of the cutting tool edge is given by:

$$L_{AC} = \bar{\tau}_{AC} b_1 l v_c = 0,6875 \tau_p b_1 l \frac{v}{k_a}. \quad (6)$$

Here, τ denotes the average shear stress in the AC region, N/m².

Then, the amount of heat released over 1 second is:

$$Q_{AC} = \overline{q}_{AC} b_1 l = 0,6875 q\ b\ l \quad (7)$$

Here, q represents the average heat release intensity in the AC region.

From equations (6) and (7), we obtain the following expression:

$$q_{ï} = \tau_p \frac{v}{k_a} = \frac{\tau_p v B}{\cos\gamma + B\sin\gamma} \quad (8)$$

From the given equation, it can be seen that the heat release intensity on the rake face of the cutting tool increases with an increase in cutting speed and with a decrease in the thickness (cross-sectional engagement) of the chip.

The mechanical energy of friction in the contact region on the flank face of the cutting tool is:

$$L_{AD} = \overline{\tau}_{AD} b \Delta v \cos\alpha = 0,5 \tau_p b \Delta v \cos\alpha \quad (9)$$

Here, $\overline{\tau}_{AD}$ – denotes the average shear stress in the AD region, N/m²;

Δ - is the size of the contact region between the flank face of the cutting tool edge and the machined surface (Figure 1), m;

b – is the width of the flank face of the cutting tool edge, calculated according to equation (9), m.

Then, the amount of heat released over 1 second is:

$$Q_{AD} = \overline{q}_{AD} b \Delta = 0,5 q_3 b \Delta \quad (10)$$

Here, $\overline{q}_{AD}$ – denotes the average heat release intensity in the AD region.

According to equations (9) and (10), we obtain:

$$q_{ç} = \tau_p v \cos\alpha \quad (11)$$

From expression (11), it can be seen that an increase in the strength τ_p of the material being machined and the cutting speed v, as well as a decrease in the clearance angle α, leads to an increase in the heat release intensity on the flank face of the cutting tool edge. Taking into account that the sum of the average heat fluxes is equal to q_n and q_3, and considering equations (8) and (11), we obtain:

$$\overline{q}_{ï} = 0,6875 \frac{\tau_p v B}{\cos\gamma + B\sin\gamma}; \quad (12)$$

$$\overline{q}_{ç} = 0,5 \tau_p v \cos\alpha \quad (13)$$

The heat generated by friction on the rake face of the cutting tool edge is distributed between the chip, the workpiece being machined, and the cutting tool itself. The scheme developed for calculating thermal phenomena during the cutting process is shown in Figure 1.

According to S.S. Silin, the mechanical energy on the rake face of the cutting tool edge and the corresponding frictional heat are expressed by the following equation:

$$L_{ï} = Q_{ï} = F_{ï} v_{ñ} = F_{ï} v \frac{B}{\cos\gamma + B\sin\gamma} \quad (14)$$

$$F_{ï} = \tau_p a_1 b_1 \left(\frac{\cos\gamma + \sin\gamma}{B} - \cos\gamma + \sin\gamma \right)$$

we obtain:

If we take into account the formula developed for

$$Q_{ï} = \tau_{ð} a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - B\sin\gamma)}{\cos\gamma + B\sin\gamma} \quad (15)$$

This heat $Q_п$ is distributed between the chip and the cutting tool:

$$Q_{ï} = Q_{ñ.ï} + Q_{ð.ï}, \quad (16)$$

where $Q_{c.p}$ and $Q_{r.p}$ are the portions of frictional heat transferred from the contact surface to the chip and to the cutting tool, respectively, J/s.

According to S.S. Silin, the amounts of heat transferred to the chip and to the cutting tool are expressed as follows:

$$Q_{\text{ë.}} = n\tau_p\ a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}; \quad (17)$$

$$Q_{\text{ë.}} = (1-n)\tau_p\ a_1 b_1 v \frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}. \quad (18)$$

Then, the following expressions for the heat fluxes are valid:

$$\overline{q}_{\text{ñ.ï}} = \frac{Q_{\text{ñ.ï}}}{b_1 l} = \frac{0,6875 n\tau_p v B}{\cos\gamma + B\sin\gamma}; \quad (19)$$

$$\overline{q}_{\text{ñ.ï}} = \frac{Q_{\text{ñ.ï}}}{b_1 l} = \frac{0,68759(1-n)\tau_p v B}{\cos\gamma + B\sin\gamma}. \quad (20)$$

Equations (17)–(20) take into account only the frictional heat in the contact region $b_1 l$ and do not consider the heat generated in the conditional shear plane AB.

The maximum temperature generated by friction is expressed as follows [74]:

$$\theta_{\text{ì}} = 0,9675 \frac{n\tau_p \sqrt{\text{Pe}}}{c_p} \sqrt{\frac{\cos\gamma + \sin\gamma - B(\cos\gamma - \sin\gamma)}{\cos\gamma + B\sin\gamma}}; \quad (21)$$

To theoretically determine the overall temperature in the cutting process, the following formula is applied [4]:

$$\theta = \frac{\tau_p \text{erf}\sqrt{\frac{\text{Pe}}{4}}}{c_p B(1+k)} \left[1 + 0,73\psi_M + 0,5k\left(1 + \frac{\sin^{0,25}\alpha}{\sqrt{PeE}\,B^{1,25}} + 1,72\psi_N \right) \right]; \quad (22)$$

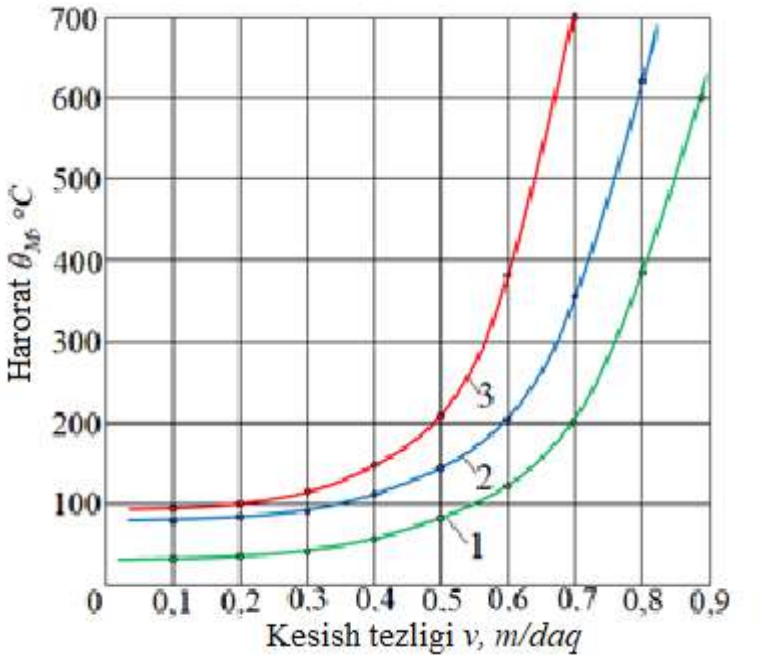
As can be seen from equation (21), the maximum temperature generated by friction on the rake face of the cutting tool edge increases with an increase in the strength τ_p of the material being machined and the cutting condition parameter Re, and decreases with an increase in the thermal conductivity λ of the material being machined and the inclination angle of the conditional shear plane.

It is known that white cast irons are characterized by high hardness, strength, and resistance to wear, which makes their mechanical machining extremely difficult. Based on equation (21), we theoretically investigated the variation of the temperature generated by friction on the rake face of the cutting tool during the mechanical machining of white cast irons as a function of the type of white cast iron (τ_p) and the cutting speed (v).

The following initial data were used in the calculations: for the cutting tool edge: VK6; geometric parameters: γ = 12°; α = 12°; φ = 45°; φ_1 = 15°; r = 0; thermal conductivity coefficient: $\lambda_{VK6} = 62.8\ \text{J/(m} \cdot \text{s} \cdot {}^\circ\text{C)}$; for the material being machined: resistance to plastic deformation $\tau_p = 4.5 \ldots 7.5 \times 10^9\ \text{N/m}^2$; thermal conductivity coefficient: $\lambda_{\text{white cast iron}} = 80.4\ \text{J/(m} \cdot \text{s} \cdot {}^\circ\text{C)}$; specific volumetric heat capacity: $c_p = 7.02 \times 10^6\ \text{J/(m}^3 \cdot {}^\circ\text{C)}$; thermal diffusivity coefficient: $a = 12 \times 10^{-6}\ \text{m}^2/\text{s}$; cutting conditions: feed $s = 0.2 \times 10^{-6}\ \text{m/rev}$; depth of cut $t = 2 \times 10^{-3}\ \text{m}$; uncut chip thickness $a_1 = 0.141 \times 10^{-3}\ \text{m}$; $b_1 = 2.83 \times 10^{-3}\ \text{m}$; cutting speed: v was taken in the range of $0.05 \ldots 0.9\ \text{m/min}$.

CONCLUSIONS AND SUGGESTIONS

Based on the results of the theoretical calculation of the temperature θ_M generated by friction in the contact region on the rake face of the cutting tool edge during mechanical turning of white cast irons as a function of the cutting speed v, the corresponding graph is presented in Figure 2 (Figure 2).



1 – hypoeutectic white cast iron; 2 – eutectic white cast iron; 3 – hypereutectic white cast iron

Figure 2. Graph showing the variation of the temperature generated by friction on the rake face of the cutting tool edge as a function of the resistance of white cast irons to plastic deformation.

From the presented graph, it can be seen that as the resistance of white cast iron to plastic deformation increases, the temperature generated by friction in the contact region on the rake face of the cutting tool edge during machining rises sharply.

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THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF SUSTAINABLE DEVELOPMENT OF THE REGIONAL ECONOMY

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Abstract: This article examines the theoretical and methodological foundations of sustainable development of the regional economy. It provides a scientific analysis of the economic content of the sustainable development concept, the specific features of regional development, and the mechanisms for effective management of territorial economic systems. Particular attention is paid to the key factors ensuring regional economic sustainability, including investment activity, efficient use of resources, the institutional environment, digital transformation, and social stability. In addition, modern methodological approaches used to assess regional development are systematized, and their practical significance is substantiated.

Key words: regional economy, sustainable development, regional development, economic sustainability, methodological approach, territorial governance, investment, socio-economic development, institutional factors.

Annotatsiya: Mazkur maqolada mintaqa iqtisodiyotini barqaror rivojlantirishning nazariy va metodologik asoslari tadqiq etilgan. Unda barqaror rivojlanish konsepsiyasining iqtisodiy mazmuni, mintaqaviy rivojlanishning o‘ziga xos xususiyatlari hamda hududiy iqtisodiy tizimlarni samarali boshqarish mexanizmlari ilmiy jihatdan tahlil qilinadi. Tadqiqotda mintaqa iqtisodiyotining barqarorligini ta’minlovchi asosiy omillar — investitsion faollik, resurslardan oqilona foydalanish, institutsional muhit, raqamli transformatsiya va ijtimoiy barqarorlik masalalariga alohida e’tibor qaratilgan. Shuningdek, mintaqaviy rivojlanishni baholashda qo‘llaniladigan zamonaviy metodologik yondashuvlar tizimlashtirilib, ularning amaliy ahamiyati asoslab berilgan.

Kalit so‘zlar: mintaqa iqtisodiyoti, barqaror rivojlanish, mintaqaviy rivojlanish, iqtisodiy barqarorlik, metodologik yondashuv, hududiy boshqaruv, investitsiya, ijtimoiy-iqtisodiy rivojlanish, institutsional omillar.

Аннотация: В данной статье исследуются теоретические и методологические основы устойчивого развития региональной экономики. В работе научно анализируются экономическое содержание концепции устойчивого развития, специфические особенности регионального развития, а также механизмы эффективного управления территориальными экономическими системами. В исследовании особое внимание уделено ключевым факторам обеспечения устойчивости региональной экономики, таким как инвестиционная активность, рациональное использование ресурсов, институциональная среда, цифровая трансформация и социальная устойчивость. Кроме того, систематизированы современные методологические подходы, применяемые для оценки регионального развития, и обоснована их практическая значимость.

Ключевые слова: региональная экономика, устойчивое развитие, региональное развитие, экономическая устойчивость, методологический подход, территориальное управление, инвестиции, социально-экономическое развитие, институциональные факторы.

INTRODUCTION

In the context of contemporary globalization and the digital economy, the intensification of economic disparities between regions, differences in the efficiency of resource utilization, and imbalances in socio-economic development have brought the issue of sustainable regional economic development to the forefront as a pressing scientific and practical problem. Sustainable development requires not only ensuring economic growth rates, but also the harmonious advancement of social stability, environmental balance, and institutional efficiency.

The regional economy constitutes an integral component of a country's overall economic system, and its sustainable development is one of the key factors determining the long-term competitiveness of the national economy. Therefore, assessing regional development solely on the basis of macroeconomic indicators is insufficient. There is a growing need for a comprehensive analysis of regional resource potential, production structure, infrastructure development, and governance mechanisms.

At present, scientific research on sustainable regional economic development demonstrates a diversity of theoretical approaches. However, systematizing these approaches within a unified methodological framework and adapting them to national and regional specificities is of particular importance. In this regard, the present study aims to identify the theoretical and methodological foundations of sustainable regional economic development and to substantiate the possibilities for their practical application.

REVIEW OF LITERATURE ON THE SUBJECT

Issues related to sustainable regional economic development have been widely examined within economic theory and regional economics. In foreign academic literature (Solow, Porter, Krugman, Sachs), sustainable development is interpreted as being closely linked to economic growth, innovative development, and competitiveness. These studies emphasize the importance of clustering, improving the investment climate, and institutional reforms in promoting regional development.

The concept of sustainable development is defined in the documents of the United Nations and the World Bank as the balanced development of economic, social, and environmental components. This approach requires comprehensive and long-term strategies in the formulation of regional policy. In the works of domestic scholars, regional economic development is primarily examined in connection with the spatial allocation of productive forces, the activation of investment processes, and infrastructure development. At the same time, the literature review indicates that issues related to the systematization of methodological approaches and the assessment of sustainable regional development using modern econometric methods and integrated indices have not been sufficiently explored. This circumstance necessitates the expansion of scientific research in this direction.

RESEARCH METHODOLOGY

The study employs a comprehensive set of general scientific and specialized economic research methods. Theoretical methods include analysis and synthesis, induction and deduction, comparison, and generalization. These methods were used to systematize theoretical views and conceptual approaches to sustainable regional economic development.

Within the framework of empirical research, statistical analysis, dynamic and structural analysis, the method of integrated indicators, and comparative analysis of economic indicators were applied. Based on official statistical data, trends in changes in key economic indicators were identified to assess the level of socio-economic development of the region.

In addition, elements of econometric modeling were used to identify the factors influencing sustainable regional economic development and to assess their interrelationships. These methods contributed to ensuring the reliability and scientific validity of the research results.

ANALYSIS AND RESULTS

In the twenty-first century, growing economic disparities between regions, imbalances in resource utilization, increasing pressure on the environment, and socio-economic inequalities are intensifying the need to optimize economic policy at the territorial level. For this reason, the issue of sustainable regional economic development occupies a central place not only in national development strategies, but also on the agendas of international organizations such as the WTO, the United Nations, UNDP, the Economic Cooperation Organization, and others.

Sustainable regional economic development is not limited to aggregate economic growth; rather, it represents a comprehensive approach aimed at ensuring long-term development through the integration of economic, social, and environmental sustainability. Contemporary trends such as digital transformation, the transition to a green economy, industrialization, and the expansion of the services sector require a fundamental rethinking of economic governance approaches at the regional level.

From this perspective, the academic literature does not offer a single unified conceptual approach to sustainable regional economic development. Various economic schools and researchers examine this issue through several key dimensions. The neoclassical approach emphasizes growth through the maximization of resource efficiency. Endogenous growth theories identify innovation, human capital, and the institutional environment as the primary drivers of development. Theories of regional economic growth focus on territorial

factors such as agglomeration, clustering, migration, and transport infrastructure. The sustainable development model, in turn, seeks to balance economic, environmental, and social sustainability.

The works of John Glasson and Tim Marshall on regional development theories, policies, and practical planning approaches address centralized and decentralized models, economic equilibrium and sustainability, interregional disparities, and urban integration. Particular attention is also paid to planning models aimed at ensuring environmental sustainability. In the studies of Harry W. Richardson, key economic models of regional economics are analyzed, including transport costs, regional employment, investment, and the role of state intervention. His research compares Keynesian and neoclassical approaches and discusses strategies for reducing regional disparities. The works of J. Vernon Henderson and Jacques-François Thisse encompass some of the most advanced theories and empirical studies in regional economics, including sections devoted to centralization, agglomeration, infrastructure, and the sustainable development of spatial economic systems. In these studies, the effectiveness of regional policy is assessed using complex mathematical models. Research by Arsenio Balisacan and Hal Hill examines sustainable economic growth and regional development in the context of efficient resource utilization, environmental protection, and institutional reforms. Based on the experience of the European Union, David Shaw, Daniel Galland, and Andreas Faludi analyze regional policy, multi-level governance, cohesion policy aimed at regional equity, and planning mechanisms for achieving environmental balance. Their research highlights the principles of subsidiarity and the foundations of institutional sustainability.

Despite the richness of these theoretical frameworks, significant methodological challenges arise in integrating them into practical application. In particular, indicator systems, development criteria, methodologies for measuring factors affecting sustainability, and approaches to modeling and assessing sectoral and interregional disparities remain insufficiently developed.

In the case of Uzbekistan in particular, economically relatively weaker regions such as the Republic of Karakalpakstan, Kashkadarya, Surkhandarya, and Jizzakh face persistent obstacles to sustainable development, including low efficiency of resource utilization, limited investment attractiveness, insufficient service-sector infrastructure, and heightened environmental risks. In the studies of N.X. Xodjayev, the theoretical foundations of regional economics, Uzbekistan's system of economic regionalization, efficient resource use, and pathways to achieving socio-economic stability are examined. In particular, the levels of economic development of the Republic of Karakalpakstan and the country's regions are assessed.

In the research of R.X. Xakimov, the impact of region-specific economic resources, transport and logistics infrastructure, and social infrastructure on sustainable development in Uzbekistan's regions is analyzed. A methodological framework based on comprehensive sectoral analysis and SWOT methods is applied. S.S. G'ulomov investigates the theoretical foundations for the formation of innovative clusters, technoparks, and R&D centers in regions, based on the interconnection between the innovation economy and regional development. Institutional conditions and regulatory–legal mechanisms are also examined.

In the study by B.M. Nurmuxamedov, the importance of shaping sustainable growth trajectories of Uzbekistan's economy through regional policy is substantiated. Interregional disparities, efficiency of resource utilization, and public investment are analyzed, and the integration of macro- and micro-level approaches is proposed. Sh.J. Raximov develops sustainability indices based on socio-economic indicators at the regional level. The influence of demographic, environmental, and investment factors on regional sustainability is examined using statistical and regression models, with particular attention paid to digital transformation and the green economy.

The works of R.A. Alimov and A.X. Axmedov provide an in-depth analysis of regional development theories, governance instruments, and Uzbekistan's practical experience. Sectoral development in regions is studied on the basis of specialization, infrastructure, labor markets, and resource allocation. Although the studies of Uzbek scholars cover important issues related to sustainable regional economic development, several significant gaps remain. Many studies rely on traditional economic indicators and infrastructure-based approaches, while the impact of the digital economy on regional development—such as the integration of IoT, big data, artificial intelligence, and e-commerce—has been insufficiently explored.

Although Sh.J. Raximov addresses environmental factors, modern scenario-based modeling of climate risks and their long-term economic consequences—such as CGE, DSGE, or dynamic panel analyses—remains underdeveloped. Issues related to increasing the role of vulnerable groups, including women, youth, and persons with disabilities, in regional economies and integrating social equity into economic analysis are largely absent. While public investment is considered, the participation of the private sector has not been sufficiently analyzed within financial modeling frameworks, particularly with regard to risk sharing and contract sustainability. Moreover, interregional and cross-border economic cooperation with neighboring countries and its impact on sustainable development have not been adequately examined.

Although S.S. G'ulomov discusses innovative clusters, empirical analyses of regional innovation indices, patent activity, and technological transfer flows remain limited. In many studies, analytical approaches are predominantly static and descriptive, and modern dynamic econometric models are rarely employed.

Therefore, the development of systematic, indicator-based, and model-driven methodological foundations for sustainable regional economic development represents one of the most pressing scientific and practical challenges. Such approaches should be enriched through the application of modern digital technologies, big data processing, simulation techniques, and scenario analysis.

In our view, priority should be given to developing indices based on regional digital indicators and empirically assessing their impact on sustainability; applying climate–economic models at the regional level and incorporating green economy transformation indicators; constructing inclusive sustainability indices and conducting differentiated regional analyses; performing empirical evaluations of the impact of public–private partnership projects on regional sustainability; and developing regional integration models for economic clusters and logistics corridors, for example along the Kashkadarya–Termez–Mazar-i-Sharif axis.

To assess innovative potential, it is advisable to adapt the Regional Innovation Scoreboard (RIS) framework and conduct sustainability assessments using dynamic panel models—such as Arellano–Bond GMM and VECM—based on regional variables including population size, industrial output, and export capacity.

In this study, the problem areas insufficiently addressed by the above-mentioned scholars and the proposed solutions are presented in Table 1 (Table 1).

Table 1. Analysis of Problems and Solutions in Sustainable Regional Economic Development

Problem area	Scholars with insufficient coverage	Proposed solution
Impact of the digital economy	Xodjayev, Xakimov, Alimov	Indices based on digital indicators
Climate and environmental models	Raximov (limited), others	CGE/DSGE models, green indices
Inclusive economic analysis	All	Gender-disaggregated economic analysis
Public–private partnership (PPP)	G‘ulomov, Nurmuxamedov	Analysis based on financial risk models
Cross-border regional integration	Xodjayev, Raximov	Regional cluster and logistics models
Innovation indices	G‘ulomov (core), others	Analysis based on RIS and GII
Dynamic economic models	All	Forecasting using VAR/VECM and GMM models

Within the framework of this research, we propose a scientific research topic and a corresponding methodological model designed to address existing research gaps in the sustainable development of Uzbekistan’s regional economy.

CONCLUSIONS AND SUGGESTIONS

The analysis of foreign and domestic academic sources demonstrates that sustainable regional economic development is a multifaceted, complex, and interdisciplinary scientific and practical challenge. Regional planning theories developed by John Glasson and Tim Marshall substantiate the need to balance centralized and decentralized governance approaches, mitigate interregional disparities, and integrate environmental sustainability into territorial policy. These approaches highlight the decisive role of institutional mechanisms in regional development.

The results of the analysis indicate that existing studies insufficiently address the impact of digital economy factors—including big data, artificial intelligence, IoT, and e-commerce—on sustainable regional development. Moreover, long-term scenario-based modeling of climate risks and environmental threats, efforts to enhance the role of vulnerable social groups in regional economies, in-depth analysis of private sector participation within financial sustainability models, and issues of cross-border economic cooperation remain inadequately explored in academic research.

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THE INTERRELATIONSHIP BETWEEN MIGRATION AND THE INDUSTRIAL ECONOMY

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Abstract: This scientific study summarizes international experience confirming the close interrelationship between migration and industrial development through the mechanisms of employment, structural transformation of the labor market, labor productivity, and innovation.

Key words: migration, industrial economy, labor market, productivity, innovation, clusters, Germany, ILO.

Annotatsiya: Ushbu ilmiy ishda bandlik, mehnat bozori tarkibiy qayta tuzilishi, mehnat unumdorligi va innovatsiyalar mexanizmlari orqali migratsiya va sanoat rivoji o‘rtasidagi uzviy bog‘liqlikni tasdiqlovchi xalqaro tajriba umumlashtiriladi.

Kalit so‘zlar: migratsiya, sanoat iqtisodiyoti, mehnat bozori, unumdorlik, innovatsiyalar, klasterlar, Germaniya, XMT.

Аннотация: В данной научной работе обобщается международный опыт, подтверждающий тесную взаимосвязь между миграцией и промышленным развитием через механизмы занятости, структурной перестройки рынка труда, производительности труда и инноваций.

Ключевые слова: миграция, промышленная экономика, рынок труда, производительность, инновации, кластеры, Германия, МОТ.

INTRODUCTION

International experience unequivocally demonstrates the deep interconnection between migration processes and the development of the industrial economy. This section analyzes the key dimensions of this relationship, including the impact of migration on employment and labor market structure; its effects on labor productivity, workforce skill levels, and innovative activity; as well as the role of migrants in the formation of industrial clusters and the development of specific economic sectors. The analysis is conducted both at the level of migrant-receiving countries (i.e., how the inflow of foreign labor affects the host economy) and at the level of migrant-sending countries (the significance of labor outflows and inflows for industrial development in migrants' countries of origin).

One of the primary issues concerns how migrant inflows influence employment and labor market dynamics in industrialized economies. Empirical evidence shows that, when properly managed, migration often complements the domestic workforce by alleviating labor shortages, particularly in the context of population aging. For example, in Germany, employment growth between 2005 and 2023 was entirely driven by workers with a migration background: the number of employed migrants increased by 6.3 million, while employment among those without a migration background actually declined. This indicates that, without migration, Germany's labor market would not only have failed to grow but would have contracted, with negative consequences for industry and public finances. Similar patterns are observed in other European countries with low fertility rates, where migrants have effectively become "fresh blood" for labor markets.

At the same time, large-scale migrant inflows often generate concerns among native populations regarding competition for jobs. However, most economic studies do not confirm significant long-term displacement of local workers by migrants. The main reason is that migrants tend to fill vacancies for which there are insufficient local applicants, whether due to low wages, difficult working conditions, or the need for geographical mobility. As a result, labor market segmentation emerges: migrants concentrate in specific sectors and occupations, complementing rather than directly replacing the local workforce. For instance, the share of foreign workers is extremely high in construction and agriculture in many countries, while it remains very low in the public sector, education, and administrative occupations.

REVIEW OF LITERATURE ON THE SUBJECT

The interrelationship between migration and the industrial economy has long been a central theme in economics, economic geography, and labor studies. Classical economic thought already acknowledged labor mobility as a factor of industrial development. Alfred Marshall emphasized the importance of labor pooling and industrial districts, noting that the concentration of industries attracts workers and, in turn, benefits from a diverse and flexible labor force. This early insight laid the foundation for later analyses of migration as both a response to and a driver of industrialization.

In neoclassical migration theory, migration is primarily explained through wage differentials and employment opportunities between regions. Michael Todaro and John Harris argued that migration decisions are influenced by expected income rather than current wages, highlighting the role of industrial job creation in shaping migration flows. Industrial expansion increases the demand for labor, particularly in urban and manufacturing centers, thereby attracting migrants from less developed or agrarian regions. This framework has been widely applied to explain rural-to-urban migration during phases of rapid industrial growth.

Structural and institutional approaches have further enriched the understanding of migration–industry linkages. Simon Kuznets, in his work on economic growth and structural transformation, demonstrated that industrialization is typically accompanied by shifts of labor from agriculture to industry and services. Migration functions as the mechanism through which this reallocation occurs. Similarly, Arthur Lewis's dual-sector model described how surplus labor from traditional sectors is absorbed by the modern industrial sector, enabling capital accumulation and productivity growth. Although initially developed for developing economies, Lewis's model remains influential in contemporary analyses of industrial labor demand and migration.

More recent empirical studies focus on the role of migrants in enhancing industrial productivity and innovation. George Borjas examined the labor market impacts of immigration, showing that migrants often complement native workers by filling skill gaps, particularly in manufacturing and technology-intensive industries. While Borjas also emphasized distributional effects and wage competition in certain segments, subsequent studies by Gianmarco Ottaviano and Giovanni Peri demonstrated that immigration can increase overall productivity by fostering task specialization and skill complementarity within firms and industries. Their research on European and US economies provides strong evidence that migrant labor contributes positively to industrial output and competitiveness.

The relationship between migration and industrial innovation has been explored extensively by AnnaLee Saxenian. In her studies of Silicon Valley, she showed how highly skilled migrants played a decisive role in the development of high-technology clusters, not only as workers but also as entrepreneurs and transnational network builders. Migrants facilitate knowledge transfer between countries, linking industrial economies through global value chains and innovation networks. This perspective aligns with the work of Richard Florida, who emphasized the importance of human capital mobility for regional industrial dynamism and creative economic growth.

From a global perspective, international organizations have contributed significant analytical insights. The International Labour Organization has consistently highlighted the role of migrant workers in sustaining industrial sectors facing demographic decline and labor shortages, particularly in advanced economies. Reports published by the ILO stress that well-managed labor migration supports industrial resilience, productivity growth, and structural adjustment, especially in manufacturing, construction, and logistics. Similarly, the Organisation for Economic Co-operation and Development has documented how migration supports industrial upgrading by supplying both high-skilled and mid-skilled labor essential for modern production systems.

At the same time, scholars have examined the implications of migration for sending countries and their industrial development. Oded Stark's work on the "new economics of labor migration" argues that migration decisions are often made at the household level to overcome market imperfections. Remittances sent by migrants can finance small-scale industrial activities, support human capital formation, and stimulate local manufacturing. However, Dani Rodrik cautioned that without appropriate industrial and institutional policies, migration alone cannot guarantee sustainable industrial development in origin countries and may even exacerbate structural imbalances.

RESEARCH METHODOLOGY

This study applies a mixed-methods approach to examine the relationship between migration and the industrial economy. The research combines qualitative theoretical analysis with quantitative empirical methods to capture both structural mechanisms and measurable economic effects. The qualitative component is based on a systematic review of classical and contemporary economic theories on migration, industrialization, and labor markets. This analysis provides the conceptual framework for identifying key transmission channels

linking migration with industrial employment, productivity, and innovation. The quantitative analysis relies on secondary data from international sources such as the International Labour Organization, the OECD, and the World Bank. Panel data regression models are used to assess the impact of migration on industrial value added and labor productivity, while controlling for macroeconomic and demographic factors.

ANALYSIS AND RESULTS

Statistical evidence confirms that migrants occupy a substantial share of jobs in physically demanding industries. Globally, according to ILO estimates, approximately 26.7% of all migrant workers are employed in industry (including construction, mining, and manufacturing), about 7.1% work in agriculture, and the remaining 66% are engaged in the service sector. This structure differs markedly from that of the native population, for whom the share employed in industry is often lower. In some economies, migrants play a critical role in specific industries: for example, in the United States, migrants account for 25–30% of all construction workers (reaching 25.5% in 2023), more than 35% of workers in cleaning and care services, and around 15% in manufacturing. In the Gulf countries (such as the UAE and Qatar), the number of foreign workers vastly exceeds that of nationals, and their economies rely almost entirely on imported labor.

An important effect of migration is the smoothing of labor market imbalances. During periods of economic expansion, when industrial output grows, migrants can rapidly fill newly created vacancies, preventing labor market overheating and restraining excessive wage growth. Conversely, during economic downturns, migrants' mobility allows them to return to their home countries or relocate to regions with higher labor demand, thereby mitigating unemployment pressures in host countries. In this sense, migration functions as a shock absorber. A notable example is Spain during the construction downturn of 2009, when a significant share of Latin American and Moroccan workers left the country, partially returning as economic conditions improved.

For labor-sending countries (such as Uzbekistan, Tajikistan, and Bangladesh), labor outflows can reduce domestic unemployment pressures while simultaneously creating labor shortages in certain sectors at home, particularly among skilled workers. Achieving balance is crucial. The outflow of surplus labor is often beneficial for countries of origin, as it reduces hidden unemployment and generates income through remittances. However, large-scale emigration of skilled workers leads to the phenomenon of "brain drain." For the industrial development of donor countries, it is essential to create conditions for circular migration—where workers return with accumulated capital and knowledge—or, at a minimum, to ensure that migration primarily involves surplus labor resources that are not effectively utilized domestically.

There is also the question of migration's impact on wage levels. In theory, an influx of additional labor may restrain wage growth—particularly in the low-skilled segment—by intensifying competition for jobs. Some studies identify a moderate downward pressure exerted by migrants on the wages of low-skilled native workers, amounting to approximately a 1–2% decline when the share of migrants increases by 10%. However, these effects are limited in scale and are usually localized. Moreover, in many advanced economies where migrants have filled specific labor market niches, native workers have either moved into higher positions (for example, migrants take assembly-line jobs while locals become supervisors) or shifted to other sectors. As a result, overall unemployment often declines as immigration increases, contrary to intuitive fears. Comparative research across OECD countries shows that regions with higher migrant inflows do not experience a deterioration in employment outcomes for natives; on the contrary, migration frequently stimulates job creation through demand-multiplier effects.

Poland provides a clear example. The large inflow of Ukrainian workers after 2014 coincided with a decline to historically low unemployment levels in Poland (around 3% by 2019). Ukrainians filled vacancies in sectors where Polish workers were no longer willing or able to meet labor demand, such as construction, logistics, and care services. As a result, industrial growth accelerated, firms were not forced to relocate production abroad due to labor shortages, and the local population did not face rising unemployment. This case illustrates the principle of labor complementarity between migrants and native workers.

Naturally, the effects of migration are uneven across population groups. Low-skilled native workers may face stronger competitive pressures, while high-skilled workers tend to benefit from economic expansion. Therefore, to mitigate potential negative effects, migration policy should be accompanied by active labor market measures supporting domestic workers, including education and retraining programs, incentives for hiring nationals in specific sectors, and robust protection of labor standards to prevent wage dumping through the exploitation of migrants. Countries that successfully integrate migrants typically enforce minimum wage regulations, unified labor standards, and effective labor inspections, thereby avoiding the emergence of a "two-tier" workforce. For example, in Canada and Australia, migrants are protected by the same labor laws as citizens, which significantly reduces the risk of declining labor standards.

Overall, migration affects the labor market in both positive ways—by alleviating labor shortages, creating new jobs, and increasing market flexibility—and in ways that pose challenges, such as heightened competition in certain segments and the need for effective integration policies. The prevailing consensus in OECD and IMF research is that the overall impact of migration on native employment and unemployment is, on average, neutral or slightly positive, provided that sound macroeconomic policies are in place. The industrial economy, as a major employer, typically benefits from the inflow of additional labor, thereby increasing potential GDP.

Migration influences not only the quantity of labor supply but also the qualitative characteristics of the industrial economy, including labor productivity, the accumulation of knowledge, and the diffusion of new ideas and technologies. Several key channels of this influence can be identified.

First, the qualifications and skills of migrants merit attention. Migration flows are often polarized, consisting primarily of either highly skilled professionals or low-skilled workers. Both groups affect productivity, but in different ways. Highly skilled immigrants contribute directly to innovation. Numerous examples show that inflows of foreign scientists and engineers have strengthened the research capacity of host countries. In the United States, for instance, the share of foreign-born scientists in universities exceeds 50% in several technical disciplines, leading to higher levels of academic publications and patenting. Estimates suggest that migrants educated at U.S. universities made their inventions approximately 23% more productive after migration, measured by the increase in patents per inventor. Immigrant entrepreneurs have also founded a large number of technology companies, creating new products and jobs. This phenomenon is not limited to the United States; in Europe as well, firms founded by migrants—for example in the United Kingdom—have, on average, demonstrated higher growth rates.

Low-skilled migrants influence productivity indirectly by freeing local workers for more productive tasks. This is often described as the “labor reallocation” effect: when migrants take on routine jobs (such as cleaning or simple manual work in manufacturing), local workers can be reassigned to more complex, skill-intensive operations. As a result, overall productivity rises because human capital is used more efficiently. For example, the availability of migrant domestic workers enables highly qualified women in advanced economies to return to work after childbirth, thereby increasing the overall contribution of skilled labor to the economy.

Migration can also stimulate the diffusion of knowledge and technologies. As people move, they carry with them practices, experience, and ideas. In industry, this is evident when cross-border teams in multinational corporations bring together specialists from different countries, facilitating the exchange of best practices. Similarly, when workers from a sending country gain experience in foreign factories and later return home, they can help modernize domestic production. It is no coincidence that countries such as China and India actively encourage the return of citizens who have acquired education and professional experience in the West to support the development of domestic innovation clusters (for example, China’s “Thousand Talents” program and India’s initiatives to attract returning scientists). This form of return migration, or “brain circulation,” has positive effects on global science and industry by promoting the worldwide dissemination of knowledge.

With regard to labor productivity, migrants often display high motivation and strong work ethic, initially compensating for potential language or skill gaps. Many employers note that migrants tend to work harder, are more willing to take overtime, and acquire new skills more rapidly in order to secure their positions. OECD statistics indicate that migrants, on average, work more hours per year than native workers, partly due to multiple job holding or irregular working arrangements. This increases overall output. On the other hand, if migrants are employed in low-productivity activities (for example, manual labor instead of automated processes), their availability may reduce incentives for technological upgrading. Some researchers have observed that the abundance of cheap migrant labor has delayed robotization in sectors such as Southern European agriculture or construction in Gulf countries. In this sense, easy access to low-cost labor can potentially slow productivity growth driven by innovation. However, this is largely a matter of policy: advanced economies typically aim to attract migrants while simultaneously promoting technological adoption, as the two objectives are not mutually exclusive when supported by sound industrial policy.

Innovation and migration have been widely studied together. Quantitative indicators, such as patent counts, show a positive correlation with the share of immigrants. In the United States, around 36% of registered patents include at least one foreign-born inventor, a figure far exceeding immigrants’ share of the population (approximately 14%). This indicates that migrants are disproportionately active in inventive activity. The reasons include selection effects (those migrating on work visas are often already highly skilled), diversity effects (the combination of different ideas generates novel solutions), and dynamism (the determination and entrepreneurial spirit often associated with migrants). Silicon Valley is a classic example: without the inflow of talent from around the world, it would not have become a global innovation leader. Similarly, in Germany, growth in the IT sector is partly supported by migrants (such as engineers from India and Eastern Europe), contributing to the digital transformation of industry under the Industry 4.0 framework.

Another important dimension concerns industrial clusters and migration networks. Migrants can facilitate the establishment of international linkages between firms. For example, Chinese and Indian engineers who gained work experience in the United States later founded businesses that connected Silicon Valley with Asian markets, thereby stimulating two-way investment flows and trade. A World Bank study notes that a 10% increase in the size of a diaspora in country X leads, on average, to approximately a 1.5% increase in exports from country X to the diaspora's country of origin, driven by market knowledge and personal networks. This phenomenon is often referred to as "diaspora diplomacy" or the network effect of migration.

From the perspective of sectoral innovation, migrants play a dual role: they act both as consumers of new products—introducing diverse demand patterns—and as founders of startups, particularly in fields such as information technology and biotechnology. Many countries actively seek to attract migrant entrepreneurs through special visa programs, recognizing their contribution to technological development. For instance, France has launched the Tech Visa, and the United Kingdom offers the Global Talent visa to encourage the inflow of startup founders and highly skilled innovators.

For labor-exporting countries, the impact on innovation is twofold. On the one hand, the emigration of young talent (for example, a programmer leaving Uzbekistan to work in the United States) represents a loss for the domestic innovation ecosystem. On the other hand, some of this talent can contribute remotely or return later with enhanced skills and experience. In the era of globalization, remote work mitigates this dilemma: individuals can now work for foreign companies while remaining in their home countries. This emerging trend—whereby many IT specialists in developing economies work remotely for firms in advanced economies—generates income for the home economy and upgrades human capital without causing physical outmigration. This form of "virtual migration" also affects productivity and knowledge exchange.

Education and migration represent another critical aspect. Migrants often seek to upgrade their skills, and in several countries the children of migrants demonstrate strong academic performance when integration policies are effective. As noted in the German case, children of immigrants born in Germany have significantly improved their educational outcomes over the past two decades. This suggests that, in the long run, migration can increase a country's overall human capital by adding new cohorts of educated citizens. The industrial sector benefits accordingly through an expanded pool of skilled labor.

CONCLUSIONS AND SUGGESTIONS

In conclusion, migration affects the productivity of the industrial economy in a multifaceted manner. The inflow of labor with diverse skill levels optimizes task allocation and enables countries to focus on their comparative advantages—for example, highly skilled migrants strengthen knowledge-intensive industries, while low-skilled migrants support labor-intensive sectors without pushing them offshore. When effectively managed, these dynamics raise total factor productivity. Countries that have historically remained open to migration, such as the United States, Canada, and Australia, exhibit high rates of innovation and economic flexibility, in part due to the continuous inflow of new talent and motivated workers.

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THE IMPACT OF ESG PRINCIPLES ON THE HOTEL INDUSTRY

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Abstract: ESG concepts are now essential for strategic decision-making, operational management, and investment allocation in the worldwide hotel business. As climate change accelerates and social expectations shift, hospitality firms are under unprecedented pressure to decrease environmental impact, improve labor conditions, and strengthen governance processes. This research investigates how ESG frameworks affect hotel performance, stakeholder participation, competitiveness, financial results, and long-term resilience. The article examines the operational advantages of ESG adoption using academic research, industry data, and sustainability case studies, such as reduced resource consumption, increased staff involvement, improved customer satisfaction, and increased access to green finance. Governance improvements, including as transparency, risk management, and ethical compliance, help to strengthen organizational credibility and investor trust. Emerging economies, such as Uzbekistan, provide fresh insights into how tourist expansion intersects with ESG adoption problems and potential. The findings indicate that ESG integration is no longer optional, but rather a strategic essential for hotels seeking future competitiveness and conformity with worldwide sustainability norms.

Key words: ESG, sustainability, hotels, tourism, corporate governance, social responsibility, hospitality industry, Uzbekistan, environmental management.

Annotatsiya: ESG konsepsiyalari bugungi kunda jahon mehmonxona sanoatida strategik qarorlar qabul qilish, operatsion boshqaruv va investitsiyalarni taqsimlash jarayonlarining ajralmas qismiga aylandi. Iqlim o‘zgarishlari jadallashib borar ekan va ijtimoiy kutilmalar o‘zgarayotgan bir sharoitda, mehmondo‘stlik sohasi korxonalari ekologik ta’sirni kamaytirish, mehnat sharoitlarini yaxshilash hamda boshqaruv jarayonlarini mustahkamlash borasida misli ko‘rilmagan bosimga duch kelmoqda. Ushbu tadqiqot ESG tizimlarining mehmonxona faoliyati samaradorligi, manfaatdor tomonlar ishtiroki, raqobatbardoshlik, moliyaviy natijalar va uzoq muddatli barqarorlikka ta’sirini tahlil qiladi. Ilmiy adabiyotlar, tarmoq ma’lumotlari va barqarorlikka oid amaliy misollar asosida ESG joriy etilishining operatsion afzalliklari, jumladan resurslar iste’molining qisqarishi, xodimlar faolligining oshishi, mijozlar qoniqishining yaxshilanishi va yashil moliyalashtirishga kirish imkoniyatlarining kengayishi yoritib beriladi. Shaffoflik, risklarni boshqarish va etik me’yorlarga rioya etish kabi boshqaruv takomillashtirishlari tashkilot obro‘si va investorlar ishonchini mustahkamlashga xizmat qiladi. O‘zbekiston kabi rivojlanayotgan iqtisodiyotlar turizm kengayishi va ESG joriy etish muammolari hamda imkoniyatlari o‘rtasidagi o‘zaro bog‘liqlikni tahlil qilish uchun yangi nuqtayi nazarlarni taqdim etadi. Tadqiqot natijalari ESG integratsiyasi endilikda ixtiyoriy emas, balki kelajakdagi raqobatbardoshlik va global barqarorlik standartlariga moslashishni ko‘zlagan mehmonxonalar uchun strategik zarurat ekanini ko‘rsatadi.

Kalit so‘zlar: ESG, barqarorlik, mehmonxonalar, turizm, korporativ boshqaruv, ijtimoiy mas’uliyat, mehmondo‘stlik sanoati, O‘zbekiston, ekologik boshqaruv.

Аннотация: Концепции ESG в настоящее время становятся неотъемлемым элементом стратегического принятия решений, операционного управления и распределения инвестиций в мировой гостиничной индустрии. В условиях ускорения климатических изменений и трансформации социальных ожиданий гостиничные компании сталкиваются с беспрецедентным давлением, направленным на снижение экологического воздействия, улучшение условий труда и укрепление механизмов корпоративного управления. В данном исследовании анализируется влияние ESG-подходов на эффективность деятельности гостиниц, вовлечённость заинтересованных сторон, конкурентоспособность, финансовые результаты и долгосрочную устойчивость. На основе научной литературы, отраслевых данных и практических кейсов в области устойчивого развития рассматриваются операционные преимущества внедрения ESG, включая сокращение потребления ресурсов, рост вовлечённости персонала, повышение удовлетворённости клиентов и расширение доступа к зелёному финансированию. Улучшения в сфере корпоративного управления, такие как повышение прозрачности, управление рисками и соблюдение этических норм, способствуют укреплению доверия инвесторов и институциональной репутации. Развивающиеся экономики, включая Узбекистан, предоставляют новые аналитические возможности для изучения взаимосвязи между ростом туризма и проблемами и перспективами внедрения ESG. Полученные результаты свидетельствуют о том, что интеграция ESG перестала быть добровольным элементом и превратилась в стратегическую необходимость для гостиниц, ориентированных на долгосрочную конкурентоспособность и соответствие международным стандартам устойчивого развития.

Ключевые слова: ESG, устойчивое развитие, гостиницы, туризм, корпоративное управление, социальная ответственность, гостиничная индустрия, Узбекистан, экологическое управление.

INTRODUCTION

The hotel sector is undergoing a major shift, fueled by rising environmental concerns, societal expectations, regulatory reforms, and investor demand. Environmental, Social, and Governance (ESG) principles are currently the main paradigm used by hospitality businesses to measure and promote their sustainability performance. Hotels are large energy and water consumers, garbage producers, and greenhouse gas emitters (UNWTO, 2023). At the same time, they rely significantly on human labor, community bonds, and open government institutions. Because of its interdependence, the industry is especially vulnerable to ESG problems. According to research, tourism accounts for around 8% of worldwide carbon emissions, with lodging accounting for the majority of that (Lenzen et al., 2018). Climate hazards to the hotel sector include heatwaves, increased energy prices, water scarcity, extreme weather events, and changed visitor tastes. As a result, hotel brands, investors, and tourism authorities are progressively incorporating ESG initiatives into long-term planning and operational decision-making (WTTC, 2022; KPMG, 2023). Financially, ESG performance has been connected to capital availability, asset valuation, and investment attractiveness. Institutional investors increasingly want hotels to demonstrate credible decarbonization plans, transparent reporting, and ethical governance (Deloitte, 2023). Consumers are also increasingly interested in sustainable housing alternatives, with research showing that more than 70% of travelers consider environmental considerations when purchasing hotels (booking.com, 2023).

The combination of environmental, social, and economic factors generates both obstacles and possibilities. ESG provides a strategic avenue for major international hotel companies to decrease operating costs, attract eco-conscious customers, and maintain a competitive edge. ESG implementation in small independent hotels may necessitate capacity development, training, and financial assistance. For emerging economies like Uzbekistan, fast tourist expansion highlights the significance of incorporating ESG principles to secure long-term industry success. This study investigates the influence of ESG principles on the hotel business in four key areas: environmental management, social responsibility, governance systems, and financial repercussions. A specific section examines ESG implementation in Uzbekistan in the context of national tourist growth. The study finishes with recommendations for expediting ESG adoption and outlining future research objectives.

REVIEW OF LITERATURE ON THE SUBJECT

The environmental component is sometimes the most apparent and quantifiable aspect of ESG in the hotel industry. Hotels utilize a lot of resources, such as energy, gas, water, food, chemicals, and disposable items. They also create significant amounts of waste, effluent, and pollutants. As a result, environmental sustainability has become a strategic objective for both multinational hotel chains and individual hotels seeking operational efficiency and regulatory compliance. Energy usage is one of the most expensive operating costs in hotels, accounting for 3-6% of overall expenses (International Finance Corporation [IFC], 2020). Heating, ventilation, and air conditioning (HVAC) systems account for about half of total usage, followed by lighting, kitchen operations, and laundry services. ESG frameworks encourage hotels to adopt energy-efficient technologies such as:

- LED lighting and motion sensors
- Smart energy-management systems
- High-efficiency chillers and boilers
- Heat recovery and heat pump systems
- Solar photovoltaic (PV) installations
- District heating systems sourced from renewables

According to empirical studies, hotels that employ energy-management solutions save 20-40% on their energy consumption. Hilton estimates a 42% reduction in carbon emissions intensity since 2008 as a result of systematic efficiency improvements (Hilton, 2023). Marriott has established a climate action plan that aims to reduce Scope 1 and Scope 2 emissions by 30% by 2030 as part of its Science Based Targets program (SBTi).

Boutique eco-hotel chains such as Guldsmeden Hotels in Copenhagen demonstrate that high environmental performance is achievable not only by large international operators but also by smaller market players. By sourcing renewable electricity, installing energy-efficient heating systems, and integrating sustainable architectural and interior design features, such hotels align their operations with evolving regulatory requirements, including the European Union's Corporate Sustainability Reporting Directive (CSRD), which mandates comprehensive energy consumption and carbon emissions disclosure.

Water management represents another critical environmental challenge for the hotel industry, as water is essential for guest comfort, hygiene, food services, and landscaping. According to UNWTO data from 2023, luxury hotels may consume between 300 and 1,000 liters of water per guest per night. To control and reduce

this intensive consumption, ESG-oriented approaches emphasize the use of low-flow fixtures, greywater reuse systems, rainwater harvesting, smart leak detection technologies, and water-efficient laundry and dishwashing equipment. Practical experience confirms the effectiveness of such measures. For instance, Scandic Hotels achieved substantial water savings by installing water-saving bathroom technologies and optimizing laundry processes, as reported in 2023. In regions facing water scarcity, including Southern Europe, the Middle East, and Central Asia, effective hotel water management contributes directly to the long-term resilience of tourism destinations.

Solid waste generation is another significant environmental footprint of hotel operations. Hotels produce large volumes of waste, including food residues, plastics, paper, textiles, glass, and hazardous substances. ESG systems promote comprehensive waste management strategies that focus on food waste monitoring and composting, cooperation with food rescue organizations, the introduction of refillable bathroom amenities, recyclable packaging solutions, elimination of single-use plastics, and upcycling initiatives such as furniture and textile reuse. Large hotel groups provide illustrative examples of these practices. Marriott, for instance, eliminated single-use toiletry bottles in many markets, preventing millions of plastic containers from entering waste streams annually, as reported in 2022. Similarly, CitizenM introduced circular procurement models that prioritize refurbishing and recycling furniture and equipment. Waste reporting aligned with GRI 306 standards also supports the calculation of Scope 3 emissions and improves transparency across hotel value chains.

Environmental certifications play a crucial role in structuring and verifying sustainability performance within the hotel industry. Standards such as LEED, BREEAM, Green Key, EU Ecolabel, Green Globe, and EarthCheck provide clear criteria for environmental management and continuous improvement. Empirical research by the World Green Building Council in 2021 indicates that certified hotels typically achieve 15–25 percent lower energy consumption while also benefiting from higher consumer trust. Certification thus serves not only as an operational tool but also as a marketing asset and a mechanism for meeting investor and regulatory expectations.

Beyond environmental considerations, the social dimension of ESG is particularly important in the hotel industry due to its reliance on human capital and front-line service staff. Social performance encompasses labour rights, employee wellbeing, stakeholder engagement, community impact, and guest safety. High staff turnover remains a persistent challenge, often exceeding 50 percent, according to Deloitte's 2023 findings. ESG-aligned hotels address this issue by investing in structured training and upskilling programs, employee engagement initiatives, diversity, equity, and inclusion policies, mental health support, and safe working environments. Research by Jones and co-authors from 2016 demonstrates that hotels with strong social policies experience lower employee turnover, higher guest satisfaction levels, and enhanced employer branding.

Hotels also exert a meaningful influence on local communities through their procurement and social engagement practices. By sourcing food, crafts, and services locally, partnering with non-governmental organizations, supporting cultural heritage initiatives, engaging in charitable activities, and prioritizing local employment, hotels contribute to inclusive economic development. Social impact reporting enables hotels to measure and communicate these contributions effectively. In emerging markets such as Uzbekistan, socially responsible hotel operations play a particularly important role in job creation, skills development, and community empowerment.

Guest wellbeing and health and safety have gained heightened importance in the post-COVID-19 context. Social responsibility in hotels now extends to enhanced hygiene and cleaning protocols, robust safety measures, universal accessibility through inclusive design, and guest education on sustainability practices. These initiatives not only protect guests and staff but also strengthen hotel reputations and support service differentiation in an increasingly competitive market.

Transparent ESG reporting underpins all environmental and social initiatives in the hotel industry. Hotels increasingly rely on internationally recognized frameworks such as the Global Reporting Initiative, Sustainability Accounting Standards Board, Carbon Disclosure Project, Corporate Sustainability Reporting Directive and European Sustainability Reporting Standards, the UN Global Compact, and the Task Force on Climate-Related Financial Disclosures. High-quality ESG reporting enhances investor confidence, improves risk management, and enables benchmarking across the industry, reinforcing the strategic value of sustainability integration in hotel management.

RESEARCH METHODOLOGY

This study employs a mixed-method analytical approach to examine the implementation and impacts of ESG principles in the hotel industry, with a particular focus on Uzbekistan. Secondary data were collected from international and national sources, including UNWTO, IFC, UNDP, World Bank reports, corporate sustainability disclosures of international hotel chains, and peer-reviewed academic literature. Descriptive and comparative

analysis methods were used to assess environmental, social, and governance practices across different hotel categories. Key ESG indicators related to energy efficiency, water consumption, waste management, labour practices, and governance transparency were systematically reviewed and mapped against international ESG frameworks such as GRI, SASB, and CSRD/ESRS. In addition, qualitative content analysis was applied to policy documents and sustainability reports to identify institutional drivers and barriers to ESG adoption. The findings are interpreted within the context of sustainable tourism development and emerging market conditions, allowing for an integrated assessment of ESG readiness and performance in the hotel sector.

ANALYSIS AND RESULTS

As a starting point for the analysis, existing academic research provides a foundation for assessing the relative importance of ESG factors in the hotel industry. Scholarly literature consistently identifies energy efficiency as the most critical sustainability challenge in hotel operations. Bohdanowicz and Martinac emphasize that rational energy use not only reduces environmental impact but also significantly lowers operating costs. Complementing this view, empirical studies by Han and co-authors demonstrate that green hotels outperform conventional hotels in terms of guest satisfaction and operational efficiency. These findings indicate that ESG considerations should be understood not merely as regulatory obligations, but as strategic instruments that enhance economic performance.

Social sustainability also occupies a central position in analytical assessments of the hotel sector. Research highlights that employee wellbeing, labour rights, and working conditions exert a direct influence on organisational outcomes. Studies conducted by Kim and colleagues reveal a strong positive relationship between employee satisfaction and overall hotel performance, confirming that human capital management is a key determinant of service quality and competitiveness. Governance-related aspects, while comparatively less explored in earlier literature, have gained increasing academic attention in recent years. Emerging research, including the work of Ehlers and co-authors, suggests that transparent ESG disclosures are associated with improved financial performance and enhanced risk mitigation, reinforcing the strategic relevance of governance mechanisms.

These theoretical and empirical insights are particularly relevant in the context of Central Asia, including Uzbekistan. In recent years, sustainable tourism development has become an explicit policy priority, with international organizations such as UNDP noting the gradual adoption of ESG principles across the region. This creates a need for a more detailed examination of both enabling conditions and structural barriers affecting ESG integration.

Within this context, Uzbekistan's hotel industry demonstrates considerable potential for ESG-driven transformation. Rapid tourism growth, increased construction of new hotels, and the entry of international hospitality brands provide favourable conditions for embedding ESG principles at an early stage of development. The country's high solar radiation levels support the adoption of renewable energy solutions, while new hotel projects create opportunities to apply energy-efficient design standards and international green building certifications. In addition, the availability of green financing from international development institutions and the growing use of digital and smart technologies enable more effective resource management. These factors form the analytical basis for the subsequent assessment of ESG implementation pathways, challenges, and performance outcomes in Uzbekistan's hotel sector.

ESG has increasingly emerged as a strategic imperative for hotels rather than a voluntary or peripheral activity. Research findings indicate that the integration of ESG frameworks into hotel operations delivers tangible economic, environmental, and organisational benefits that directly influence long-term competitiveness. Through systematic improvements in energy efficiency, water conservation, and waste reduction, hotels are able to significantly lower operating costs while simultaneously reducing their environmental footprint. These efficiency gains translate into more stable financial performance, particularly in a context of rising energy prices and increasing resource scarcity.

Beyond cost efficiency, ESG implementation strengthens hotels' market positioning by aligning their offerings with the growing preferences of environmentally and socially conscious travellers. Sustainability-oriented practices enhance brand reputation, increase guest loyalty, and support differentiation in highly competitive tourism markets. At the same time, strong ESG performance improves access to capital, as international investors, financial institutions, and development banks increasingly require transparent ESG disclosures as a prerequisite for funding. Hotels that demonstrate compliance with recognised ESG standards are therefore better positioned to attract long-term investment and favourable financing conditions.

ESG integration also enhances organisational resilience by enabling hotels to better manage climate-related risks, regulatory pressures, and labour market challenges. ESG-aligned hotels are generally more adaptable to environmental disruptions, evolving sustainability regulations, and workforce expectations related

to fair employment practices and wellbeing. These advantages reflect a broader global shift toward sustainable tourism development, where environmental stewardship, social responsibility, and sound governance are increasingly viewed as core components of business strategy. Academic research consistently confirms a positive relationship between ESG performance and organisational competitiveness, reinforcing the strategic importance of ESG adoption in the hotel industry, as evidenced by studies conducted by Jones and colleagues in 2016, Han and co-authors in 2011, and Ehlers and co-authors in 2022.

CONCLUSIONS AND SUGGESTIONS

This paper explored the impact of Environmental, Social, and Governance (ESG) principles on the global hotel industry, highlighting the increasing relevance of sustainability, transparency, and ethical management in hospitality. ESG frameworks have moved beyond voluntary initiatives and are now integral to operational efficiency, competitiveness, financial resilience, and value creation.

The environmental dimension—covering energy, water, waste, and emissions reduction—demonstrates measurable improvements in cost savings and carbon mitigation. Social sustainability emphasises workforce wellbeing, diversity and inclusion, and community engagement, which collectively enhance service quality and organisational culture. Governance systems form the backbone of ESG maturity, ensuring transparency, ethical conduct, risk mitigation, and alignment with investor expectations.

Empirical evidence from international hotel groups shows that ESG adoption strengthens market positioning, increases attractiveness to eco-conscious travellers, and expands access to green financing. Industry benchmarks reveal that hotels integrating ESG strategies outperform non-ESG hotels in operational efficiency and customer satisfaction.

Ultimately, ESG principles provide hotels with a strategic framework to address current challenges and future uncertainties. As global regulations tighten and consumer preferences shift, the hotels that successfully integrate ESG into their core business models will be best positioned for sustainable growth, investment attractiveness, and market differentiation.

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CURRENT STATUS OF INDUSTRIAL PRODUCTION AND SERVICES MARKET IN KASHKADARYA REGION

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Abstract: This article discusses the current situation in the market of industrial products and services in the Kashkadarya region and the sustainable development of the local industrial digital services market, including conducting big data analysis, various goals and objectives, methods of processing information resources of industrial enterprises, various situations and data processing processes, tracking the source of products in the process of virtual surveillance, identifying shortcomings in the stable operation of work processes and taking necessary measures to eliminate these shortcomings, and at the same time ensuring cybersecurity is one of the most important tasks in the sustainable development of the digital regional industry. In this current digital economy, the activities of the regional industry aimed at protecting information systems, networks, and programs from digital attacks are highlighted.

Key words: Ensuring cybersecurity, information systems of the regional industry in the digital economy, information resources of industrial enterprises, stages of industry development, technical and technological re-equipment, introduction of the digital services market.

Annotatsiya: Mazkur maqolada Qashqadaryo viloyatida sanoat mahsulotlari ishlab – chiqarish va xizmatlar bozorida hozirgi holati hamda Mahalliy sanoat raqamli xizmatlar bozorini barqaror rivojlanishida katta ma'lumotlar tahlilini olib borish, turli maqsad va vazifalar, sanot korxonalarining axborot resurslariga ishlov berish usullari, turli xil holatlar hamda ma'lumotlarni qayta ishlash jarayonlari, Virtual kuzatuv jarayonida mahsulot manbasini kuzatib borish, ish jarayonlarini barqaror borishida kamchilliklarini aniqlash va ushbu kamchiliklarni bartaraf etishda kerak choralar ko'rilishi va bir qatorda raqamli mintaqa sanoatini barqaror rivojlantirishda kiberxavfsizlikni ta'minlash ham juda muhim vazifalardan biridir. Bu hozirgi raqamli iqtisodiyot sharaitida mintaqa sanoatinining axborot tizimlari, tarmoqlari, va dasturlarini raqamli hujumlardan himoyalashga qaratilgan faoliyatlari yoritilgan.

Kalit so'zlar: Kiberxavfsizlikni ta'minlash, raqamli iqtisodiyot sharaitida mintaqa sanoatinining axborot tizimlari, sanot korxonalarining axborot resurslari, Sanoatning rivojlanish bosqichlari, texnik va texnologik qayta jihozlash, raqamli xizmatlar bozorini joriy etish.

Аннотация: В статье рассматривается текущее состояние рынка промышленных товаров и услуг в Кашкадарьинской области и устойчивое развитие местного рынка цифровых услуг для промышленности, проводится анализ больших данных, рассматриваются различные цели и задачи, методы обработки информационных ресурсов промышленных предприятий, различные ситуации и процессы обработки данных, отслеживание источника продукции в процессе виртуального наблюдения, выявляются недостатки в стабильном функционировании рабочих процессов и принимаются необходимые меры по их устранению, а также рассматривается обеспечение кибербезопасности как одна из важнейших задач устойчивого развития цифровой региональной промышленности. В статье освещаются мероприятия, направленные на защиту информационных систем, сетей и программ региональной промышленности от цифровых атак в условиях современной цифровой экономики.

Ключевые слова: обеспечение кибербезопасности, информационные системы региональной промышленности в условиях цифровой экономики, информационные ресурсы промышленных предприятий, этапы развития отрасли, технико-технологическое переоснащение, внедрение рынка цифровых услуг.

INTRODUCTION

Virtual monitoring is also important in the implementation of analytical processes. In the process of virtual monitoring, it is necessary to monitor the source of the product, identify shortcomings in the stable operation

of work processes and take necessary measures to eliminate these shortcomings. At the same time, ensuring cybersecurity is also one of the most important tasks in the sustainable development of the digital regional industry. This is an activity aimed at protecting the information systems, networks, and programs of the regional industry from digital attacks in the current digital economy. Ensuring cybersecurity combines technology, people, information, and processes to guarantee operations in the presence of attackers. In the sustainable development of the local industry digital services market, big data analysis is carried out, various goals and objectives, methods of processing information resources of industrial enterprises, various situations, and data processing processes are implemented. According to comparative analyses of scientific research conducted by foreign and domestic scientists, it was concluded that the principles of innovative development of the industrial structure of the region using digital technologies should be emphasized on the gradual formation of a new digital transformation process, and this process is associated with the fourth generation of industry.

Based on comparative analyses, today the market of digital services in industry is gradually diversifying under the influence of the digital economy through the introduction of modern technologies for data management. As a result, the work carried out in our country on the modernization of industrial enterprises, technical and technological re-equipment, and the effective use of information and communication technologies in the management system is contributing to increasing the volume and quality of production in the regions and taking a worthy place in the world market.

REVIEW OF LITERATURE ON THE SUBJECT

In particular, the research of Russian scientists AN Romanov, VP Koserov, GA Titorenko presented the fundamental foundations of the development of information systems, methodological aspects of the design and development of information systems for industries and sectors of the national economy, econometric models, statistical analysis and automated advisory information systems. Creation of the first chess-playing program (In 1954, REND analysts A. Newell, J. Shaw and G. Simon began writing a chess-playing program. A. Turing and K. Shannon, as well as a group of Dutch psychologists, volunteered to help them. The Chess Program (NSS) was written in 1957. Its work was based on heuristics, that is, rules for choosing a solution in the absence of theoretical foundations;

As D.O. Rogozina noted, the use of information and communication technologies (ICT) and complex data analysis to analyze the key factors of value creation and digitize industrial production processes will lead to a qualitative leap in efficiency, reduce costs, and become one of the important factors in shaping the competitiveness of industrial enterprises.International Data Corporation (IDC)International Data Corporation) According to data from the Institute for Advanced Research, the market for cognitive systems and artificial intelligence technologies in 2016 was worth about $7.9 billion in monetary terms. In 2017, it is expected to grow by 59.3% and reach $12.5 billion. Analysts believe that by the end of this decade, the average annual growth rate will be 54%. As a result, the value of products in the industry in 2020 will exceed $46 billion. The largest share of this market is occupied by cognitive applications that automatically study data and make various predictions, recommendations or forecasts. Investments in AI software platforms that provide tools, technologies and services based on structured and unstructured data amount to $2.5 billion per year. The AI market in the region, healthcare and life sciences, is also expected to grow by 40% annually, reaching $6.6 billion in 2021, according to Frost & Sullivan.

RESEARCH METHODOLOGY

This study is aimed at a comprehensive assessment of the current state of the industrial production and services market in the Kashkadarya region, in which systemic, regional and economic-analytical approaches were adopted as the methodological basis. The research methodology is based on the principles of considering the regional economy as an integrated socio-economic system, identifying the interdependence of industry and service sectors, and assessing their impact on regional development. The study ensured the combination of theoretical and empirical methods. Within the framework of theoretical methods, the methods of analysis and synthesis of economic literature, induction and deduction, comparison and generalization were used. Through these methods, foreign and domestic scientific views on the development of industrial production and the services market were systematized, and their aspects relevant to the conditions of the Kashkadarya region were identified.

ANALYSIS AND RESULTS

According to global macro models and analysts' estimates, Uzbekistan's industrial production is expected to grow by 8.50 percent this quarter. In the long term, Uzbekistan's industrial production is expected to trend

around 8.50 percent in 2022 according to our econometric models. In the development of the digital services market in the industry, it is important to provide the necessary elements to bring technological progress and strengthen the economy, as well as to apply the following industry trends.

First: Conducting analytical processes, that is, developing better systems for manufacturers in the context of recent events and the use of digital technologies to manage various types of processes.

Second: Supporting new levels of flexibility in implementing digital investments.

Third: It is necessary to expand its capabilities to reduce trade impacts and other disruptions in ensuring supply chain stability.

Fourth: Manufacturers need to know where and when to recalibrate global production volumes, and the supply chain needs to be digitally enabled, enabling real-time operations across complex supply chains.

The system models the process taking into account economic and real-time production tasks: the degree of conversion of hydrocarbon feedstock in the process changes depending on the variables affecting pyrolysis (reaction temperature, residence time of the feedstock in the furnace coil, pressure), as well as the selectivity of the process for various reaction products. For each possible operating mode of the RTO furnace, the composition and value of the target products in the cakes are calculated. Various digital technologies are used to design the market for digital services in industrial production. In particular, from cyber-physical systems,cloud computingfrom systems,internet tools(Internet of Things, IoT) and industrial Internet tools (Industrial Internet of Things, IIoT),Artificial intelligence, digital twins and other technologies.

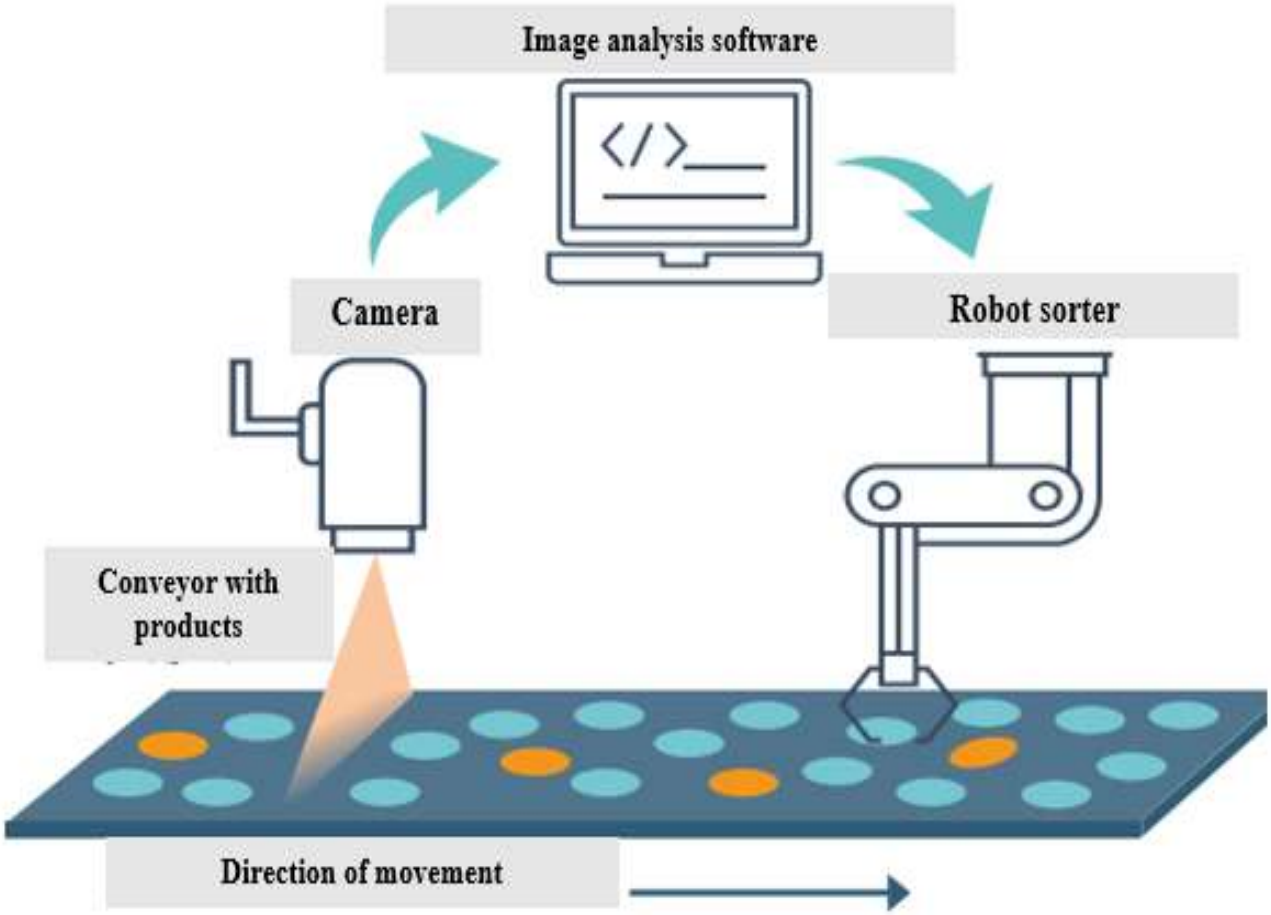

Figure 1.Organizing the digital transformation process in the industrial digital services market

Artificial intelligence actually includes various software systems and the methods and algorithms used in them, the main feature of which is the ability to solve intellectual problems as a person would think about solving them. Among the most popular applications of artificial intelligence are predicting various situations, evaluating any digital information with an attempt to draw conclusions from it, as well as analyzing various data by searching for hidden patterns (data mining).

Based on a retrospective analysis of the digital services market in industry, the views of scientists on economic relations and the management of scientific and technological progress are summarized in Table 1.

Table 1. Key strategic directions for organizing the digital transformation process in the industrial digital services market

Strategic directions of the transformation process	Duties
Application of BIM technologies in the life cycle of commercial infrastructure facilities	-BIM-based digitization covers all processes of the life cycle of commercial infrastructure facilities, ensuring an increase in the quality of use and service provision;
Formation of a common «Electronic Systems System» based on Bigdata and Artificial Intelligence	- formation of a single integrated electronic commerce system; -the integrated system includes information on city infrastructure and a number of other data; - the use of big data technology and Artificial Intelligence in the process of managing the digital services market
Using digital platforms and IoT technology to organize the digital services market	- Introduction of Internet technology in the process of managing trade and obtaining information directly from sensors of business facilities, as well as meters;
Application of information and analytical tools in managing the digital services market	- Expanding the use of information and analytical tools in business, including semantic analysis of text and speech, multidimensional statistical analysis, and processing of complex events in the process of considering citizens' appeals;
Implementation of Blockchain Technology in the Digital Services Market	- Using technology to increase the transparency of commerce, conduct digital transactions, documents, voting results, as well as develop crowdsourcing projects and monitor the work performed.

BIM- this is a technology that allows you to create a multidimensional model of a construction object, which contains all the information about it. Moreover, this model is used not only for construction, but also for the operation of the object. Therefore, it is absolutely wrong to think that BIM is only a graphic 3D projection. The capabilities of the technology are very wide. Information modeling implies a completely new approach to building construction and management, in which absolutely everything is taken into account. All this allows you to avoid possible changes in the design, reduce construction costs, and most importantly, save time. The introduction of BIM has made it possible to make the right decisions at all stages of the life cycle - from investment to commissioning and even demolition.

However, this technology also requires financial costs. In particular, it is necessary to purchase special software and equipment for training. However, in the future, these costs will be offset by reducing the costs of designing and organizing the construction of the building.

Big data(big data) - a very large volume of heterogeneous and rapidly flowing digital data that cannot be processed by conventional methods. In some cases, the concept of big data also includes the processing of this data. Basically, the object of analysis is called big data. The term bigdata was coined in 2008. Clifford Lynch, editor of the journal Nature, used the term Bigdata in a special issue dedicated to the very rapid growth of the world's data. However, big data existed before. According to experts, data flows of more than 100 gigabytes per day are called big data.

Big data analysis helps to identify patterns that are beyond human perception. This in turn creates opportunities to improve and enhance all areas of our daily lives, including government, medicine, telecommunications, finance, transportation, manufacturing, and more, and to find alternative solutions to problems.

IoT-These are physical devices, vehicles, appliances, and other objects, all of which use electronic circuits, software, sensors, and mechanical actuators connected to the Internet. This connectivity allows these objects to communicate with each other and exchange data, thereby creating more opportunities for direct integration between the real world and computer systems, thereby increasing efficiency and economic benefits. It reduces physical labor for people. In 2017, the number of IoT devices grew by 31 percent compared to the previous year, reaching 8.4 billion devices, and according to estimates, this number will reach 30 billion by 2020. The global value of the IoT market is estimated to reach $ 1.7 trillion. IoT involves extending Internet connectivity to devices beyond conventional devices, such as desktops, laptops, smartphones, and tablets, and extending it to non-smart devices without Internet connectivity. Devices using this technology can communicate and interact with each other over the Internet; they can also be monitored and controlled remotely.

Blockchain— this is a technology that allows system participants to securely transfer assets to each other without intermediaries. For example, blockchain can store records of money transfers. In cryptocurrencies, blockchain is used to record information about who transferred virtual money, to whom, and how much. However,

other assets can also be stored on blockchain. In general, everything that can be written on paper can also be written on blockchain, with the only difference being that blockchain cannot be tampered with or forged.

In general, if we analyze in depth the digital services market and its policies in the current industry of developed countries, we certainly looked at its history and development evolution, and as a result of the research, we examined a number of developed countries based on comparative analysis:

It is appropriate to analyze the development of the industrial sector in countries based on the study of the dynamics of key indicators reflecting their development in the context of global changes in economic processes. First of all, it should be noted that the main and most important indicators in analyzing the industrial sector, both in a separate region and in the country, are gross domestic product (GDP) and gross value added.

The table below shows the dynamics of the gross domestic product of countries currently ranked among developed countries in 2022-2024, as well as the economic growth rates for the year under review.

Table 2. GDP growth rates of CIS and G7 countries in 2022-2024

Countries	Growth rate, %			GDP, billion dollars		
	2022	2023	2024	2022	2023	2024
Armenia	2.8	3.0	3.1	11.3	11.7	12.3
Azerbaijan	2.9	3.1	2.7	44.2	45.5	48.8
Belarus	0.6	0.8	2.1	57.6	58.1	60.3
Canada	1.4	1.8	1.8	1702.4	1719.4	1783.3
France	1.6	1.7	1.7	2462.2	2562.2	2650.2
Germany	1.3	1.4	1.2	3517.0	3617.0	3727.6
Italy	0.6	0.8	0.8	1789.4	1879.4	1922.2
Japan	0.5	0.8	0.2	5005.7	5085.7	5163.7
Kazakhstan	2.5	2.8	3.2	171.5	188.5	204.6
Kyrgyzstan	4.8	2	4.9	7.1	7.6	8.0
Moldova	3.4	3.8	3.8	7.6	8.1	8.5
Russia	1.1	1.5	1.5	1552.0	1654.0	1712.0
Tajikistan	5.2	5.5	6.0	7.6	8.2	8.9
Turkmenistan	4.8	5.1	5.0	50.0	52.0	57,669
USA	1.4	1.6	1.9	2589.8	2607.8	2689.841
England	1.8	2.1	1.8	21109.3	21239.3	22063.044
Uzbekistan	5.8	6.0	6.0	72.3	75.5	79,742

According to the data presented in Table 2, it can be observed that the three leaders in terms of GDP are the following countries: the USA, Japan and Germany. The countries that lag behind among the countries studied are Kyrgyzstan, Moldova and Tajikistan. Table 3. Indicators of industrial production volume due to the digital transformation process in 2020-2024 by country

Table 3. (billions, dollars)

Countries	2018	2019	2020	2021	2020	2022
Belarus	98.3	109.4	120.1	132.8	151.0	178.6
France	366.7	362.6	368.8	371.0	378.3	379.7
Canada	233.9	245.6	244.4	244.3	257.6	266.1

Italy	490.4	485.1	493.6	500.3	515.8	522.7
Germany	1160. 8	1176. 5	1193. 6	1209. 4	1242. 2	1254
Japan	1735. 8	1765. 9	1743. 5	1744. 5	1793. 8	1813.2
Kazakhstan	72.4	72.5	71.34	69.6	75.4	77.7
Moldova	2.10	2.3	2.27	2.3	2.37	2.5
Russia	556.4	569.8	565.1	577.6	589.5	606.6
USA	3239.6	3339.0	3305.	3241.0	3316.2	3446
England	445.6	451.8	457.1	461.6	466.56	471.3

Based on the data presented in Table 3, the following conclusions can be drawn: The largest values in this table are given by the indicators of Germany, Japan and the USA; In the Russian Federation, the indicators of industrial production during the period under study show a positive growth trend. Thus, in 2022 this indicator amounted to 606.69 billion US dollars, in contrast to the corresponding period in 2014, which amounted to 556.4. We can see that the scientific approach to managing and ensuring the security of the digital services market in industry was adequately developed by world economists Taylor, Frank, Lilian Gilbreth and Henry Gantt. As the creators of the digital services market management in industry, they achieved high efficiency in improving many manual labor operations by automating them using observations, measurements, logic and analysis. Analyzing production efficiency and finding its main components is the first phase of the informatization of industrial production. Taylor, for example, measured how much iron ore and coal a person could lift with shovels of various sizes. They recorded the observations made at the research site with a film camera on magnetic tape and, in order to accurately measure, studied what movements a person made to perform certain operations and how much time he spent on each movement.

As a result of the reforms carried out to develop the region's industry in the context of the digital economy, methods of using modern technologies to develop the industrial structure are emerging. More attention is being paid to communication services and communication services. The creation of modern models of regional industry depends more on information exchange and improvement of information models.

Here, we will consider the structure of the information model of the development of the industrial structure by sector and the experience of analyzing and calculating it based on calculations performed in ICT. The general scheme of the calculation experiment is shown in Figure 1.

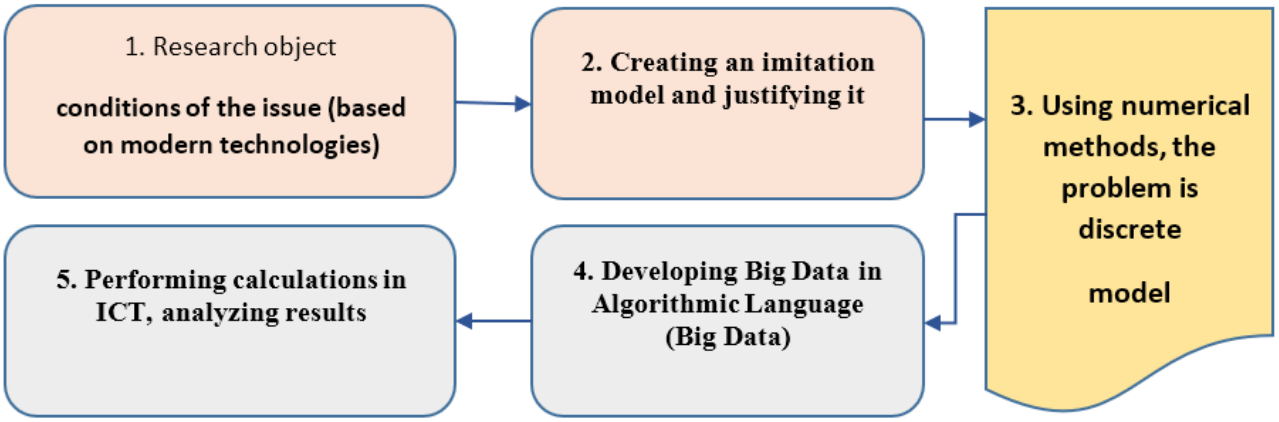

Figure 1. General scheme of the experience of calculating the information model of the digital services market in the regional industry

In big data computing (BDC), the numerical results obtained are deeply analyzed and evaluated. Since the database consists of a large amount of data, the following security principles are developed in order to maintain the security and confidentiality of big data, and the database security specialist, depending on the results, draws conclusions about the process being analyzed, influences its implementation based on a specific goal, develops control tools, and makes recommendations.

This is shown in Figure 2.

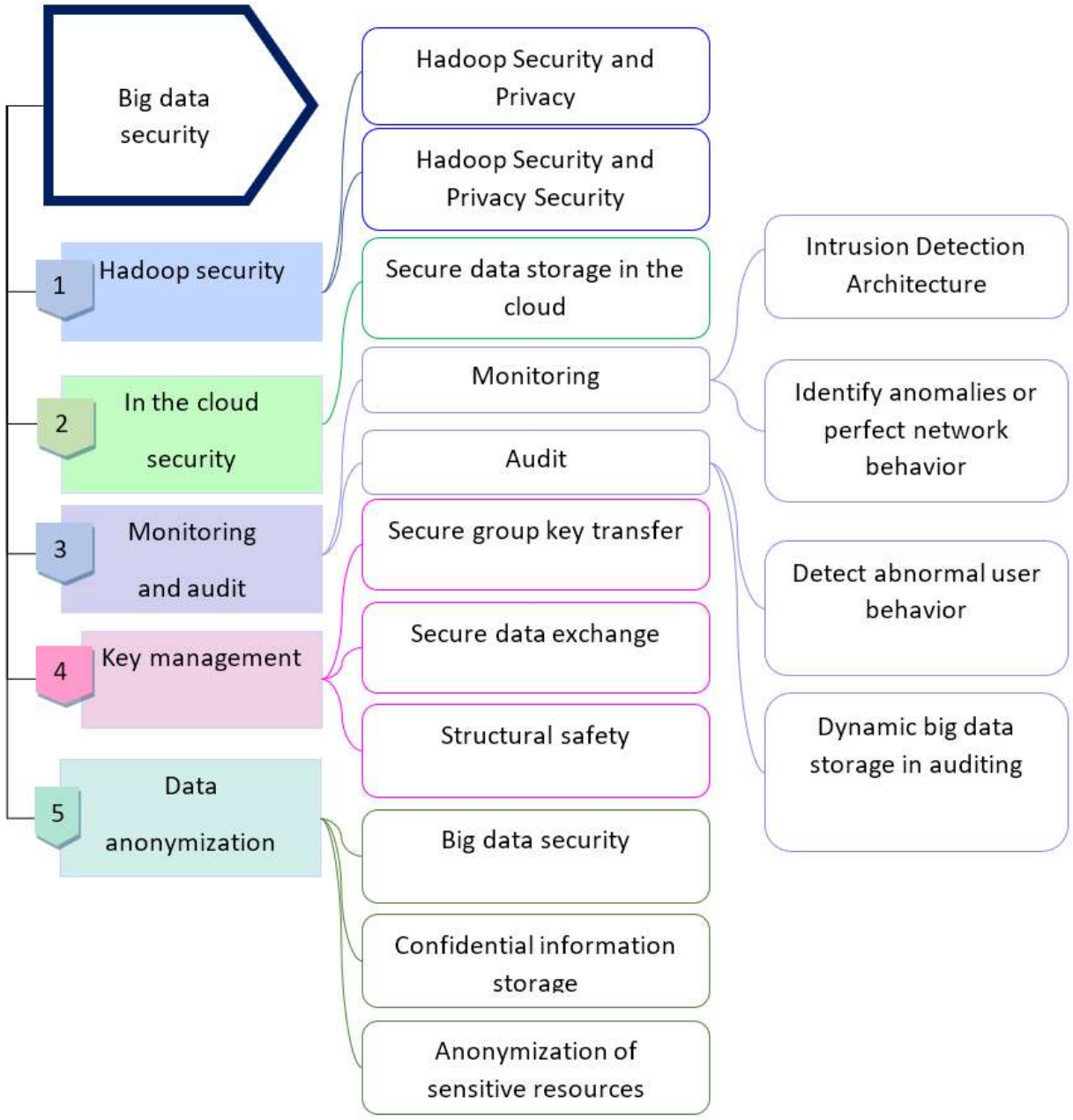

Figure 2 Creating a global database for implementing digital services market processes in industry

In the process of digitizing the digital services market in the regional industry, a large database will certainly be formed. It is also necessary to implement a number of measures for the stable operation of electronic resources of the digitized industrial system. These include Hadoop security, cloud security, monitoring and auditing, key management, and data anonymization. The use of these security parameters is of great importance in managing the electronic systems of the regional industry. Various digital technologies are used to develop e-commerce in industrial production. In particular, cyber-physical systems,cloud computingfrom systems,internet tools (Internet of Things, IoT) and industrial Internet tools (Industrial Internet of Things, IIoT), Artificial intelligence, digital twins and other technologies. Cyber-physical systems are a system of interacting devices, means of data transmission, processing and storage. They are the main components of the architecture of automation of complex object management and are considered promising tools.Digital twins used for virtual visualization, simulation and study of complex operational products, and then the obtained data is used to significantly improve the time to market, cost, quality, etc. of the product. Creating digital twins is essential for validating designs, modeling changes, analyzing the impact of changes and optimizing performance. Digital twins allow you to optimize the management of production processes, identify anomalies and provide predictive maintenance. Digital twins are created both for products manufactured by an industrial enterprise, and for the

enterprise itself and its workshops. A digital simulation model of the enterprise allows you to plan the optimal placement of technological, auxiliary and auxiliary equipment, create diagrams of engineering networks at the workshop and enterprise level as a whole.

Industrial Internet of Things (IIoT) is the application of IoT technology in industrial environments, specifically the connection of devices, sensors, and devices controlled by cloud technologies. The Internet of Things for enterprises enables the collection and analysis of data from connected resources, people, and places, offering actionable analytics in industrial environments.

The new concept of the digital economy is a single system for storing, processing and transmitting all information in the field of human activity using digital technologies. Through the digitalization of the economy, it is possible to build a new economy with a creative approach. According to the results of analyzes conducted by authoritative international organizations, the digital economy allows to increase gross domestic product by at least 30 percent, at the same time, eliminate the shadow economy and sharply reduce corruption. It is clear that this area will be a serious impetus for the high development of all sectors and industries in our country.

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CONCLUSION AND SUGGESTIONS

As a result, the “robot revolution,” which economists and analysts of the largest banks talk about, will allow the global economy to reduce labor costs in production by 18% to 33%, while increasing productivity by 30%. In total, there are about 400 companies engaged in the production of robotics on the global market.

Modern trends in “digital transformation” in industrial enterprises are associated with the integration of used IT systems. Adaptive production systems are being developed. There is a transition from descriptive analysis to the formation of forecasts of scientific and technical development of industrial sectors. The results of such analytical work in the context of the digitalization of the economy are increasingly used in the formation and implementation of state programs. Over the past 20 years, information technologies for leading industrial enterprises have become a driver of the development of e-business from a service function. Rapidly aging systems and applied information technologies create the essence and boundaries of possible changes in industry within the framework of digitalization and provide a completely new qualitative level of added value to their products [9]. In addition, predictive analytics, as an extension of SCADA systems - another information technology within the framework of industrial digitalization - allows you to make very accurate forecasts for the future: costs, failures, necessary repairs, etc. Brain structure analysis is reverse engineering, which involves first understanding the intricacies of the human brain and then representing what the brain does in terms of hardware and software. As a result, scientists hope to create a computer with human-level artificial intelligence. Several large projects (with investments of billions of dollars) are aimed at achieving this result. The main goal of the international Human Brain Project (HBP), led by a team from the Swiss Federal Polytechnic School in Lausanne, led by Professor Henry Markram, and involving more than 100 scientific groups from around the world, is to model the human brain. The goal of the project is to synthesize all the knowledge that humans have gained about the brain into a single complete model of the brain inside a supercomputer.

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DEVELOPMENT OF AN ARTIFICIAL INTELLIGENCE–BASED CYBERSECURITY SYSTEM FOR THE AUTOMATIC DETECTION OF FAKE FINANCIAL RECEIPTS, PHISHING URLS, AND MALICIOUS APK FILES

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Abstract: It is through phishing attacks, fake payment documents and malicious mobile applications that a large part of financial fraud around the world is happening. As a result of such attacks, users ' bank card information, personal information and financial resources are being stolen. Especially young people and users who are actively using the internet are more susceptible to this type of attack. Therefore, the issue of ensuring financial information security is one of the most important tasks of today.

Key words: cyberattack, social environment, psychological factors, financial information, fake payment, mobile application.

Annotatsiya: Dunyo bo‘yicha moliyaviy firibgarliklarning katta qismi aynan phishing hujumlari, soxta to‘lov hujjatlari va zararli mobil ilovalar orqali sodir etilmoqda. Bunday hujumlar natijasida foydalanuvchilarning bank kartalari ma’lumotlari, shaxsiy axborotlari va moliyaviy mablag‘lari o‘g‘irlanmoqda. Ayniqsa, yoshlar va internetdan faol foydalanayotgan foydalanuvchilar ushbu turdagi hujumlarga ko‘proq duch kelmoqda. Shu sababli moliyaviy axborot xavfsizligini ta’minlash masalasi bugungi kunning eng muhim vazifalaridan biri hisoblanadi.

Kalit so‘zlar: kiberhujum, ijtimoiy muhit, psixologik omillar, moliyaviy axborot, soxta to‘lov, mobil ilova.

Аннотация: подавляющее большинство финансовых махинаций во всем мире совершается именно с помощью фишинговых атак, поддельных платежных документов и вредоносных мобильных приложений. Такие атаки приводят к краже данных банковских карт, личной информации и финансов пользователей. Особенно молодые люди и пользователи, активно пользующиеся интернетом, более подвержены этому типу атак. Поэтому вопрос обеспечения финансовой информационной безопасности является одной из важнейших задач сегодняшнего дня.

Ключевые слова: киберзапугивание, социальная среда, психологические факторы, финансовая информация, поддельные платежи, мобильное приложение.

INTRODUCTION

Today, the rapid development of information and communication technologies is deeply penetrating all spheres of social life, particularly the systems of finance, banking, electronic payments, and digital services. The widespread adoption of the internet, mobile applications, and electronic payment systems, while making everyday life more convenient, has also led to the emergence of new types of risks and threats. In particular, cybercrimes carried out through fake financial receipts, phishing URLs, and malicious APK files have become one of the most pressing problems of our time. According to statistical data, a significant share of financial fraud worldwide is committed precisely through phishing attacks, counterfeit payment documents, and malicious mobile applications. As a result of such attacks, users’ bank card details, personal information, and financial assets are stolen. Young people and active internet users are especially vulnerable to these types of threats. Therefore, ensuring the security of financial information has become one of the most important tasks today.

In his speech at the 72nd session of the United Nations General Assembly in September 2017, the President of the Republic of Uzbekistan, Shavkat Mirziyoyev, placed special emphasis on the importance of youth, education, and modern technologies, stating: “The development of any state and the well-being of its people primarily depend on young people growing up educated, proficient in modern technologies, and patriotic.” These remarks clearly demonstrate the growing attention currently being paid to the development of information technologies, particularly in the fields of cybersecurity and artificial intelligence. In addition, in a series of meetings and speeches held during 2020–2023, President Shavkat Mirziyoyev identified the development of the digital economy, information security, and the strengthening of cybersecurity as priority directions of state policy. As emphasized by the Head of State, “Along with the development of digital technologies, it is necessary to ensure information security and to introduce effective mechanisms to prevent cyber threats.” In implementing these tasks, the use of artificial intelligence and machine learning technologies is of particular importance.

REVIEW OF LITERATURE ON THE SUBJECT

A cybersecurity system designed to automatically detect fake financial receipts, phishing URLs, and malicious APK files based on artificial intelligence provides effective protection against modern threats [2]. In the field of cybersecurity, artificial intelligence (AI) plays a crucial role in the rapid detection of malware, phishing attacks, and counterfeit documents. Fake financial receipts, fraudulent URLs, and malicious APK files lead to significant financial losses for users [1][2].

This system analyzes behavioral patterns using machine learning algorithms and predicts threats in advance. Phishing URLs are intended to deceive users and steal personal information and are often distributed through unofficial websites. Malicious APK files cause harm on Android devices in the form of trojans and ransomware [1][3].

Fake financial receipts are often generated using AI-based image generation techniques, allowing them to appear authentic and bypass traditional verification methods. Machine learning algorithms, such as deep learning, identify malicious files through detailed analysis. For phishing detection, website content and URL structures are thoroughly analyzed [2].

In detecting fake receipts, computer vision technologies (CNNs) are used to verify the authenticity of text, shapes, and signatures. The system consists of a data ingestion module, an AI analytical core, and a response module. Incoming files and URLs are scanned in real time, and suspicious items are blocked immediately [2].

During the training process, both supervised and unsupervised algorithms are applied. For malicious APKs, behavioral analysis is combined with static scanning. For phishing URLs, natural language processing (NLP) is used to identify fraudulent text patterns [2]. For fake receipts, pixel-level image analysis and blockchain-based verification are integrated to reduce false positives.

RESEARCH METHODOLOGY

Artificial Intelligence Algorithms, Machine Learning Methods, Software Tools, and Databases Used for Detecting Fake Financial Receipts, Phishing URLs, and Malicious APK Files

ANALYSIS AND RESULTS

In the context of globalization and digitalization, cybersecurity issues have become one of the most significant challenges, carrying not only technical but also economic and social importance. Along with the widespread adoption of digital financial services, electronic payment systems, mobile banking applications, and online commerce platforms, the scale and complexity of cybercrime have increased substantially. Practical experience shows that traditional cybersecurity tools are often unable to provide sufficient effectiveness in detecting and preventing many modern attacks. This situation necessitates a fundamental improvement of cybersecurity systems and the introduction of new approaches based on advanced technologies.

In particular, fake financial receipts are visually very similar to genuine documents, making them difficult to identify not only for ordinary users but, in some cases, even for experienced specialists. Since such documents are created using high-quality graphic tools, conventional visual inspection methods fail to deliver reliable results. At the same time, phishing URLs are designed on behalf of trusted banks or financial institutions and aim to exploit user trust to obtain login credentials, bank card details, and other sensitive information. Malicious APK files, in turn, are capable of stealing personal data without user consent, controlling financial transactions, or damaging system resources on mobile devices.

The common characteristic of these threats is that they continuously evolve and are able to bypass traditional signature-based protection mechanisms. However, it would be incorrect to view this situation solely as a limitation. On the contrary, it demonstrates the broad opportunities for applying artificial intelligence

technologies in the field of cybersecurity. AI-based approaches are particularly well suited to detecting complex, hidden, and rapidly changing cyber threats with a high level of effectiveness.

From this perspective, the development of AI-based automatic detection systems represents a highly relevant scientific and practical task. Such systems are capable of processing large volumes of data in real time, identifying anomalous behavior, and adapting to new types of attacks. For example, in image analysis, the use of OCR technologies enables in-depth examination of text, numbers, and visual elements in financial receipts. The application of natural language processing (NLP) methods in semantic analysis of texts and URLs significantly increases the accuracy of phishing link detection. With regard to malicious APK files, assessing their potential risk level is achieved through the analysis of both static and dynamic behavioral characteristics.

A key advantage of this approach is that it is not limited to detecting only known attacks but is also capable of identifying new and previously unseen cyber threats. For this reason, artificial intelligence–based cybersecurity systems serve as effective, adaptive, and resilient tools for preventing financial fraud.

This article comprehensively examines the development of a cybersecurity system designed to automatically detect fake financial receipts, phishing URLs, and malicious APK files using artificial intelligence. Particular attention is paid to the selection of modern machine learning algorithms, the evaluation of their effectiveness, and their testing on real-world data. The main objective of the study is to create a reliable and efficient mechanism for detecting cyber threats through the use of artificial intelligence technologies and to expand its practical applicability.

Within the scope of this project, the defined tasks are structured through a consistent and systematic approach. Specifically, the sources and characteristics of threats are identified through an in-depth analysis of financial cyber risks and their main types. Studying the attack mechanisms implemented via fake receipts, phishing URLs, and malicious APK files enables the proper design of the system architecture. In the process of selecting and justifying artificial intelligence and machine learning algorithms, criteria such as accuracy, speed, and adaptability are taken into account.

In addition, the formation of datasets and the design of the database represent critical stages in ensuring the stable operation of the system. By developing the software of the automatic detection system and implementing it in the form of a web platform or bot, a user-friendly and widely accessible solution is created. At the final stage, the developed system is tested, the obtained results are analyzed, and practical recommendations are formulated to further enhance system performance.

CONCLUSIONS AND SUGGESTIONS

Within the framework of the developed application, the cybersecurity system can be applied to protect users through banks and financial institutions, IT companies, electronic payment services, as well as Telegram and web platforms. The system enables rapid, reliable, and automatic detection of fake financial receipts, phishing URLs, and malicious APK files, provides a user-friendly interface, improves detection accuracy, and helps prevent financial fraud. By strengthening cybersecurity, the system contributes to reducing financial fraud incidents. In the future, the integration of quantum computing and federated learning may be considered [2]. Continuous updates and increased user awareness will further enhance the system's effectiveness.

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WAYS TO INCREASE REVENUES IN COMMERCIAL BANK OPERATIONS

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Abstract: This article provides a systematic analysis of the mechanisms for forming commercial bank revenues, the factors influencing their growth, and the role of income structure in modern banking practice. During the study, ensuring an optimal balance between interest and non-interest income, increasing the profitability of asset and liability operations, and optimizing credit portfolio quality and interest margins are identified as key directions for enhancing bank revenues. In addition, the importance of service diversification, the development of digital banking services, the implementation of effective risk management systems, and the utilization of capital market opportunities in increasing bank revenues is highlighted. The article concludes with scientifically grounded practical recommendations aimed at ensuring the sustainable and long-term growth of commercial bank revenues.

Key words: commercial banks, revenue growth, interest income, non-interest income, interest margin, credit portfolio quality, efficiency of banking operations, service diversification, digital banking services, capital market, asset and liability management, financial stability, risk management.

Annotatsiya: Ushbu maqolada tijorat banklari daromadlarining shakllanish mexanizmlari, ularni oshirishga ta’sir etuvchi omillar hamda daromadlar tarkibining zamonaviy bank amaliyotidagi o‘rni tizimli tahlil qilingan. Tadqiqot jarayonida foizli va foizsiz daromadlar o‘rtasidagi optimal nisbatni ta’minlash, aktiv va passiv operatsiyalarning rentabelligini oshirish, kredit portfeli sifati va foiz marjasini optimallashtirish kabi omillar banklar daromadlarini ko‘paytirishning asosiy yo‘nalishlari sifatida baholangan. Shuningdek, bank daromadlarini oshirishda xizmatlar diversifikatsiyasi, raqamli bank xizmatlarining rivojlanishi, risklarni boshqarishning samarali tizimini joriy etish hamda qimmatli qog‘ozlar bozori imkoniyatlaridan foydalanishning ahamiyati yoritilgan. Maqola yakunida tijorat banklari daromadlarini barqaror va uzoq muddatli o‘sishini ta’minlashga qaratilgan ilmiy asoslangan amaliy takliflar ilgari surilgan.

Kalit so‘zlar: tijorat banklari, daromadlarni oshirish, foizli daromadlar, foizsiz daromadlar, foiz marjasi, kredit portfeli sifati, bank operatsiyalari samaradorligi, xizmatlar diversifikatsiyasi, raqamli bank xizmatlari, qimmatli qog‘ozlar bozori, aktiv va passivlarni boshqarish, moliyaviy barqarorlik, risklarni boshqarish.

Аннотация: В статье проведён системный анализ механизмов формирования доходов коммерческих банков, факторов, влияющих на их рост, а также роли структуры доходов в современной банковской практике. В ходе исследования обеспечение оптимального соотношения процентных и непроцентных доходов, повышение рентабельности активных и пассивных операций, оптимизация качества кредитного портфеля и процентной маржи рассматриваются как ключевые направления увеличения банковских доходов. Кроме того, раскрывается значение диверсификации услуг, развития цифровых банковских сервисов, внедрения эффективной системы управления рисками и использования возможностей рынка ценных бумаг в процессе роста доходов банков. В заключение статьи представлены научно обоснованные практические рекомендации, направленные на обеспечение устойчивого и долгосрочного роста доходов коммерческих банков.

Ключевые слова: коммерческие банки, увеличение доходов, процентные доходы, непроцентные доходы, процентная маржа, качество кредитного портфеля, эффективность банковских операций, диверсификация услуг, цифровые банковские сервисы, рынок ценных бумаг, управление активами и пассивами, финансовая устойчивость, управление рисками.

INTRODUCTION

The intensification of competition in global financial markets, the diversification of banking services, the rapid development of digital technologies, and changes in customer needs are compelling banks to reconsider their income generation strategies. In particular, optimizing the income structure based on interest and non-

interest revenues, increasing the profitability of asset and liability operations, introducing new financial products and innovative services, improving risk management systems, and effectively utilizing digital banking services are emerging as priority directions for revenue growth.

Commercial banks play a strategically important role in ensuring the sustainable development of the national economy. The strength of banks' income bases not only determines the efficiency of the financial system but also serves as a key factor in financing the real sector of the economy, supporting investment projects, and improving the quality of financial services provided to the population. Therefore, improving the mechanisms for forming and increasing commercial bank revenues represents one of the most pressing scientific and practical tasks in the context of a modern market economy.

This importance is also emphasized in the Decree of the President of the Republic of Uzbekistan No. DP-5992[1] dated May 12, 2020, "On the Strategy for reforming the banking system of the Republic of Uzbekistan for 2020 — 2025" which highlights the need to expand banks' income sources, strengthen their activities in the capital market, issue and place corporate bonds, and deepen integration with international financial markets. These reforms create an institutional foundation for enhancing the competitiveness of the banking system, strengthening financial stability, and increasing the revenues of commercial banks [1]. From this perspective, studying ways to increase commercial bank revenues, identifying factors influencing income composition, and analyzing mechanisms for expanding the income base through innovative banking products and services are of significant scientific and practical importance. This article develops research-based recommendations on the processes of commercial bank income formation, strategic directions for revenue growth, and the effective use of digital transformation and capital market opportunities.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of increasing commercial bank revenues, ensuring their stability, and maintaining a high level of profitability remains one of the most relevant scientific problems at all stages of economic development. Effective income management in the banking system is becoming increasingly important in the context of volatility in global financial markets, intensifying competition, the development of fintech technologies, and the continuous expansion of customer segments. Therefore, scientific approaches, theoretical schools, international experience, and reforms implemented in the national banking sector aimed at increasing commercial bank revenues form a solid scientific and theoretical foundation for this study.

International academic literature has extensively examined the factors that directly affect the growth of commercial bank revenues. In particular, studies by scholars from developed countries emphasize that forming an optimal balance between interest and non-interest income, diversifying income sources, expanding the range of services, improving risk management strategies, and enhancing the efficiency of asset and liability management are key determinants of revenue growth. In addition, the integration of financial markets, liquidity management, credit portfolio quality, and interest margins have been scientifically proven to have a significant impact on the pace of revenue growth.

The systemic reforms being implemented in the banking system of Uzbekistan—such as the development of capital markets, the expansion of corporate bond issuance, the introduction of digital financial services, deeper diversification of banking products, and the improvement of risk management systems—are recognized as important institutional factors contributing to increased commercial bank revenues. Studies conducted by local scholars also demonstrate a particular focus on expanding income sources, increasing the share of non-interest income, and analyzing the impact of service innovation on profitability. Consequently, the literature review serves to reveal the theoretical foundations of increasing commercial bank revenues, to synthesize international and domestic scientific approaches, and to identify the dynamics of the development of existing academic views in this field.

In particular, A. Saunders and M. Cornett emphasize that risks affecting bank revenues—credit, liquidity, and market risks—are closely interrelated with profitability [2]. F. Mishkin scientifically substantiates that the stability of bank revenues determines the effectiveness of monetary policy [3]. The works of P. Rose and S. Hudgins extensively highlight the role of service diversification in increasing bank revenues [4]. R. Levine argues that the development of the banking system is a key driver of economic growth [5]. A. H. Demirgüç-Kunt and H. Huizinga note that internal governance indicators and macroeconomic factors have a significant impact on bank profitability [6]. A. Berger and C. Bouwman provide empirical evidence that proper liquidity management is a crucial factor in ensuring income stability [7]. P. Athanasoglou, M. Delis, and C. Staikouras identify interest margins, cost management, and credit portfolio quality as the strongest determinants of profitability [8]. Among local scholars, A. Karimov scientifically demonstrates that banking reforms have a strong positive effect on

1 https://lex.uz/docs/6972970

expanding income sources [9]. Another local researcher, N. To‘laganova, examines the strategic impact of non-interest income on bank stability [10].

Overall, existing academic research confirms that the processes of forming and managing commercial bank revenues are influenced by a complex set of factors, including risk management, diversification, macroeconomic conditions, asset quality, liquidity, interest rate policy, and managerial efficiency. Therefore, optimizing the income structure remains one of the most important strategic priorities of modern bank management.

RESEARCH METHODOLOGY

In preparing this article, regulatory and legal documents, referenced literature, and internet-based sources were used, with particular attention paid to their official status. In addition, the scientific and theoretical views of economists relevant to the topic were subjected to comparative and critical analysis. During the study, alongside general economic methods, system analysis, generalization, abstract-logical reasoning, and statistical methods were applied.

ANALYSIS AND RESULTS

An analysis of the main financial indicators of commercial banks based on the results of their activities in 2024 provided a clearer picture of the factors influencing bank revenue formation and existing constraints. In particular, the return on banking system assets declined, and as of January 1, 2025, the ratio of net profit before tax to total assets amounted to 1 percent. This indicator decreased by 1 percentage point compared to the beginning of 2024. Despite the decline in profitability, the 18 percent annual growth in total bank assets indicates that revenues are not increasing at a sufficient pace during the asset expansion process. The reduction in net profit was significantly influenced by a 41 percent increase in reserves created to cover losses on the loan and leasing portfolio.

Changes observed in the quality of the bank loan portfolio also have a direct impact on profitability dynamics. As of January 1, 2025, the share of substandard and non-performing loans in total loans reached 21 percent, representing an increase of 1 percentage point compared to the previous year. This growth necessitates higher provisioning by banks due to increased credit risks and deteriorating asset quality. As a result, the profitability burden has intensified, leading to a decline in net profit.

At the same time, the resilience of the banking system to risks improved significantly in 2024. The liquidity coverage ratio reached 194 percent, increasing by 29 percentage points compared to 2023. The net stable funding ratio also rose by 4 percentage points to 115 percent. The capital adequacy ratio remained above the established minimum requirements and stood at 17 percent as of January 1, 2025. These indicators demonstrate that banks possess financial stability, resilience to shocks, and sufficient capital capacity to support revenue growth (Figure 1).

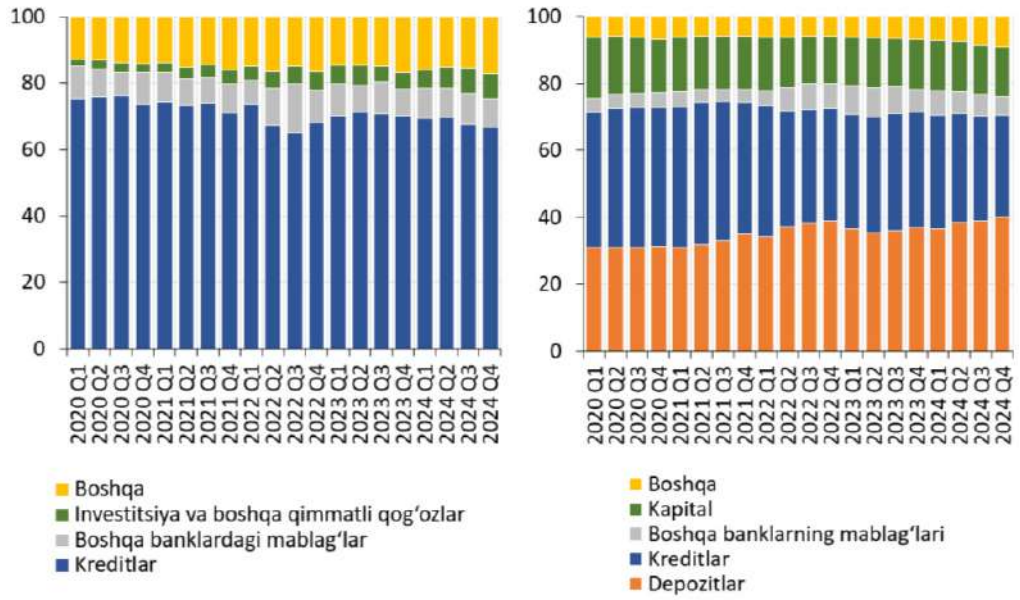

Figure 1. Decomposition of Commercial Bank Assets and Sources of Financing[2]

2 https://lex.uz/docs/6972970

Loans remain the primary source within the income structure. As of January 1, 2025, total assets of the banking system amounted to UZS 769 trillion, of which 67 percent consisted of loans. This confirms that lending activity continues to be the main revenue driver for banks. At the same time, the share of investments and the securities portfolio in total assets reached 16 percent, indicating expanding opportunities for banks to diversify their income sources.

Within the structure of banking system liabilities, the growing share of deposits has a positive effect on the stability of the resource base. In 2024, the share of deposits attracted by banks in total liabilities increased by 3 percentage points, reaching 40 percent. This strengthened the role of deposits as a low-cost and stable source of funding. Borrowed funds remain one of the key financing sources for banks, accounting for 31 percent of total liabilities. Overall, the analysis shows that although credit portfolio quality issues, rising provisions, and increasing interest expenses constrain profitability, improvements in liquidity, capital adequacy, and the expansion of the resource base are creating the necessary macro- and microeconomic conditions for increasing bank revenues. These trends require, in developing revenue growth strategies, a stronger focus on credit risk management, enhanced diversification processes, and the effective use of stable funding sources.

The capital adequacy of commercial banks is directly linked to their ability to increase revenues. Based on the results of 2024, capital adequacy indicators remained above the minimum regulatory requirements, demonstrating banks' financial stability and their capacity to absorb additional risks. The capital adequacy ratio for the banking system and systemically important banks amounted to 17.4 percent and 16.8 percent, respectively, indicating sufficient risk coverage capacity. The Tier 1 core capital adequacy ratio at the level of 14.3 percent further confirms the stability of banks' high-quality capital. At the same time, the widening dispersion of capital adequacy indicators in 2024 reflects uneven capital distribution within the banking system (Figure 2).

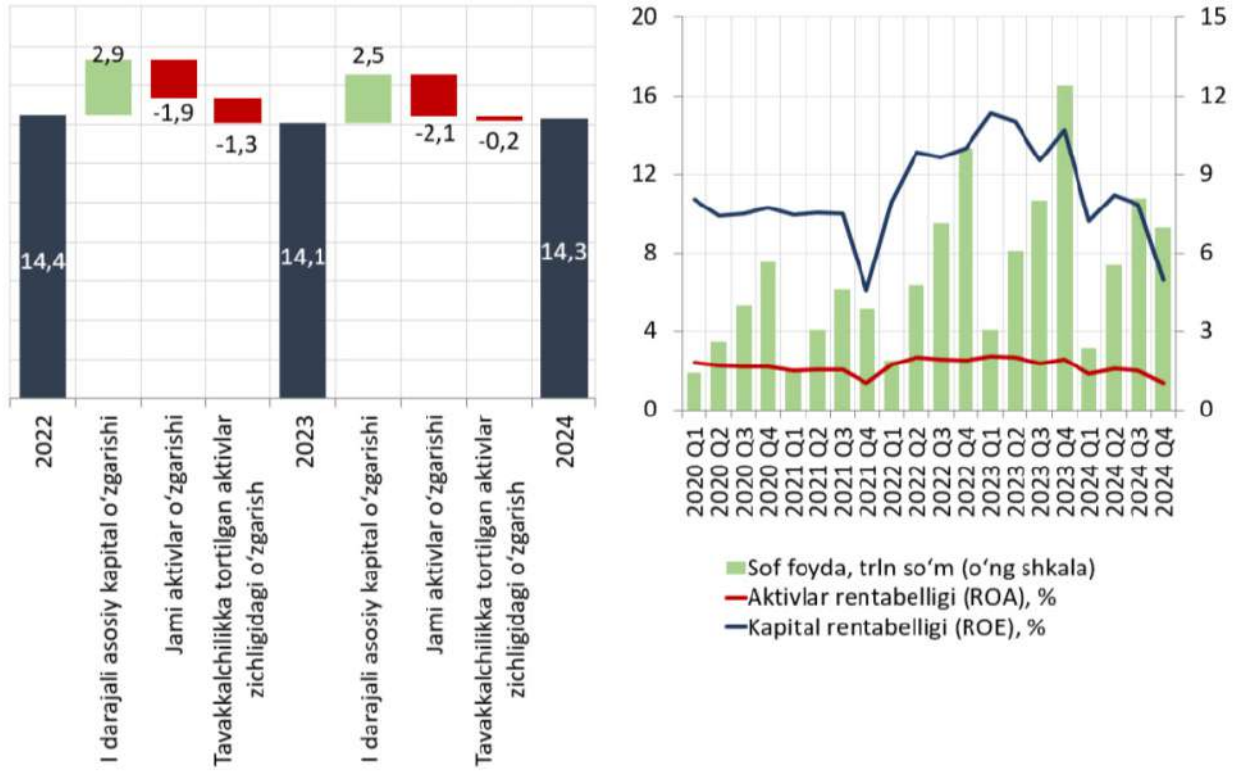

Figure 2. Distribution of Changes in the Tier 1 Core Capital Adequacy Ratio and Profitability Indicators of the Banking System[3]

The risk level of bank assets remains high. At the end of 2024, the share of risk-weighted assets accounted for 93 percent, indicating a high level of risk acceptance by banks. The fact that this indicator is higher than in Central Asian and Caucasus countries reflects the predominance of prudential, risk-based regulatory procedures in Uzbekistan. At the same time, the profitability of risk-weighted assets at 1.4 percent signals a decline in the income-generating potential of bank assets. In 2024, a clear downward trend in the profitability indicators of the banking system was observed. Net profit amounted to UZS 7 trillion, decreasing by 44 percent

3 https://cbu.uz/uz/financial-stability/report/ sayti ma'lumotlari

compared to 2023, which resulted in a return on equity (ROE) of 6.6 percent. Return on assets (ROA) also continued its downward trend, reaching 1.4 percent by the end of 2024. A 21 percent increase in operating expenses and a 45 percent rise in provisions for expected losses on assets were the main factors behind the decline in profitability.

The stable funding capacity of the banking system (NSFR) demonstrated positive dynamics. In 2024, the system-wide NSFR reached 115 percent, increasing by 4 percentage points compared to the previous year. For systemically important banks, the NSFR stood at 114 percent, while the median value of 124 percent indicates disparities in funding stability among banks. A significant increase was also observed in the liquidity coverage ratio (LCR), which reached 194 percent system-wide in 2024; for systemically important banks, the indicator amounted to 193 percent. This suggests that banks remain resilient to short-term liquidity pressures.

The increase in high-quality liquid assets further strengthened banks' operational stability and their potential to increase revenues. By the end of 2024, the share of such assets in total assets reached 17.3 percent, up by 2.5 percentage points compared to 2023. A key contributing factor was the expansion of the government securities portfolio by UZS 20 trillion.

The growing share of retail lending within the loan structure indicates progress in credit portfolio diversification. By the end of 2024, 33 percent of total loans were granted to individuals, representing a 2 percentage point increase compared to the previous year. Loans to legal entities accounted for 67 percent of total lending. The ratio of loans to legal entities and individuals to GDP stood at 24 percent and 12 percent, respectively, highlighting the role of lending in the economy.

While the ratio of loans to GDP in Uzbekistan is higher than in neighboring countries, the share of deposits in total liabilities remains relatively low. As of January 1, 2025, deposits accounted for 47 percent of total liabilities, which is below the regional median. This indicates the need for commercial banks to expand their stable and low-cost funding base.

Overall, these indicators confirm that, in developing strategies to increase commercial bank revenues, priority should be given to asset quality, risk management, efficient liquidity allocation, expansion of stable funding sources, and diversification of the loan portfolio.

Each type of banking activity differs depending on the role the bank plays in a given operation. Some of the activities discussed above fall under asset operations, while others are classified as liability operations. Income generated from each activity varies accordingly. Revenue from asset operations constitutes the main share of total bank income.

CONCLUSIONS AND SUGGESTIONS

The results of the conducted study indicate that commercial bank revenues are formed through a combination of interest and non-interest income, and their stability represents a key factor determining the overall efficiency and financial soundness of banking operations. Revenue formation mechanisms are closely linked to credit risk, interest margins, liquidity conditions, diversification of banking services, asset quality, management efficiency, and macroeconomic factors.

An analysis of empirical data shows that in 2024 the growth in loans and deposits strengthened banks' resource bases: household deposits increased by 42 percent, while loans to individuals rose by 20 percent. The 18 percent growth in net interest income reflects the effectiveness of interest rate policy; however, a 35 percent increase in interest expenses and a 36 percent decline in pre-tax profit negatively affected bank profitability. A significant rise in provisions for expected credit losses also became one of the main reasons for the decline in net profit.

The return on assets declined to 1.4 percent in 2024, while return on equity (ROE) stood at 6.6 percent. The share of risk-weighted assets at the level of 93 percent indicates the persistence of a conservative approach within Uzbekistan's banking system. At the same time, capital adequacy ratios remaining well above the minimum regulatory requirements (17.4 percent system-wide) demonstrate that banks possess a sufficient capital buffer to generate additional income. Improvements in liquidity indicators (LCR at 194 percent and NSFR at 115 percent) confirm the strengthened capacity of banks to meet both short- and long-term financial obligations. The increase in the share of high-quality liquid assets to 17.3 percent further reinforced financial stability. The rise in the share of retail loans to 33 percent of the total loan portfolio and the ratio of loans to legal entities to GDP at 24 percent highlight the important role of lending in the economy. However, the relatively low share of deposits in total liabilities (47 percent), compared to regional peers, points to the need to expand the resource base.

Overall, the analysis confirms the high importance of credit portfolio quality, resource base stability, interest margin management, service diversification, risk management systems, liquidity optimization, and digital transformation in increasing commercial bank revenues. In this regard, it is advisable to improve the

following areas. First, increase interest income by improving credit portfolio quality through automated credit risk assessment, the development of scoring systems, strengthening comprehensive measures to reduce non-performing loans, and optimizing provisioning policies for expected losses. Second, expand the share of non-interest income by developing digital banking services (mobile banking, online payments, fintech integration), increasing the range of value-added services such as consulting, trading, and investment services, and strengthening monitoring of commission-based service pricing and profitability. Third, enhance the stability of the resource base by developing incentive mechanisms for attracting household deposits, increasing the share of long-term deposits, expanding strategic cooperation with corporate clients, and improving mechanisms for attracting low-cost funding from interbank markets and international financial institutions. Fourth, optimize interest margins by revising interest rate policies for asset and liability operations, reducing the cost of resources, and strengthening liquidity management. Fifth, stabilize income from foreign exchange operations by actively using hedging instruments in foreign exchange risk management and optimizing open currency positions. Sixth, reduce operating expenses through digitalization, process automation, optimization of branch networks, and centralization of service platforms. Seventh, diversify assets by expanding participation in securities markets, increasing income sources through corporate bond issuance, and optimizing investment portfolios. Eighth, enhance market competitiveness by developing innovative banking products, expanding cooperation with fintech companies, and designing customized financial solutions tailored to customer needs.

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УДК: 332.1:330.341.1

РОЛЬ СВОБОДНЫХ ЭКОНОМИЧЕСКИХ ЗОН В РЕГИОНАЛЬНОМ РАЗВИТИИ И ЗАРУБЕЖНЫЙ ОПЫТ

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Аннотация: В данной статье изложены взгляды на создание свободных экономических зон, предоставляемые льготы, созданные условия, привлечённые инвестиции, а также экономические показатели социально-экономического развития регионов.

Ключевые слова: свободные экономические зоны, инвестиции, зарубежный опыт, виды услуг, льготы, механизмы, экономические показатели.

Annotatsiya: Ushbu maqolada erkin iqtisodiy zonalarni tashkil etish, berilayotgan imtiyozlar, yaratilgan sharoitlar, jalb etilgan investitsiyalar hamda hududlarning ijtimoiy-iqtisodiy rivojlanishining iqtisodiy ko‘rsatkichlariga oid qarashlar bayon etilgan.

Kalit so‘zlar: erkin iqtisodiy zonalar, investitsiyalar, xorijiy tajriba, xizmat turlari, imtiyozlar, mexanizmlar, iqtisodiy ko‘rsatkichlar.

Abstract: This article presents views on the establishment of free economic zones, the incentives provided, the conditions created, the investments attracted, as well as the economic indicators of the socio-economic development of regions.

Key words: free economic zones, investments, foreign experience, types of services, incentives, mechanisms, economic indicators.

ВВЕДЕНИЕ

Свободные экономические зоны играют важную роль в региональном развитии. Свободные экономические зоны (СЭЗ) представляют собой современный инструмент политики регионального развития, направленный на повышение экономической активности, создание новых рабочих мест и формирование благоприятного инвестиционного климата в различных регионах страны. Посредством развития СЭЗ государство обеспечивает более сбалансированный экономический рост регионов, способствуя сокращению различий между центральными и периферийными территориями.

Понятие свободной экономической зоны впервые было закреплено в Киотской конвенции от 1973-05-18. В соответствии с данным международным документом свободная экономическая зона определяется как часть территории страны, в пределах которой импорт и экспорт товаров осуществляются без применения таможенных и налоговых ограничений, что создаёт благоприятные условия для развития внешнеэкономической деятельности.

ОБЗОР ЛИТЕРАТУРЫ ПО ТЕМЕ

По мнению экономистов, свободные экономические зоны (СЭЗ) определяются как географические территории, на которых сокращается вмешательство государства в экономические процессы; при этом они остаются частью национального экономического пространства, а также характеризуются введением системы специальных льгот, не применяемых в других регионах страны. Кроме того, СЭЗ рассматриваются как территории, стимулирующие хозяйственную деятельность с участием иностранного капитала и обладающие льготными валютно-финансовыми и благоприятными налоговыми режимами.

Зарубежные учёные, в частности Дуглас Чжихуа Цзэн, представили развернутый анализ функционирования СЭЗ. В своей книге «Особые экономические зоны: уроки мирового опыта» [4] автор рассматривает историю становления, этапы развития, институциональные и политические аспекты, а также практику функционирования СЭЗ в различных странах. Примеры Китая, ОАЭ и Польши демонстрируют эффективность различных моделей управления и организации таких зон.

Андрес Родригес-Поуз и Сюзанна А. Фрик в статье «Глобальное распространение особых экономических зон: провал политики или двигатель развития?» [5] провели эмпирический анализ мирового распространения СЭЗ, их фактических экономических показателей и регионального воздействия. Лотта Моберг в работе «Политическая экономия особых экономических зон» [6] исследует политические и экономические основы функционирования СЭЗ, показывая взаимосвязь государственной политики и интересов частного сектора.

Среди узбекских исследователей следует отметить Ш. Н. Ахунову, которая в статье «Вопросы развития свободных экономических зон» [7] представила теоретические и практические предложения по организации и повышению эффективности деятельности СЭЗ в Узбекистане. В трудах Д. Хужамкулова [8], Б. Джураева и А. В. Вахобова [9], М. А. Райимжоновой [10], А. А. Остонкулова [10] также рассматриваются вопросы совершенствования систем управления СЭЗ и адаптации зарубежного опыта к национальным условиям.

В целом, на основе экономического анализа влияния СЭЗ на региональное развитие, инфраструктуру и инвестиционную среду в указанных исследованиях обоснована значимость государственной политики, налоговых стимулов и механизмов привлечения иностранных инвестиций как ключевых факторов повышения эффективности функционирования свободных экономических зон.

МЕТОДОЛОГИЯ ИССЛЕДОВАНИЯ

В ходе исследования использованы методы анализа и синтеза, системный и структурно-функциональный подходы, а также сравнительный анализ зарубежного опыта функционирования свободных экономических зон. Эмпирическую основу составили официальные нормативно-правовые акты Республики Узбекистан, материалы международных организаций и научные публикации отечественных и зарубежных авторов, что позволило обобщить теоретические положения и выявить особенности развития СЭЗ в различных странах. Для оценки влияния свободных экономических зон на социально-экономическое развитие регионов применялись элементы статистического и экономического анализа показателей инвестиций, занятости и экспортной активности, а также метод обобщения для формулирования выводов и практических рекомендаций.

АНАЛИЗ И РЕЗУЛЬТАТЫ

Статья 1 Закона Республики Узбекистан «О свободных экономических зонах» гласит: «Свободные экономические зоны — специально выделенные территории с чётко определёнными административными границами и особым правовым режимом, создаваемые в целях привлечения отечественного и иностранного капитала, перспективных технологий и управленческого опыта для ускоренного социально-экономического развития региона».

Свободная экономическая зона (СЭЗ) представляет собой определённую часть территории страны, в пределах которой вводится особый экономический, правовой и административный режим, создаются благоприятные условия для инвестиционной деятельности и обеспечивается более свободное осуществление внешнеэкономических операций.

Основной целью СЭЗ является привлечение иностранных и отечественных инвестиций, организация производства экспортно-ориентированной продукции, создание новых рабочих мест, внедрение передовых технологий и стимулирование устойчивого развития региональной экономики.

В мировой практике насчитывается около 30 типов свободных экономических зон. Наиболее распространёнными из них являются свободные торговые, таможенные, производственные и научно-технические зоны. Несмотря на принадлежность к общей категории СЭЗ, их функциональное назначение различается. Первые свободные экономические зоны были созданы в США в 1934 году как зоны свободной торговли.

Система организации деятельности и налогообложения компаний в Соединённом Королевстве Великобритании рассматривается как одна из наиболее развитых в международной практике. Соответствующее законодательство и нормативные акты сыграли важную роль в формировании и развитии офшорных зон. Указанный правовой механизм был закреплён в рамках Закона о финансах, принятого в 1965 году, и применяется к компаниям, осуществляющим деятельность в экономике Великобритании.

Экономика Китайской Народной Республики во многом сформировалась в результате последовательных реформ, реализованных в свободных экономических зонах. Именно КНР достигла значительных результатов в организации и функционировании зон свободной торговли, что способствовало ускоренному экономическому росту страны.

Китайская Народная Республика благодаря своей истории развития, институциональным преобразованиям и деловой культуре привлекает внимание мирового бизнес-сообщества и демонстрирует устойчивые успехи в сфере экономического обновления и интеграции в мировую экономику.

Свободные экономические зоны Китая играют ключевую роль в обеспечении высоких темпов экономических реформ. На их долю приходится около 20 % совокупных показателей развития. Китай стал одной из первых азиатских стран, принявших стратегическое решение о создании СЭЗ. До начала их формирования китайские исследователи всесторонне изучили опыт США, Японии, Гонконга, Сингапура и Тайваня.

В настоящее время в КНР функционируют пять специальных свободных экономических зон. Три из них — Шэньчжэнь, Чжухай и Шаньтоу — были созданы в 1980 году решением Постоянного комитета Всекитайского собрания народных представителей и расположены в провинции Гуандун. В октябре того же года в провинции Фуцзянь была образована свободная экономическая зона «Сямэнь». Провинция Хайнань, рассматриваемая как пятый экономический район, была сформирована в 1988-04 решением первой сессии Всекитайского собрания народных представителей 7-го созыва.

Мировой опыт подтверждает, что свободные экономические зоны являются эффективным инструментом ускорения регионального развития. Так, СЭЗ Шэньчжэнь способствовала индустриализации всей провинции Гуандун в Китае; в Польше через СЭЗ Катовице был сформирован новый производственный центр; в ОАЭ (Дубай) свободная экономическая зона Jebel Ali Free Zone обеспечила превращение страны в крупный логистический и торговый хаб.

Узбекистан также активно использует международный опыт в целях обеспечения устойчивого регионального экономического развития. В стране последовательно реализуется комплекс мер по созданию и развитию свободных экономических зон. К числу ключевых нормативно-правовых актов в данной сфере относятся Закон Республики Узбекистан «О свободных экономических зонах», принятый 1996-04-25, а также Указ Президента Республики Узбекистан от 2008-12-02 № УФ-4059 «О создании свободной индустриально-экономической зоны в Навоийской области» [1].

Одним из важнейших факторов формирования первой среди стран СНГ свободной индустриально-экономической зоны «Навои», расположенной на территории международного аэропорта города Навои, стало наличие вблизи трансконтинентального интермодального хаба, управление которым с 2009-01 осуществляет одна из ведущих мировых компаний в сфере грузовых авиаперевозок — Korean Air.

Кроме того, хозяйствующим субъектам, зарегистрированным в свободной индустриально-экономической зоне «Навои», предоставлено право:

• осуществлять расчёты и платежи в иностранной валюте на территории СИЭЗ по договорам и контрактам, заключённым между ними;

• оплачивать товары, выполненные работы и оказанные услуги в свободно конвертируемой валюте, поставляемые другими хозяйствующими субъектами — резидентами Республики Узбекистан;

• использовать наиболее удобные для них формы и условия расчётов и платежей по экспортно-импортным операциям.

В целом свободная индустриально-экономическая зона «Навои» стала первым подобным опытом в Узбекистане, а её развитие сыграло значимую роль в укреплении экономического потенциала страны. СИЭЗ формируют благоприятную правовую и налоговую среду для местных и иностранных инвесторов, способствуя привлечению прямых инвестиций в регионы. Так, после создания СИЭЗ «Навои» доля промышленности в Навоийской области существенно возросла, а объём привлечённых инвестиций превысил 200 млн долларов США.

В регионах посредством СЭЗ создаются новые производственные мощности, что способствует расширению занятости населения. В СЭЗ «Джизак» и «Хазарасп» были созданы тысячи новых рабочих мест, что позволило более эффективно использовать трудовые ресурсы. СЭЗ также способствуют формированию современных промышленных предприятий, логистических центров и развитию инфраструктуры. Например, в СЭЗ «Ангрен» были построены комплексы по производству электротехнической продукции, химических изделий и строительных материалов.

Во исполнение Указа Президента Республики Узбекистан «О дополнительных мерах по активизации и расширению деятельности свободных экономических зон» № ПФ-4853 от 2016-10-26, а также Указа Президента «О создании свободных экономических зон “Ургут”, “Гиждуван”, “Коканд” и “Хазарасп”» № ПФ-4931 от 2017-01-12, постановлением Кабинета Министров были утверждены границы территорий, входящих в состав указанных свободных экономических зон.

Данное постановление было принято при участии хокимиятов Самаркандской, Бухарской, Ферганской и Хорезмской областей, Государственного комитета Республики Узбекистан по земельным ресурсам, геодезии, картографии и государственному кадастру, Государственного комитета по архитектуре и строительству, Министерства экономики, а также Министерства внешних экономических связей, инвестиций и торговли [2].

Свободные экономические зоны создаются по различным направлениям деятельности:

1.Промышленные зоны — ориентированы на производство и переработку промышленной продукции (например, СЭЗ «Навои»).

2.Инновационные зоны — предназначены для реализации научно-исследовательских и инновационных проектов (например, инновационный технопарк «Яшнобод»).

3.Логистические и транспортные зоны — направлены на увеличение товарооборота и развитие транзитных услуг.

4.Туристические зоны — ориентированы на развитие туризма и сферы услуг.

5.Фармацевтические зоны — специализируются на производстве лекарственных средств и внедрении медицинских технологий (например, «Зомин Фарма», «Урганч Фарма»).

Свободные экономические зоны формируются как центры внедрения инновационных проектов и передовых технологий. В частности, инновационный технопарк «Яшнобод» выступает важным региональным узлом интеграции науки, производства и бизнеса.

На территориях СЭЗ установлены налоговые и иные преференции, предусматривающие освобождение от уплаты следующих налогов и обязательных платежей: земельного налога, налога на прибыль, налога на имущество юридических лиц, единого налога для микрофирм и малых предприятий, а также обязательных отчислений в Республиканский дорожный фонд при Кабинете Министров Республики Узбекистан и во внебюджетный фонд развития материально-технической базы общеобразовательных и медицинских учреждений при Министерстве финансов Республики Узбекистан. Кроме того, субъекты СЭЗ освобождаются от уплаты таможенных платежей (за исключением сборов за таможенное оформление) за оборудование, сырьё, материалы и комплектующие, ввозимые для собственных производственных нужд.

Также предусматривается освобождение от уплаты таможенных платежей за строительные материалы, не производимые в республике и импортируемые в рамках реализации инвестиционных проектов согласно перечню, утверждаемому Кабинетом Министров Республики Узбекистан.

Согласно указам, предоставляемые льготы дифференцируются в зависимости от объёма инвестиций и устанавливаются на срок от 3 до 10 лет, в частности:

- при инвестировании от 300 тыс. до 3 млн долларов США — сроком на 3 года;
- от 3 млн до 5 млн долларов США — сроком на 5 лет;
- от 5 млн до 10 млн долларов США — сроком на 7 лет;
- 10 млн долларов США и более — сроком на 10 лет.

В последующие 5 лет ставки налога на прибыль и единого налога применяются на уровне 50 % от действующих ставок.

Особое значение имеет положение, согласно которому хозяйствующие субъекты СЭЗ освобождаются от уплаты таможенных платежей за импортируемое оборудование, а также за сырьё, материалы и комплектующие, ввозимые для производства экспортно-ориентированной продукции, на весь период функционирования соответствующей зоны.

Создание в Узбекистане свободных экономических зон «Ангрен» и «Джизак» также имеет важное значение для экономики страны. Участники данных зон освобождаются от уплаты таможенных платежей за импортируемые сырьё, материалы и комплектующие на весь период их деятельности.

Предприятиям, функционирующим в СЭЗ, предоставляется комплекс налоговых и таможенных льгот, включая:

- освобождение от земельного налога, налога на имущество, налога на прибыль и ряда других платежей сроком от 5 до 10 лет;
- освобождение от таможенных платежей за импортируемое оборудование и сырьё;
- возможность свободного осуществления валютных операций;
- право беспрепятственной репатриации дивидендов.

В результате функционирования свободных экономических зон ускоряются темпы регионального экономического роста, увеличиваются бюджетные поступления, развивается инфраструктура (дорожная сеть, электроснабжение, логистические системы), повышаются доходы населения и улучшаются социально-экономические условия.

Так, по итогам 2024 года в рамках реализации более 1000 проектов в СЭЗ:

• объём освоенных инвестиций превысил 2 млрд долларов США;

• создано более 30 тыс. рабочих мест;

• доля экспорта увеличилась до 25 %.

Продукция, производимая в СЭЗ, преимущественно ориентирована на внешние рынки, что способствует укреплению экспортного потенциала регионов. В частности, продукция СЭЗ «Коканд» поставляется в Россию, Казахстан и Кыргызстан.

В целом, к концу 2024 года в свободных экономических зонах Узбекистана было реализовано свыше 1000 проектов, освоено более 2 млрд долларов США инвестиций и создано около 30 тыс. новых рабочих мест, что свидетельствует о существенном вкладе СЭЗ в экономическое развитие страны и повышение уровня её технологической модернизации.

В соответствии с Указом Президента Республики Узбекистан «О Стратегии развития Нового Узбекистана на 2022–2026 годы», разработанной на основе принципа «От Стратегии действий — к Стратегии развития» и с учётом общественного обсуждения, свободные экономические зоны рассматриваются как один из ключевых факторов обеспечения ускоренного развития национальной экономики и достижения устойчиво высоких темпов экономического роста.

Для любой страны важнейшими исходными условиями формирования свободных экономических зон являются политическая стабильность, высокий уровень международной интеграции, надёжное обеспечение электроэнергией, а также соответствие транспортных коммуникаций международным стандартам.

В целях дальнейшего развития свободных экономических зон в Узбекистане целесообразно сосредоточить внимание на решении следующих приоритетных задач:

• разработка специальной программы, направленной на комплексное регулирование хозяйственно-правовых вопросов деятельности СЭЗ;

• последовательное развитие транспортных коммуникаций;

• формирование необходимой инфраструктуры, включая системы водоснабжения, электроснабжения и социального обеспечения;

• обеспечение доступности коммерческой инфраструктуры: банковских, консалтинговых и юридических услуг;

• разработка проектов, ориентированных на расширение доступа к внутренним и внешним рынкам;

• реализация программ, направленных на повышение добавленной стоимости и производительности труда;

• развитие и модернизация существующей промышленной базы;

• создание эффективной системы административного управления свободными экономическими зонами.

ВЫВОДЫ И ПРЕДЛОЖЕНИЯ

Свободные экономические зоны являются важным драйвером регионального развития, поскольку они стимулируют экономическую активность, способствуют внедрению современных технологий, создают новые рабочие места и содействуют сокращению межрегиональных различий в уровне социально-экономического развития, формируя тем самым основу для устойчивого и сбалансированного роста страны. Выступая одним из ключевых инструментов государственной экономической политики, свободные экономические зоны ориентированы на ускорение регионального развития, активизацию инновационной деятельности, улучшение инвестиционного климата и расширение внешнеэкономических связей. Вместе с тем в процессе их функционирования проявляются отдельные аспекты, требующие дальнейшего совершенствования, включая необходимость ускоренного развития инфраструктуры, повышения уровня квалификации местных кадров и оптимизации системы управления, что обусловливает целесообразность расширения автономности региональных органов управления, предоставления льготных кредитных ресурсов для реализации инновационных и цифровых проектов, а также укрепления взаимодействия между региональными образовательными учреждениями и органами местного самоуправления в целях подготовки конкурентоспособных специалистов. В заключение следует отметить, что развитие свободных экономических зон представляет собой одно из приоритетных направлений повышения эффективности национальной экономики, её интеграции в мировое хозяйство и формирования действенного механизма стимулирования прямых инвестиций, а в условиях углубления экономической либерализации адаптация зарубежного опыта и последовательное развитие СЭЗ приобретают особое значение для устойчивого социально-экономического развития регионов страны.

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RAQAMLI IQTISODIYOTGA O‘TISH SHAROITIDA IQTISODIY O‘SISH OMILLARINING TA’SIRINI BAHOLASH METODOLOGIYASI

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Annotatsiya: Maqolada raqamli iqtisodiyotga o‘tish sharoitida iqtisodiy o‘sishga ta’sir etuvchi asosiy omillarni baholash metodologiyasini takomillashtirish masalalari ilmiy jihatdan tahlil qilingan. Raqamli texnologiyalar, inson kapitali va institutsional omillarning o‘sish jarayonidagi o‘rni asoslab berilgan.

Kalit so‘zlar: raqamli iqtisodiyot, iqtisodiy o‘sish, baholash metodologiyasi, raqamli texnologiyalar, inson kapitali, institutsional omillar, innovatsiya.

Abstract: The article provides a scientific analysis of improving the methodology for assessing the impact of key factors on economic growth in the context of the digital economy transition, emphasizing the role of digital technologies, human capital, and institutional factors.

Key words: digital economy, economic growth, evaluation methodology, digital technologies, human capital, institutional factors, innovation.

Аннотация: В статье с научной точки зрения рассматриваются вопросы совершенствования методологии оценки влияния ключевых факторов на экономический рост в условиях перехода к цифровой экономике, с акцентом на роль цифровых технологий и человеческого капитала.

Ключевые слова: цифровая экономика, экономический рост, методология оценки, цифровые технологии, человеческий капитал, институциональные факторы, инновации.

KIRISH

So‘nggi yillarda global iqtisodiy tizimda raqamli texnologiyalarning jadal rivojlanishi va ularning ishlab chiqarish, xizmatlar sohasi hamda boshqaruv jarayonlariga chuqur integratsiyalashuvi iqtisodiy o‘sishning yangi manbalarini shakllantirmoqda. Raqamli iqtisodiyotga o‘tish jarayoni an’anaviy iqtisodiy omillarning rolini qayta ko‘rib chiqishni, shuningdek, iqtisodiy o‘sishga ta’sir etuvchi omillarni baholashda yangi yondashuv va metodologiyalarni ishlab chiqishni talab etmoqda. Shu sharoitda raqamli infratuzilma, inson kapitali, innovatsion faoliyat va institutsional muhit iqtisodiy o‘sishning muhim determinantlariga aylanib bormoqda.

Mavjud ilmiy tadqiqotlar iqtisodiy o‘sishni baholashda asosan an’anaviy makroiqtisodiy ko‘rsatkichlarga tayanib kelgan bo‘lsa-da, raqamli iqtisodiyot sharoitida ushbu yondashuvlar yetarli darajada natija bermasligi ayon bo‘lmoqda. Chunki raqamli texnologiyalar ishlab chiqarish samaradorligini oshirish, tranzaksiya xarajatlarini kamaytirish va yangi qo‘shilgan qiymat yaratish orqali iqtisodiy o‘sish mexanizmlariga sifat jihatidan yangi ta’sir ko‘rsatadi. Shu bois iqtisodiy o‘sish omillarining ta’sirini baholash metodologiyasini raqamli transformatsiya jarayonlarini hisobga olgan holda takomillashtirish dolzarb ilmiy va amaliy masalaga aylandi.

Mazkur tadqiqot raqamli iqtisodiyotga o‘tish sharoitida iqtisodiy o‘sishga ta’sir etuvchi omillarni aniqlash va ularning nisbiy ahamiyatini baholash metodologiyasini rivojlantirishga qaratilgan. Tadqiqot natijalari iqtisodiy siyosatni shakllantirish, raqamli rivojlanish strategiyalarini ishlab chiqish hamda barqaror iqtisodiy o‘sishni ta’minlashda ilmiy-amaliy ahamiyat kasb etadi.

MAVZUGA OID ADABIYOTLAR SHARHI

Raqamli iqtisodiyotga o‘tish jarayonida iqtisodiy o‘sishning sifat omillari ta’sirini baholash ilmiy metodologiyasini takomillashtirish masalalari ko‘plab xorijlik olimlar, jumladan D. Tapscott [1], N. Lane [2], T. Mesenbourg [3], W. Easterly [4], J. Sachs [5], M. Bruno [6], G. Grossman [7], J. Tobin [8], V. Stevenson [9], T. W. Swan [10], P. Romer [11], S. H. Yoo [12] va boshqalar tomonidan tadqiq qilingan.

O‘zbekiston iqtisodiyotida iqtisodiy o‘sishning sifat va miqdor omillari ta’sirini samarali baholash metodologiyasini takomillashtirish, undan foydalanish hamda raqamli iqtisodiyotni joriy etishning dolzarb masalalari S. S. Gulyamov [13], K. X. Abdurahmonov [14], T. Sh. Shodiev [15], A. F. Rasulev [16], N. M. Maxmudov [17], S. V. Chepel [18], D. V. Trostyanskiy [19], U. A. Madraximov [20], O. Umarov [21] va boshqa ko‘plab yetakchi iqtisodchi olimlar tomonidan o‘rganilgan. Ularning ilmiy tadqiqotlarida ishlab chiqaruvchilar va iste’molchilarning ehtiyojlarini ta’minlaydigan, to‘g‘ridan to‘g‘ri aloqa qilish imkonini beradigan funksiyalar majmuasiga ega raqamli muhitga oid ilmiy izlanishlar alohida ahamiyat kasb etadi.

TADQIQOT METODOLOGIYASI

Tadqiqot raqamli iqtisodiyotga o‘tish sharoitida iqtisodiy o‘sishga ta’sir etuvchi omillarni baholashga qaratilgan bo‘lib, unda miqdoriy va funksional-makroiqtisodiy yondashuv qo‘llanildi. Tahlilda statistik, korrelyatsion va regressiya usullari hamda ekonometrik modellashtirishdan foydalanildi. Iqtisodiy o‘sish sifati YaIMning ekstensiv va intensiv tarkibiy qismlarini ajratish orqali baholandi. Ma’lumotlar Jahon banki va rasmiy statistik manbalarga asoslandi.

TAHLIL VA NATIJALAR

Jahonda zamonaviy fan-texnika taraqqiyoti asosida raqamli iqtisodiyot samaradorligini oshirish, mahsulot va xizmatlarga mijozlar talabini oshirish, ishlab chiqarish jarayoniga yangi texnika va texnologiyalar joriy etish orqali sifatli tovarlar taklif qilishni ta’minlash asosiy maqsadga aylandi. Bugungi kunda «raqamli iqtisodiyotning rivojlangan mamlakatlar yalpi ichki mahsulotidagi ulushi 5,5%ga, rivojlanayotgan mamlakatlarda esa 4,9%ga teng. Bu ko‘rsatkich Buyuk Britaniyada - 12,4 %, Janubiy Koreyada – 8 %, Xitoyda - 6,9 %, Hindistonda - 5,6 %, Rossiyada - 2,8 %, Qozog‘istonda - 3,9 %ni tashkil etadi» [22]. «Raqamli iqtisodiyot»ning afzalliklari juda ko‘p bo‘lib, eng muhimi, u xufiyona iqtisodiyotning oldini oladi va korrupsiyani yo‘q qilishga yordam beradi. Natijada, BCG ma’lumotlariga ko‘ra, «internet mahsulotlari 2020 yilda 1,9 trillion dollardan 14,4 trillion dollargacha hajmda qo‘shimcha daromad keltirgan bo‘lsa, 2025 yilga borib jahon iqtisodiyotiga taxminan 6 trillion dollar qo‘shilishi mumkin» [23]. Bu esa raqamli iqtisodiyotga o‘tish sharoitlarida iqtisodiy o‘sish omillaridan samarali foydalanishning ahamiyatini yanada kuchaytiradi.

Hozirgi kunda jahonning etakchi ilmiy markazlari va tadqiqot muassasalarida raqamli iqtisodiyotga o‘tish muammolarini hal etishga qaratilgan ko‘plab izlanishlar olib borilmoqda. Raqamli iqtisodiyotning amal qilish va rivojlanish shart-sharoitlari, raqamli iqtisodiyotga o‘tishning asosiy bosqichlari va izchilligi, mazkur sharoitlarda iqtisodiy o‘sish barqarorligini ta’minlash, iqtisodiy o‘sishning sifat omillari namoyon bo‘lish xususiyatlari, ularning umumiy muvozanat va barqarorlikka ta’siri, ushbu ta’sirni baholash metodologiyasidagi muammolar va ularni hal etish yo‘llari, rivojlangan va rivojlanayotgan mamlakatlar iqtisodiyotida raqamlashtirishning umumiy va xususiy jihatlari, iqtisodiy o‘sish omillari tarkibida raqamli texnologiyalar ta’siri ulushini optimallashtirish kabi tadqiqot yo‘nalishlari shular jumlasidandir.

O‘zbekistonda milliy iqtisodiyotni tubdan modernizasiya qilish borasida olib borilayotgan keng ko‘lamli islohotlar mamlakatning ijtimoiy-iqtisodiy hayoti va davlat boshqaruvi tizimiga raqamli texnologiyalarni joriy etishni talab qilmoqda. «Raqamli iqtisodiyotni rivojlantirish, iqtisodiyotda davlat boshqaruvini kamaytirish, davlat va xususiy sektorlarning o‘zaro foydali hamkorligining zamonaviy shakllarini, «Elektron hukumat» tizimini rivojlantirish bo‘yicha chora-tadbirlarni amalga oshirish» [24] masalasi ustuvor vazifalar sifatida belgilangan. O‘zbekiston Respublikasining «Elektron hukumat» tizimini rivojlantirish konsepsiyasi loyihasiga muvofiq, 2025 yilga borib AKTning yalpi ichki mahsulotdagi ulushini 5,0 foizga etkazish ko‘zda tutilgan. Bugungi kunda ushbu ko‘rsatkich qiymatini 7-8%ga etkazish borasida O‘zbekiston Respublikasida milliy iqtisodiyotni raqamlashtirish sezilarli ishlarning olib borilishini taqozo etadi. Bu borada «raqamli iqtisodiyot» milliy konsepsiyasini ishlab chiqish, raqamli iqtisodiyotni rivojlantirish orqali yalpi ichki mahsulot hajmini qo‘shimcha oshirish bilan bog‘liq ilmiy tadqiqotlarni amalga oshirish muhim ahamiyat kasb etadi.

Texnologik (kafolatlangan) o‘sish sur’ati iqtisodiyotning doimiy tuzilishi va tashqi ta’sirlarning yo‘qligi sharoitida o‘sish sur’atini tavsiflaydi. O‘zgarmas tuzilma modelning parametrlari o‘zgarmasligini bildiradi (masalan, s, υ - doimiylar). Tashqi ta’sirlarning pastligi ekzogen o‘zgaruvchilarning yo‘qligini bildiradi (A(t) = 0).

Matematika nuqtai nazaridan texnologik o‘sish sur’ati makroiqtisodiy model uchun bir hil differensial tenglama echimining asimptotik harakati bilan tavsiflanadi. Standart Harrod-Domar modelida (1)-tenglamaning A(t) = 0 bilan echimi quyidagi shaklga ega,

$$Y(t) = Y(0)\exp(\omega t) \quad (1)$$

Shuning uchun ushbu standart modelning texnologik o‘sish sur’ati qiymat bilan tavsiflanadi $\omega = \frac{s}{\vartheta}$ 6 tenglama Harrod-Domar modelini xotirasiz va kechiktirmasdan belgilaydi, bu erda milliy daromad Y(t)ning xatti-harakati avtonom investitsiyalar A(t) dinamikasi bilan belgilanadi. (1)-tenglamaning echimi vaqt o‘tishi bilan avtonom xarajatlar o‘zgarishi haqida taxmin qilingan narsalarga bog‘liq. Bunda iqtisodiy o‘sish modellariga no‘ananaviy modellar, ya’ni innovasion model (iqtisodiy o‘sishga erishishda innovasiyalar va IT-texnologiyalar omil sifatida ko‘rib chiqilgan) [25].

Ushbu holatlar zamonaviy biznesning muvaffaqiyati mezonlarini, avvalambor, raqamli iqtisodiyot nuqtai nazaridan qayta ko‘rib chiqishni talab qiladi. «Turli xil hisob-kitoblarga ko‘ra, raqamli iqtisodiyot turli sohalarning 50 %dan ortig‘i uchun ulkan o‘zgarishlarni keltirib chiqaradi. Bu axborot texnologiyalari va platformalari biznes modellarini tubdan o‘zgartirishi, vositachilarni yo‘q qilish va optimallashtirish orqali ularning samaradorligini oshirishi bilan bog‘liq bo‘lib, Jahon banki ekspertlarining fikriga ko‘ra, Internetdan yuqori tezlikda foydalanuvchilar sonining 10 foizga ko‘payishi YaIMning yillik o‘sishini 0,4 dan 1,4 foizgacha oshirishi mumkin» [26], deb ta’kidlab o‘tilgan.

Iqtisodiyotni raqamlashtirish darajasini baholash uchun tadqiqotchilar turli mezonlardan foydalanadilar, yakuniy baholashda ular turli nuqtai- nazarlardan e’tirofga olish borasida fikrlar beradilar. Jumladan, «Strategy &» kompaniyasining mutaxassislari 6 ko‘rsatkichni hisobga olishni taklif qilmoqdalar: hamma joyda mavjudlik (foydalanuvchi va biznesning raqamli xizmatlar va dasturlarga kirishi, birinchi navbatda keng polosali va mobil aloqa tarmoqlarining mavjudligi, shaxsiy kompyuterlar va mobil qurilmalar soni), kirish imkoniyati (Internetga ulanish narxi, Internet-provayderlar), ishonchlilik (raqamli xizmatlarning sifati), tezlik (raqamli xizmatlarga real vaqt rejimida Mbit/s tezlikda kirish), qulaylik (elektron tijorat va davlat xizmatlarining rivojlanish darajasi, mamlakatda 100 kishiga to‘g‘ri keladigan domenlar va IP-manzillar soni, oyiga ijtimoiy tarmoqlardan foydalanuvchilar soni), kasbiy mahorat (har 100 kishiga to‘g‘ri keladigan mutaxassislar soni, ish bilan band bo‘lganlar foiz ko‘rsatkichi, o‘rta-maxsus va oliy ma’lumot) [27].

Ayrim iqtisodchilarning fikriga ko‘ra, aniqroq natijalar jahon iqtisodiy forumi mutaxassislari tomonidan ishlab chiqilgan Tarmoq tayyorligi indekslari (NRI) bilan ta’minlanadi, ular uchun hisoblagichlarning uchta guruhidan foydalaniladi: iqtisodiy va siyosiy sharoitlarning mavjudligi, normativ-huquqiy baza va infratuzilma; korxonalar, davlat idoralari va oddiy fuqarolarning AKTdan foydalanishga tayyorligi; AKTdan foydalanishning iqtisodiy va ijtimoiy ta’siri [28].

Yuqorida aytib o‘tilgan I-DESI indeksi doirasida tahlil qilishda aloqaning rivojlanish darajasi, inson kapitali, Internetdan foydalanish, aholiga raqamli texnologiyalarni va raqamli xizmatlarni amalga oshirish darajasi hisobga olinadi [29]. Tadqiqotlar shuni ko‘rsatadiki, iqtisodiyotning ushbu sohasiga investitsiyalar jalb qilishdan kelgusida ko‘p narsalarni kutish mumkin, garchi hozirgi kunda bu borada ma’lum ijobiy o‘zgarishlar mavjud bo‘lsa-da.

O‘zbekiston Respublikasida iqtisodiy o‘zgarishlarning asosiy vazifasi respublikaning raqobatli ustunliklarini hisobga olgan holda tarkibiy o‘zgarishlarni amalga oshirish va barqaror iqtisodiy o‘sishdir. Shu munosabat bilan nafaqat yuqori o‘sish sur’atlarini ta’minlash, balki iqtisodiyot tarkibidagi qayta ishlash tarmoqlari foydasiga sifat jihatidan o‘zgarishini ta’minlash zarur bo‘lib, bu o‘sishning yangi manbalarini izlash zarurligini anglatadi. Jumladan:

- iqtisodiyotning yangi tarmoqlarini rivojlantirish va yangilikning tarqalish maydonini kengaytirish;
- investitsion iqlimni yaxshilash va investitsiyalar jalb qilishni kengaytirish kabi ustuvor vazifalarni amalga oshirish;
- barqaror, sifatli iqtisodiy o‘sishni ta’minlash, mavjud muammolar va ularni bartaraf etish yo‘llarini o‘rganish.

Shu bilan birga, mavjud salohiyatga qaramay, uni milliy iqtisodiyotni rivojlantirish manfaatlaridan foydalanish uchun iqtisodiy o‘sishning yuqori sur’atlarini ta’minlashda O‘zbekistonning salohiyati va real imkoniyatlarini ta’minlash uchun sifat jihatidan yangi mexanizmni yaratish zarur. Albatta, bu jarayon ham o‘ziga yarasha ma’lum kamchilik va muammolardan iborat.

Yangi strategik yo‘nalishlarni ishlab chiqishda muhim muammolar qatorida ularning iqtisodiy jihatlari etarlicha o‘rganilmagan, bu iqtisodiy o‘sish sifatining ustuvorliklari, uning ko‘rsatkichlari va prognozlash amaliyotida modellar [30] dan foydalanishni talab etadi. O‘zbekistonda iqtisodiy o‘sishni belgilab beradigan eng muhim omillar sifatida iqtisodiy o‘sishning ma’lum bir mezonlarga javob beradigan foydali ta’sirini hisobga olish kerak.

Iqtisodiy o‘sishni tarkibiy qismlarga ajratishda asosiy mezon - bu joriy ishlab chiqarish xarajatlarini prognoz xarajatlar bilan taqqoslaganda yuzaga kelishi mumkin bo‘lgan resurslarning me’yoridan ortiqcha sarflanishi hisoblanadi. Ko‘rinib turibdiki, bunday sharoitda intensiv o‘sish yangi texnologiyalarni ishlab chiqarish yoki

xizmatlar tarmoqlariga joriy etish va mavjud texnologiyalarni modernizasiya qilish hisobiga ta'minlanmagan. Shuning uchun bu davrni ko'plab omillar ta'sirining kuchayishi yoki saqlanib qolishi ta'minlanmagan o'sishi deb hisoblash to'g'ri bo'ladi. $YaIM_{komp}$ning iqtisodiy o'sishining ekstensiv tarkibiy qismi YaIMmincost xarajatlarini ishlab chiqarish uchun resurslarning minimal xarajatlari hisobiga hosil bo'ladigan potensial yalpi ichki mahsulot bilan hisobot qilingan YaIMUM o'rtasidagi farq sifatida tavsiflanadi.

$$YaIM_{komp} = YaIM_{mincost} - YaIM_{UM}$$

bu yerda $YaIM_{komp}$ – YaIM iqtisodiy o'sishining ekstensiv tarkibiy qismi;
YaIMmincost – YaIM minimal xarajatlari
YaIMUM – umumiy YaIM yoki potensial YaIM.

YaIMSIF – iqtisodiy o'sishning sifat o'sishi YaIMning intensiv tarkibiy qismi qoldiq tamoyiliga muvofiq belgilanadi, ya'ni hisobot qilingan yalpi ichki mahsulot va iqtisodiy o'sishning ekstensiv tarkibiy qismi o'rtasidagi farq sifatida.

$$YaIM_{SIF} = YaIM_{UM} - YaIM_{komp}$$

Quyidagi formulalar YaIMmin va YaIMUM yalpi mahsulot qiymatini ishlab chiqarishga sarflangan haqiqiy xarajat - Xreal, mahsulot va xizmatlarni etkazib berish uchun nazariy resurs xarajatlari - Xmin o'rtasidagi farq sifatida ko'rsatish yo'li bilan hisoblab chiqilgan.

$$YaIM_{iomp} = X_{real} - X_{min}$$

Hisob-kitoblar YaIMkomp raqamlari va YaIMSIF miqdori, YaIMUM shakllanishining keng va intensiv omillariga bo'linishini aks ettiradi. $\Delta YaIM_{SIF}$ iqtisodiy o'sishining sifati YaIMSIF va YaIMkomp o'rtasidagi nisbatlarning o'zgarishi orqali tahlil qilinadi

$$\Delta YaIM_{SIF} = \frac{YaIM_{SIF}}{YaIM_{IIM}}$$

$\Delta YaIM_{SIF}$ indikatori 0-1 oralig'ida. $\Delta YaIM_{SIF}$ qiymatlarining talqini quyidagi 5-rasmda keltirilgan.

0	Tahlil qilinayotgan mamlakatning rivojlanishi ommaviy resurslarni birlamchi qayta ishlash quvvatlarining faol o'sishi sharoitida ro'y berib, amaldagi texnologiyalar resurslarni talab qiladi va mamlakat yalpi mahsulotining kamida 2/3 qismi oraliq iste'molga to'g'ri keladi.
$0 < \Delta YaIM_{SIF} \leq 0.25$	Bunday sharoitda iqtisodiyotda keng omillar hukmronlik qilib, rivojlanish texnologik jihatdan rivojlangan davlatlardan import qilinadigan katta xajmdagi resurslarni yuqori sifatli resurslarga almashtirish tamoyiliga asoslanadi.
$0.26 < \Delta YaIM_{SIF} < 0.5$	Iqtisodiyotning takror ishlab chiqarish jarayonlarida bosqichma-bosqich $YaIM_{komp}$ va $YaIM_{SIF}$ ulushlarini tenglashtirishga o'tiladi, bu esa rivojlanishning intensiv variantiga o'tish uchun zarur shart-sharoitlarni yaratadi va bunda iqtisodiy o'sish sifati o'rtacha bo'ladi.
$0.51 \leq \Delta YaIM_{SIF} \leq 0.75$	Bunday holda, $YaIM_{komp}$ rivojlanishning keng holatini aks ettiruvchi $YaIM_{SIF}$ ga nisbatan o'z ulushini oshiradi.
$0.76 \leq \Delta YaIM_{SIF} \leq 1$	$YaIM_{komp}$ ning salbiy hissasi shuni ko'rsatadiki, iqtisodiyotda intensiv omillar keng omillar o'rnini bosadi. Amalda, iqtisodiy rivojlanishning bunday varianti ehtimoldan yiroq emas va u nazariy jihatdan muhimroqdir.

1-rasm. $\Delta YaIM_{SIF}$ qiymatlarini talqin qilish [31]

Bizning fikrimizcha, iqtisodiy o‘sishni ta’minlash uchta asosiy modelda o‘z ifodasini topadi. Jumladan:

Birinchidan, ekstensiv - mamlakat iqtisodiyotining rivojlanishi ishlab chiqarishning miqdoriy o‘sishi asosida sodir bo‘lishini taxmin qiladi. Ikkinchisi shuni anglatadiki, mamlakatda qayta ishlash darajasi past bo‘lgan resurslar iste’molining o‘sish sur’ati ularning iste’molchi tarmoqlari mahsulotining jismoniy hajmi indeksidan oldinda bo‘ladi. Belgilangan model tizimli va texnologik inqirozda bo‘lgan, iqtisodiyotning cheklangan sonli sohalariga (asosan eksportga yo‘naltirilgan) yo‘naltirilgan texnologiyalarni faol ravishda qarz olayotgan sanoat tipidagi mamlakatlar uchun xosdir. Bu model bo‘yicha iqtisodiy o‘sish sifati past;

Ikkinchidan, intensiv - asosan xizmat ko‘rsatish sohasida yaratilgan YaIMSIF ga asoslangan iqtisodiy o‘sishning shakllanishini ko‘rsatadi. Bu turdagi davlatlar resurslarni ko‘p talab qiladigan tarmoqlarni ishlab chiqarish tannarxi past bo‘lgan davlatlarga o‘tkazishni amalga oshirmoqdalar, bu esa ma’lum narx ustunligini yaratadi. Innovasiyalar va intellektual mulkni rivojlantirishga e’tibor qaratish bizga yuqori texnologiyali mahsulotlar bozorida etakchi o‘rinlarni saqlab qolish imkonini beradi. Ushbu modelga muvofiq, yalpi ichki mahsulotda YaIMSIF hajmi ustunlik qiladi, bu iqtisodiy o‘sish sifatining oshishini ta’minlaydi;

Uchinchidan, tanlov - bu variant doirasida iqtisodiy o‘sish modeli intensivdan ekstensivga va aksincha o‘zgaradi. Iqtisodiy o‘sish modelini o‘zgartirishning asosi - mamlakatning ijtimoiy-iqtisodiy rivojlanishini davlat boshqaruvi mexanizmlarining rejalashtirilgan iqtisodiyotdan bozor iqtisodiyotiga o‘zgarishi, mamlakatning sanoatdan postindustrialga ixtisoslashuvi va boshqalar. Bu o‘sish modeli yalpi ichki mahsulotni YaIMSIF, YaIMkomp komponentlari o‘rtasida taxminan bir xil taqsimlanishi bilan tavsiflanadi. Bunda iqtisodiy o‘sish sifati o‘rtachani tashkil etadi.

Iqtisodiyotni ekonometrik modellashtirish nafaqat tashkiliy-texnik tomonidan, balki ularning uslubiy va nazariy jihatlari bo‘yicha ham murakkab hisoblanadi. U xalqaro andozalarga asoslanib yangi konsepsiya tashkil etish, amalda foydalanib kelinayotgan konsepsiyalardan samarali foydalanish, ularni tanqidiy o‘rganish va modernizasiya qilish bo‘yicha takliflar ishlab chiqish, prognoz qilishni talab etadi. Hodisalar o‘rtasidagi baholashni ifoda etuvchi statistik modellarni qurish vaqtida korrelyatsion va regression tahlil metodiga katta e’tibor berilmoqda.

XULOSA VA TAKLIFLAR

Shunday qilib, zamonaviy ijtimoiy-iqtisodiy tizimlarning raqamli o‘zgarishi quyidagilardan iborat:

1. Iqtisodiy o‘sish muammolarini har tomonlama ilmiy asoslash, o‘rganish, takror ishlab chiqarish va funksional-makroiqtisodiy yondashuv iqtisodiy o‘sishning boshqa omillari bilan uzviy bog‘liqligini to‘la-to‘kis aniqlashga imkon beradigan, bir-birini to‘ldiruvchi va funksional-makroiqtisodiy yondashuvdan samarali foydalanish va iqtisodiy o‘sish omillari, shuningdek, ayrim omillarning iqtisodiy o‘sishga qo‘shgan hissasini miqdoriy jihatdan aniqlash imkonini beradi. Bu bugungi kunning eng muhim masalalari hisoblanadi;
2. Tahlilning omilli darajasi iqtisodiy o‘sishning sifat tavsifi, tovar ishlab chiqarish faoliyati dinamikasi va samaradorligi mezoni sifatida foydalanidishi muhim. Strukturali iqtisodiy daraja nuqtai nazaridan, iqtisodiy o‘sishning yuqori sifati tarkibiy xilma-xillik bilan ta’minlanadi. Ilm-fan talab qiladigan tarmoqlar, xom ashyoni qayta ishlash darajasi yuqori bo‘lgan korxonalarning ustunligi, nomoddiy kapital to‘planishi infratuzilmaning rivojlanishiga olib keladi. Tahlilning ijtimoiy-iqtisodiy tomoni zamonaviy iqtisodiy o‘sishning inson ehtiyojlarini qondirish bilan bog‘liqlik darajasi bilan belgilanadi, uning o‘lchami mehnat jarayonida shaxsning o‘zini namoyon qilishi uchun shart-sharoitlarda etilganligiga bog‘liq;
3. Iqtisodiy o‘sish muammolarini har tomonlama o‘rganish iqtisodiy o‘sishning boshqa shakllari bilan uzviy bog‘liqligini, u ishlab chiqarish va o‘sish omillariga bo‘ysunishini, miqdoriy jihatdan aks ettirishga imkon beradigan yondashuvlar - takror ishlab chiqarish va funksional-makroiqtisodiy yondashuvlar yordamida aniqlashini bildiradi. Individual omillarning hissasini baholash yalpi milliy mahsulot hamda milliy daromad, hududiy mahsulotlar ishlab chiqarishga qay darajada yalpi ko‘rsatkich sifatida aniqlash imkoniyatini paydo qiladi;
4. Iqtisodiy o‘sish sifatining asosiy mezoni jadal iqtisodiy o‘sishning o‘ziga xos xususiyati bo‘lib, iqtisodiy o‘sishning intensiv omillaridan foydalanishni hisobga olgan holda, inson taraqqiyoti indeksi (HDI) o‘sishining ijobiy dinamikasi bilan ifodalanishi mumkin, jumladan tabiiy va ekologik omillar, milliy xavfsizlik manfaatlarining saqlanishini ta’minlash ham shular jumlasidandir. Milliy iqtisodiyot o‘sishining sifat jihatidan yangi mazmunini shakllantirishning strategik yo‘nalishi - ko‘p tarmoqli iqtisodiyotni shakllantirish uchun xom ashyo resurslaridan oqilona foydalanish, to‘plangan fundamental bilimlarni samarali ishlatiladigan aqlli texnologiyalarga aylantirishdan iborat. Yangi texnologiya talab qiladigan mahsulotlar ishlab chiqarish va yuqori qo‘shimcha qiymatga ega xizmatlar yaratish. Hozirgi vaqtda ichki iqtisodiyotni diversifikasiya qilish darajasi hali ham etarli emas, bu o‘sishning jahon tovar bozoridagi narx-navoga bog‘liqligi bilan tasdiqlanadi;
5. Ko‘p o‘zgaruvchan regressiya modellariga asoslangan modellashtirish usuli yordamida asosiy miqdoriy va sifat omillardan foydalangan holda o‘sish strategiyasining taklif qilingan variantlari ishlab chiqarish modelining

yuqori samaradorligini ko‘rsatadi, bu esa hayot sifati va investitsiyalarning o‘sishi uchun strategik ko‘rsatmalarni taqsimlashni nazarda tutadi.

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FINTECH TRENDS: NEW TOOLS FOR ATTRACTING FINANCING IN THE CONTEXT OF DIGITAL TRANSFORMATION

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Abstract: This article explores contemporary fintech trends and new funding tools that have emerged in the context of accelerated digital transformation. Key technologies—blockchain, artificial intelligence, crowdfunding, crowdlending, asset tokenization, and digital platforms—are analyzed, along with their impact on capital accessibility and the transformation of financial markets. Particular attention is paid to changes in investment models, the transition to a platform economy and decentralized forms of financing, and fintech development trends.

Key words: fintech, digital transformation, investment, crowdfunding, blockchain, artificial intelligence, asset tokenization, fintech ecosystem, financial innovation, digital economy.

Annotatsiya: Ushbu maqolada zamonaviy fintech tendentsiyalari va tezlashtirilgan raqamli transformatsiya sharoitida paydo bo‘lgan yangi moliyalashtirish vositalari o‘rganiladi. Asosiy texnologiyalar - blokcheyn, sun'iy intellekt, kraudfanding, kraudkreditlash, aktivlarni tokenlashtirish va raqamli platformalar - kapitalga kirish imkoniyati va moliya bozorlarining o‘zgarishiga ta'siri bilan birga tahlil qilinadi. Investitsiya modellaridagi o‘zgarishlar, platforma iqtisodiyotiga o‘tish va markazlashtirilmagan moliyalashtirish shakllari hamda fintech rivojlanish tendentsiyalariga alohida e'tibor qaratiladi.

Kalit so‘zlar: fintech, raqamli transformatsiya, investitsiya, kraudfanding, blokcheyn, sun'iy intellekt, aktivlarni tokenlashtirish, fintech ekotizimi, moliyaviy innovatsiya, raqamli iqtisodiyot.

Аннотация: В данной статье рассматриваются современные тенденции в сфере финансовых технологий и новые инструменты финансирования, появившиеся в контексте ускоренной цифровой трансформации. Анализируются ключевые технологии — блокчейн, искусственный интеллект, краудфандинг, краудлендинг, токенизация активов и цифровые платформы — а также их влияние на доступность капитала и трансформацию финансовых рынков. Особое внимание уделяется изменениям в инвестиционных моделях, переходу к платформенной экономике и децентрализованным формам финансирования, а также тенденциям развития финансовых технологий.

Ключевые слова: финансовые технологии, цифровая трансформация, инвестиции, краудфандинг, блокчейн, искусственный интеллект, токенизация активов, экосистема финансовых технологий, финансовые инновации, цифровая экономика.

INTRODUCTION

Digital transformation is fundamentally reshaping the financial sector by creating new mechanisms for capital attraction and fostering the emergence of innovative business models. Traditional financing instruments are increasingly being replaced by flexible and technology-driven platform-based solutions. The emergence of blockchain, artificial intelligence, big data, and smart contracts has created the conditions for the formation of a new architecture of financial markets.

Modern fintech instruments enable companies and investors to interact directly, reducing transaction costs, increasing transparency, and accelerating decision-making processes. The widespread adoption of blockchain, artificial intelligence, big data, smart contracts, and digital platforms has made it possible to establish a new financial market architecture based on openness, accessibility, and high-speed data processing.

Under these conditions, the study of fintech trends and new financing instruments becomes particularly significant, as they increasingly serve as key drivers of economic growth, innovation, and investment activity.

In our view, the foundation for such measures is a comprehensive regulatory and legal framework, primarily including the “Digital Uzbekistan–2030” Strategy. Within the framework of its implementation, the Coordination Commission has been tasked with developing mechanisms for assessing the social and economic

effectiveness of artificial intelligence implementation projects, ensuring their execution based on the principles of transparency and competition, and regularly reviewing the progress of priority initiatives.

In addition, provisions have been made for adjusting the list of projects and datasets based on big data in response to emerging needs. For institutional support, a specialized public institution—the "Center for the Development of Artificial Intelligence and the Digital Economy"—is being established on the basis of the Digital Economy Research Center under the Ministry of Digital Technologies.

LITERATURE REVIEW

Empirical studies demonstrate that digital technologies reduce entry barriers, expand access to capital, and enhance the efficiency of financial resource allocation.

The works of Lee and Shin further confirm that fintech is shaping a new technological paradigm in financial services, based on automation, data-driven processes, and digital channels [2]. Contemporary researchers emphasize the role of fintech as a key driver of financial services transformation and investment attraction [3].

Building on this perspective, the works of Egorova and Sokolova further confirm that fintech is shaping a new technological paradigm in financial services based on automation, data-driven processes, and digital channels, while contemporary researchers emphasize its role as a key driver of financial services transformation and investment attraction.

Research by Cao, L., Yang, Q., and Yu, P. S. indicates that regulated fintech sandboxes increase the investment attractiveness of the sector and stimulate the entry of new market participants [5].

Thus, contemporary academic literature increasingly regards fintech as a strategic instrument for enhancing investment activity and modernizing financial infrastructure.

RESEARCH METHODOLOGY

The development of the methodological framework of this study is based not only on classical scientific methods, but also on an analysis of global economic and technological challenges that have shaped the contemporary fintech market and led to the emergence of new financing instruments. The research employs an analysis of international and national practices in the implementation of fintech solutions, as well as an evaluation of investment data and digital market indicators.

ANALYSIS AND RESULTS

The analysis of FinTech technologies makes it possible to identify global and regional trends in FinTech development that stimulate investment activity. Key fintech trends include the platformization of financial services, the development of decentralized finance (DeFi), asset tokenization, algorithmic lending, and the expansion of digital payment ecosystems [3].

The study examines new financing instruments such as crowdfunding, crowdlending, crowdinvesting, ICO/STO mechanisms, decentralized protocols, and digital banking services. An assessment of contemporary FinTech technologies enables the identification of major global and regional trends that shape new approaches to investment attraction and transform the financial sector [4].

Table 1. Key Trends in FinTech Development

Trend	Investment Potential	Examples of Capital Attraction Channels
Mobile payments and super apps	High profitability and scalability, rapid access to mass markets.	Venture capital funds, strategic bank investments, IPOs.
Open Banking and API platforms	Open the market to numerous niche startups, increasing competition and innovation.	Government grants, acceleration programs, corporate venture funds.
Artificial intelligence in finance	Reduction of operational costs and risks, increased accuracy of credit scoring.	Venture financing, direct investments, international grants (IFC, EBRD).
Blockchain and asset tokenization	Capital raising through STO/ICO mechanisms, creation of global investment platforms.	Crowdfunding, crowdinvesting, crypto funds.
Regulatory sandboxes	Minimization of entry barriers for startups, safe testing of business models.	Government subsidies, public–private partnerships (PPPs).
Digital onboarding and biometrics	High scalability and strong demand in banking, telecommunications, and e-commerce sectors.	Strategic deals with technology corporations, venture investments.

These trends create new mechanisms for capital attraction and increase the accessibility of investments. As a result of digital transformation, a broad set of new financing instruments is emerging, based on the decentralization, automation, and platformization of financial services. These instruments provide wider access to capital, accelerate investment processes, and create conditions for the participation of a significantly broader range of investors, including retail participants.

New Financing Instruments

- Crowdfunding. Used primarily at early stages of projects (creative, technological, and social). It simplifies access to capital for startups and micro-businesses.
- Crowdlending. Forms an alternative credit market in which individuals and companies directly provide loans to small and medium-sized enterprises (SMEs).
- Crowdinvesting. Enables capital raising in exchange for equity participation in a business. It accelerates fundraising processes and expands the pool of private investors.
- Asset tokenization and digital tokens (ICO, STO). Facilitate asset fractionalization, lower entry barriers, and create new forms of liquidity. STOs, in particular, provide regulatory compliance and enhanced investor protection.
- DeFi platforms. Offer access to lending, deposits, asset exchange, and insurance services without intermediaries, relying primarily on smart contracts.
- Super apps (neobanks, fintech platforms). Create new investment products, including micro-investments, P2P lending, and digital bonds.

The findings indicate that the development of fintech innovations leads to a comprehensive transformation of the investment environment. First, the use of innovative instruments significantly reduces transaction costs and expands access to capital for a wide range of participants. Second, fintech platforms enhance overall market liquidity through asset tokenization and the automation of financial operations. In addition, the adoption of artificial intelligence technologies improves the accuracy of risk assessment and accelerates investment decision-making processes.

At the same time, crowdfunding and crowdinvesting platforms open up financing opportunities for early-stage projects without the need to rely on traditional banking institutions. Blockchain technology serves as a key element of the ecosystem: its transparency and immutability increase investor confidence and strengthen the sustainability of financial flows.

Existing Challenges and Possible Solutions in Digital Finance

- Regulatory gaps – development of flexible regulatory frameworks and the introduction of regulatory sandboxes for testing new services.
- Cybersecurity risks – strengthening cybersecurity through encryption, regular audits, and training for personnel and users.
- Low digital literacy – implementation of educational programs, webinars, and campaigns to improve financial and digital literacy.
- Insufficient venture financing – creation of national and international support programs, grant mechanisms, and incentives for investment in fintech startups.

In 2024, the Central Bank launched a pilot Open Banking project involving ten of the country's largest banks. Initially, APIs were introduced for account balance verification and basic payment services. In the future, the functionality is expected to expand to include credit products, investment services, and integration with government platforms. This initiative will create a foundation for the emergence of local fintech ecosystems and attract international investors interested in a rapidly growing and still underdeveloped market.

CONCLUSION AND RECOMMENDATIONS

The conducted analysis confirms that fintech trends are shaping a new architecture of the financial market in which traditional mechanisms are being replaced by more flexible and technologically advanced instruments for capital attraction. The digitalization of financial processes, the development of the platform economy, the growing role of artificial intelligence, and the widespread adoption of blockchain technologies create favorable conditions for expanding investment activity and increasing the accessibility of financial resources for a broad range of participants.

International experience demonstrates that the development of fintech instruments represents a global trend, while successful countries exhibit similar patterns of transformation:

The United Kingdom has become a global leader in crowdfunding and crowdlending due to the early introduction of regulatory sandboxes and a transparent regulatory framework. Platforms such as Funding Circle and Crowdcube have created an effective financing market for SMEs, providing access to capital that is often unavailable through traditional banking channels.

The United States has actively developed the markets for ICOs and asset tokenization (e.g., Coinbase, Circle), as well as venture crowdinvesting platforms within the framework of the JOBS Act. This has led to the formation of an alternative investment ecosystem oriented toward startups and private investors.

Singapore and Hong Kong have built strong digital ecosystems through state support, tax incentives, and the promotion of DeFi projects. These economies have become regional hubs for asset tokenization, digital payments, and automated financial services.

China represents one of the most large-scale examples of financial platformization. The ecosystems created by Alibaba and Tencent have developed proprietary microfinance and digital investment tools, such as Ant Group, which have significantly expanded financial access for tens of millions of SMEs.

The analysis of these successful models confirms that the key prerequisite for the development of new financing instruments is the combination of technological innovation, regulatory flexibility, and government support. Countries that have adopted a comprehensive approach—from digital infrastructure development to startup support programs—have been able to substantially increase investment activity and create an attractive environment for innovative business.

For countries undergoing active digital transformation, international best practices highlight the importance of:

1. implementing regulatory sandboxes for new fintech products;
2. creating conditions for the growth of digital platforms by supporting alternative financing mechanisms (crowdfunding, P2P lending, tokenization);
3. developing human capital and competencies in artificial intelligence, blockchain technologies, and digital law;
4. enhancing the financial and digital literacy of the population.

Thus, fintech instruments are becoming a global driver in the formation of an accessible, transparent, and inclusive financial system. When international best practices are implemented effectively, fintech can serve as a strategic factor for sustainable economic growth and increased investment attractiveness of the national economy.

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CHALLENGES AND PROSPECTS FOR THE DEVELOPMENT OF E-COMMERCE IN UZBEKISTAN

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Abstract: The article analyzes the state and prospects for the development of e-commerce in the Republic of Uzbekistan in the context of global digital transformation. Key trends in the development of e-commerce in the world and their impact on the formation of the national market are considered. It is shown that e-commerce is considered as an important factor of economic growth, expansion of sales markets, and increasing the competitiveness of businesses, primarily small and medium-sized enterprises. The work systematizes both the advantages and growth points of e-commerce in Uzbekistan, including the features of the payment environment, logistics infrastructure, digital skills of the population, and regulatory and legal regulation. A comprehensive approach to assessing the country's readiness to develop e-commerce has been proposed. Based on the analysis results, measures were proposed to increase the effectiveness of state policy and strategic measures to stimulate e-commerce.

Key words: e-commerce, digital economy, e-commerce market, e-commerce maturity index, digital infrastructure, cashless payments, logistics, digital literacy, regulation, Uzbekistan.

Annotatsiya: Maqolada global raqamli transformatsiya sharoitida O‘zbekiston Respublikasida elektron tijoratning holati va rivojlanish istiqbollari tahlil qilinadi. Dunyoda elektron tijorat rivojlanishining asosiy tendentsiyalari va ularning milliy bozorni shakllantirishga ta'siri ko‘rib chiqiladi. Elektron tijorat iqtisodiy o‘sish, savdo bozorlarini kengaytirish va biznesning, birinchi navbatda kichik va o‘rta korxonalarning raqobatbardoshligini oshirishning muhim omili sifatida qaralishi ko‘rsatilgan. Ishda O‘zbekistonda elektron tijoratning afzalliklari va o‘sish nuqtalari, jumladan, to‘lov muhiti, logistika infratuzilmasi, aholining raqamli ko‘nikmalari va normativ-huquqiy tartibga solishning xususiyatlari tizimlashtirilgan. Mamlakatning elektron tijoratni rivojlantirishga tayyorligini baholashga kompleks yondashuv taklif qilingan. Tahlil natijalari asosida davlat siyosati samaradorligini oshirish va elektron tijoratni rag‘batlantirish bo‘yicha strategik choralar taklif qilingan.

Kalit so‘zlar: elektron tijorat, raqamli iqtisodiyot, elektron tijorat bozori, elektron tijorat yetuklik indeksi, raqamli infratuzilma, naqd pulsiz to‘lovlar, logistika, raqamli savodxonlik, tartibga solish, O‘zbekiston.

Аннотация: В статье анализируется состояние и перспективы развития электронной коммерции в Республике Узбекистан в контексте глобальной цифровой трансформации. Рассматриваются ключевые тенденции развития электронной коммерции в мире и их влияние на формирование национального рынка. Показано, что электронная коммерция рассматривается как важный фактор экономического роста, расширения рынков сбыта и повышения конкурентоспособности предприятий, прежде всего малых и средних. В работе систематизированы как преимущества, так и точки роста электронной коммерции в Узбекистане, включая особенности платежной среды, логистической инфраструктуры, цифровых навыков населения, а также нормативно-правового регулирования. Предложен комплексный подход к оценке готовности страны к развитию электронной коммерции. На основе результатов анализа предложены меры по повышению эффективности государственной политики и стратегические меры по стимулированию электронной коммерции.

Ключевые слова: электронная коммерция, цифровая экономика, рынок электронной коммерции, индекс зрелости электронной коммерции, цифровая инфраструктура, безналичные платежи, логистика, цифровая грамотность, регулирование, Узбекистан.

INTRODUCTION

Electronic commerce refers to the sale of goods and services through digital platforms and networks, and today it has become an integral part of the global economy. From a theoretical perspective, the development of e-commerce brings a number of economic benefits: a reduction in transaction costs through the elimination of intermediaries, expansion of market access for enterprises (especially small and medium-sized enterprises, SMEs), growth of employment in the IT sector, and increased competitiveness driven by innovations in digital trade. Globally, e-commerce has been experiencing exponential growth. The COVID-19 pandemic accelerated the shift toward e-commerce, while the expanding adoption of mobile technologies has further stimulated online shopping.

According to eMarketer [1], global retail e-commerce sales increased by 27.6% in 2020, reaching USD 4.28 trillion. This growth trend has continued, and in 2024 global e-commerce sales exceeded USD 6 trillion, with an average annual growth rate of 7.7%. Despite a gradual slowdown in growth rates, the overall trend remains positive, indicating the stable development of global e-commerce. In 2025, e-commerce is expected to account for 20.5% of total global retail sales, compared to 19.9% in 2024. Demand for online shopping is expected to continue rising, as an increasing number of consumers prefer using mobile devices for shopping rather than visiting physical stores.

In Uzbekistan, the development of e-commerce is regarded as one of the key drivers of economic growth and modernization, as reflected in the country's strategic policy documents. The "Digital Uzbekistan–2030" Strategy identifies the digital economy as a central driver of socio-economic modernization and sustainable development [2]. The government is implementing large-scale reforms within the framework of digital transformation, including the adoption of the "National Strategy for the Development of Electronic Commerce" (draft for 2023–2027) [3], developed in cooperation with international partners.

Nevertheless, the regulatory environment is still evolving. Further harmonization of legislation, simplification of procedures for online businesses, and effective enforcement of consumer protection laws in the digital environment are required. According to World Bank assessments, e-commerce regulation remains fragmented, which constrains the sector's growth. Harmonization of rules at the national and regional levels, taking into account integration into global digital markets, is an important factor in achieving e-commerce maturity.

LITERATURE REVIEW

The development of electronic commerce is widely discussed in the literature as a key component of the digital economy, contributing to economic growth, market expansion, and enhanced business competitiveness, particularly for small and medium-sized enterprises (SMEs). Studies by UNCTAD (E-commerce and Digital Economy Programme, 2024) emphasize the role of e-commerce in digital transformation and highlight the need to support countries in strengthening their digital readiness and infrastructure to participate effectively in the global digital economy. UNCTAD's international reports also stress the importance of policy measures and institutional reforms in creating an enabling environment for e-commerce and digital integration, rather than focusing solely on technological aspects.

In the context of Uzbekistan, several studies have analyzed factors influencing the development of electronic commerce. For instance, the study by Madina Khushmurodova and Urazov Komil (2023) examines the evolution of e-commerce through the lens of institutional conditions, consumer behavior, and platform strategies, pointing to the necessity of coordinated reforms and trust among market participants.

Another study analyzing the development of electronic services in Uzbekistan (Jurakulov Shohruh et al., 2025) documents the dynamics of growth in digital services, their economic nature, and challenges related to integration into the digital economy, confirming that institutional and infrastructural barriers remain significant.

Research focusing on the critical success factors of e-commerce in Uzbekistan identifies key variables such as access to payment systems, logistics infrastructure, and digital literacy, emphasizing the importance of a comprehensive and integrated approach to sector development (Irina Kerimova & Zamira Ataniyazova, 2024).

Legal and regulatory aspects are also examined within the framework of digital trade. Studies analyzing the regulatory environment, including Big Data governance and e-commerce regulation in Uzbekistan, underscore the importance of a robust legal framework for the sustainable development of the sector (Khakimov A. et al., 2025).

Moreover, global-level research on e-commerce development demonstrates that digital platforms, comprehensive policy frameworks, and integration into international digital markets play a crucial role in shaping modern electronic commerce. These conclusions are supported by international publications analyzing global development models, trends, and the impact of digital trade on the economies of both developing and developed countries (Alla O. Kasych et al., 2024).

Global Trends in Electronic Commerce

At the global level, electronic commerce has become one of the key economic sectors. The global e-commerce market is expanding due to the increasing integration of advanced technologies such as artificial intelligence (AI), virtual reality (VR), and augmented reality (AR), as well as growing consumer interest in online shopping, rising investment volumes, expanded cooperation, and an increasing number of government initiatives. The COVID-19 pandemic significantly accelerated these trends, leading to a sharp increase in the share of online sales. Major online platforms (Amazon, eBay, Alibaba, Walmart, among others) substantially increased their revenues during the pandemic, reinforcing their market dominance [4].

An analysis of e-commerce development reveals several key global trends:

In developed countries, more than half of internet users now shop online, while this share remains significantly lower in developing economies. Globally, approximately 2.71 billion people make online purchases. The global e-commerce market was valued at USD 18.77 trillion in 2024, and it is projected to reach USD 75.12 trillion by 2034, with a compound annual growth rate (CAGR) of 14.88% over the forecast period (2025–2034) [5].

Expanded internet access, increased smartphone penetration, and the rapid development of social commerce have driven the growth of mobile commerce. According to a Dynamic Yield study by Mastercard, 76% of surveyed consumers make purchases using mobile devices, citing time savings as the primary reason. At the same time, 42% of respondents indicated that security concerns represent a significant barrier to mobile shopping [6].

The implementation of flexible payment options, including Buy Now, Pay Later (BNPL) services, has stimulated consumer demand. E-commerce increasingly relies on digital payment platforms, cryptocurrencies, and national payment gateways, making financial services more accessible to underserved populations. For example, the global BNPL market reached approximately USD 492.8 billion in 2024 and is expected to grow to USD 560 billion in 2025, with an average annual growth rate of 13.7% [7].

Emerging technologies such as AI, VR, and AR are transforming product presentation and consumer interaction in online environments. AI algorithms are widely used for personalized recommendations, marketing automation, dynamic pricing, and logistics optimization. These applications enhance customer satisfaction and increase conversion rates. Currently, around 90% of leading international companies use AI for personalization, resulting in higher customer engagement and sales growth [8].

Sustainable commerce and ecommerce are gaining importance as younger generations become a dominant force in the e-commerce market. Key sustainability trends include the growing popularity of eco-friendly brands, transparency and traceability, environmentally friendly packaging, and the circular economy. Surveys show that 62% of Generation Z consumers (born after 1997) prefer environmentally responsible brands, and 73% are willing to pay a premium for eco-friendly products. Both Generation Z and Millennials are more likely to make purchasing decisions aligned with their personal, social, and environmental values [9].

Digital marketplaces now play a crucial role in expanding export opportunities for producers and entrepreneurs, including women entrepreneurs and rural producers [10]. In 2019, global cross-border e-commerce exceeded USD 780 billion, and it is projected to grow to USD 4.82 trillion by 2026 [11].

Overall, the e-commerce market demonstrates sustained growth driven by digitalization, technological innovation, and personalization. Younger generations' emphasis on environmental and social values is shaping demand for sustainable consumption and ecommerce. The rapid expansion of cross-border trade and digital platforms enhances opportunities for SMEs while intensifying global competition. Under these conditions, e-commerce is evolving into a high-tech, adaptive ecosystem that requires digital maturity and flexibility from all market participants.

International Comparative Analysis

To assess the development prospects of the e-commerce market in Uzbekistan, it is useful to compare its position in the field of electronic commerce with that of other countries. A comparison with regional neighbors and global leaders makes it possible to identify the relative achievements and gaps of the domestic market.

Within Central Asia, Kazakhstan is the leading e-commerce market, accounting for the largest share of online sales in the region. In Kazakhstan, approximately 10% of retail trade is already conducted online, and the market volume is expected to reach USD 5 billion by the end of the current year [12]. Kazakhstan benefits from early internet liberalization, higher population engagement, and the entry of major international players. At the same time, neighboring Kyrgyzstan and Tajikistan lag behind Uzbekistan. These countries are considered "nascent" markets with limited potential, primarily due to low levels of digital connectivity and underdeveloped payment infrastructure. In this context, Uzbekistan can be regarded as a "rising star" in the region—currently the second most promising market after Kazakhstan—with one of the highest projected growth rates (around 40% CAGR).

The gap between Uzbekistan and advanced economies in the field of e-commerce remains significant. For example, the United States and China generate multi-trillion-dollar volumes of online trade, deeply embedded in consumers' daily lives. In the United States, approximately one-quarter of retail spending occurs online; in China, nearly one-third; and in South Korea, almost one-half. These countries have developed powerful e-commerce ecosystems, ranging from logistics giants (FedEx, Cainiao) to payment systems (PayPal, Alipay) and global platforms (Amazon, Alibaba). According to UNCTAD's e-commerce readiness index—which considers internet access, payment systems, logistics, and digital skills—developed countries score above 90 points, whereas Uzbekistan scored approximately 40–45 points in the latest available year (2020) [13]. Nevertheless, it should be noted that developed countries followed a long path of e-commerce development starting in the late 1990s, while Uzbekistan now has the opportunity to catch up more rapidly by adopting existing technologies and business models.

It is also instructive to examine countries that have achieved rapid progress in e-commerce over the past decades, such as India, Indonesia, and Vietnam. Similar to Uzbekistan, these countries have large domestic markets and initially low internet penetration; however, through targeted investments and reforms, they have achieved rapid growth in electronic commerce. India, for instance, addressed logistical and payment barriers through initiatives such as the Digital India program and the development of payment infrastructure (UPI systems). As a result, India's e-commerce market grew from negligible levels to USD 125.5 billion in 2024 and continues to expand at double-digit rates [14]. In Vietnam, the share of e-commerce exceeded 8% of retail sales due to a national e-commerce development program and inflows of foreign investment into platforms such as Lazada and Shopee. These cases demonstrate that a combination of government strategy, private investment, and consumer trust can enable countries to approach global standards relatively quickly. Uzbekistan may adopt similar approaches, for example, by attracting global platforms and logistics companies while simultaneously supporting domestic startups.

Regional integration represents another important dimension of international comparison. Individually, the domestic markets of Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan are relatively small; however, collectively Central Asia—with a population exceeding 83 million—constitutes a sizeable market. The creation of a unified digital market and the harmonization of trade regulations among these countries could remove many existing barriers. Currently, initial steps are being taken: since 2023, the World Bank has been implementing the E-GATE program to promote e-commerce growth in Kyrgyzstan, Tajikistan, and Uzbekistan. The program aims to eliminate barriers and coordinate efforts between governments and the private sector. Regional forums have also been organized, such as the E-commerce Conference in Tashkent in 2023. Nevertheless, further coordinated actions are required to simplify cross-border payments, delivery, returns, and taxation. The experience of the European Union's Digital Single Market demonstrates that such measures can significantly expand market opportunities for local companies. Central Asian countries are still at the discussion stage regarding similar initiatives.

Overall, the international comparative analysis highlights that Uzbekistan possesses substantial potential for e-commerce growth; however, realizing this potential requires narrowing the gap with leading countries across key dimensions. An optimistic development scenario involves replicating the success of dynamic Asian economies, with a doubling or tripling of e-commerce's share in retail trade over the coming years. A pessimistic scenario would involve the persistence of a niche market status amid growing competition from foreign platforms and insufficient reforms. The following section presents a forecast of e-commerce development in Uzbekistan up to 2030, taking into account the identified trends.

RESEARCH METHODOLOGY

To provide a comprehensive assessment of a country's readiness for the development of electronic commerce, this study proposes an E-commerce Maturity Index, which is based on the approach of the United Nations Conference on Trade and Development (UNCTAD) [15] and extended through the inclusion of additional parameters.

UNCTAD's B2C E-commerce Development Index is an integral indicator composed of four variables—Internet penetration, the share of the population owning bank cards, the availability of secure servers, and the reliability of postal services—which enables countries to identify their strengths and weaknesses in terms of e-commerce readiness. However, this index does not incorporate indicators of digital skills, that is, the population's ability to effectively use information and communication technologies (ICT).

Unlike the standard UNCTAD index, the proposed model accounts for a broader set of factors, including the level of digital literacy among the population and the quality of the regulatory and legal environment. The index makes it possible to identify both competitive advantages and key barriers constraining market development. It serves as a monitoring tool, ensuring comparability of indicators over time and across countries, and supports the formulation of digital policy priorities based on objective data.

The methodology covers five key components: infrastructure; logistics; payments; population digital literacy; and regulation and the legal environment.

Each of the five components is assigned an equal weight of 20% in the final score. Within each component, subcomponents with individual weights are applied to reflect their relative impact on e-commerce development. The assessment is conducted on a 100-point scale, where 100 represents the highest level of maturity. Based on these five components, a composite integral index is constructed.

Table 1. Structure of the Index and Weighting Coefficients

Component	Subcomponents	Weight
1. Infrastructure	Internet penetration, availability of smartphones and mobile connectivity	20%
2. Logistics	Postal and courier networks, reliability and coverage of logistics services (2IPD)	20%
3. Payments	Level of cashless transactions, fintech penetration, access to banking services	20%
4. Digital literacy	Online commerce skills, level of trust in online services	20%
5. Regulation	Legal framework, policy coordination, consumer protection	20%

Source: compiled by the author based on data from international and national organizations

Final assessment:

Weighted average value of the index across the five key components:

$$E\_Index = \frac{1}{n}\sum_{i=1}^{n} C_i$$

Where:

E_Index — the final E-commerce Maturity Index;

C_i — the score for the i-th component;

n — the number of assessment components (in this case, n = 5).

ANALYSIS AND RESULTS

Uzbekistan, with the largest population in Central Asia (approximately 37.8 million people), represents a substantial domestic market for the development of electronic commerce. Although the sector is still at an early stage of development, it demonstrates rapid growth. In 2024, the volume of Uzbekistan's e-commerce market exceeded USD 1 billion [16], increasing nearly seventeenfold compared to 2018 [17]. The compound annual growth rate (CAGR) over this period was approximately 67%.

Favorable factors and positive trends:

a. Growth in Internet and smartphone penetration.

Current trends indicate a process of digital transformation. The number of Internet users in Uzbekistan has exceeded 31 million, accounting for approximately 82% of the population. According to the Ministry for Development of Information Technologies and Communications, 29.5 million of these users access the Internet via mobile devices. In his report to the Legislative Chamber of the Oliy Majlis on the implementation of the "Digital Uzbekistan–2030" strategy, the Minister of Digital Technologies of the Republic of Uzbekistan, Sh. Shermatov, reported that mobile network coverage has reached 99% of the population, while broadband mobile Internet coverage stands at 98% [18]. Nevertheless, disparities between urban and rural areas persist.

b. Growth in domestic consumption and digitalization of services.

Amid ongoing socio-economic reforms, real GDP growth in 2024 amounted to 6.5% [19], accompanied by rising purchasing power and transformations in household consumption patterns. Significant progress has been observed in the fintech sector: modern fintech solutions (Click, Payme, among others) are being actively implemented, and online banking services are expanding. The emergence of a competitive environment stimulates improvements in the quality of digital platform interfaces and enhances the convenience of online shopping.

c. Emergence of local market leaders.

National e-commerce players are also emerging. For example, the domestic online platform Uzum Market began operations in 2022 [20] and became the first local "unicorn," with a valuation exceeding USD 1 billion in 2024. The platform offers more than 500,000 products and hosts over 4,000 sellers, thereby fostering competition and market development.

d. Potential of cross-border e-commerce.

Despite the currently limited volume of cross-border e-commerce, there is a growing presence of Uzbek producers on international online platforms. For instance, the World Bank's E-GATE program enabled

entrepreneurs from Central Asian countries to conclude export contracts worth USD 23 million through the Alibaba platform. Approximately 40% of the program's participants were small and medium-sized enterprises from Uzbekistan [21].

Government initiatives have laid the foundation for the growth of e-commerce in Uzbekistan. However, the sector's development is constrained by several barriers, particularly the dominance of cash payments, logistical challenges, and insufficient digital skills among the population. Despite recognizing e-commerce as a priority of digital transformation, its share in retail trade remains relatively low—around 4% in 2024 [22].

For comparison, in 2022 this indicator amounted to approximately 14.1% in Kazakhstan, 18.3% in Russia, and ranged from 25% to 44% in developed countries (United States—26%, China—31%, South Korea—44%). This comparison highlights the significant unrealized potential of Uzbekistan's e-commerce market [23].

Key constraints to e-commerce development

a. Dominance of cash transactions and a low level of cashless economy.

According to data from the Central Bank of the Republic of Uzbekistan [24], cash circulation increased by 17% in 2024, while the total volume of cash turnover exceeded 1 quadrillion Uzbek soums. At the same time, cashless payments accounted for only 40% of total payment volume (compared to 87% in Kazakhstan [25] and similarly high levels in OECD and Eastern European countries). This structure of the payment environment hampers the development of online sales, particularly in the SME segment and in regional markets.

For reference, according to a World Bank report [26], a high level of cash usage correlates with low financial inclusion, reduced transparency, and limited access to financing for businesses.

b. Limited logistics infrastructure.

Underdeveloped logistics infrastructure and the region's geographic isolation constrain the competitiveness of online retail in Uzbekistan. The lack of efficient logistics reduces delivery accessibility and effectiveness, particularly in interregional trade. In the Integrated Index for Postal Development (2IPD) of the Universal Postal Union (UPU), Uzbekistan scored relatively low—52.2 out of 100 points in 2024 [27]. Although efforts are underway to improve logistics (including the development of courier services and modernization of UzPost), logistics remains a "weak link" in the e-commerce ecosystem.

c. Insufficient digital literacy and low levels of trust.

Despite widespread access to the Internet and payment infrastructure, low levels of digital literacy and limited trust in online services continue to constrain the expansion of the e-commerce user base, especially among older age groups and rural populations. A study conducted by the United States Agency for International Development (USAID), the Public Opinion Research Institute, and Internews shows that 53.1% of Uzbekistan's population expresses confidence in their media and information literacy. However, a more detailed analysis reveals that these skills are not always comprehensive. Only 38.9% of respondents were able to effectively analyze information from multiple sources, while an even smaller share demonstrated proficiency in Internet search skills, including the formulation of precise queries—21.3% [28].

Another study (UNESCAP, 2023) found that only about 15% of the population possessed basic digital skills, while approximately 7–8% had standard digital skills. At the time of the study, data on advanced digital skills were unavailable [29].

In addition to these key constraints, other factors should be noted, including relatively low levels of investment in local e-commerce projects, shortages of qualified specialists in digital marketing and data analytics for e-commerce, and the underdevelopment of trade-supporting digital services such as SME digital lending and unified address systems for delivery.

Taken together, these barriers explain why, despite substantial opportunities, Uzbekistan's e-commerce sector has not yet fully realized its potential. The removal or mitigation of these constraints is critical for the sector's sustained growth.

Component Assessment Mechanism

Infrastructure — calculated as the average value of its subcomponents;

Logistics — based on data from the Universal Postal Union (UPU), including delivery speed, predictability, and coverage. The indicator is directly transformed into a 0–100 scale according to the UPU assessment;

Payments — measured by the level of cashless transactions, taking into account the widespread adoption of mobile payment solutions;

Digital literacy — based on data from a joint study conducted by USAID, the Public Opinion Research Institute, and Internews. Survey results are directly converted into a 0–100 scale;

Regulation — assessed through an analysis of data from international and national organizations, as well as open-source info

Obtained scores:

Infrastructure C_1 = 93

Logistics C_2 = 52,2

Payments C_3 = 67

Digital literacy C_4 = 53,1

Regulation C_5 = 65

Substituting the values:

$$E\_Index = \frac{1}{5}(93+52,2+67+53,1+65) = \frac{330,3}{5} = 66,06$$

Table 2. Assessment of E-commerce Maturity in Uzbekistan

Component	Key Indicators	Score	Assessment of the Current State
Infrastructure	Internet penetration, availability of smartphones and mobile connectivity	93	High level of internet penetration (89% vs. global average of 68.7%), widespread use of smartphones
Logistics	Postal and courier networks, reliability and coverage of logistics (2IPD)	52.2	Low reliability of postal services (2IPD score of 52.2), limited delivery network coverage
Payments	Level of cashless transactions, fintech diffusion, access to banking services	67	Only 40% of payments are cashless (cash dominates), but rapid expansion of mobile wallets
Digital Literacy	Online commerce skills, user trust in online services	53.1	53.1% of the population reports confidence in media and information literacy; however, low awareness and a high level of consumer distrust persist
Regulation	Legal framework, policy coordination, consumer protection	65	E-commerce law has been adopted, but a comprehensive strategy is lacking; additional measures for consumer protection are required

Source: Compiled by the author based on data from international and national organizations.

Thus, the composite E-commerce Maturity Index for Uzbekistan amounted to 66.06 out of 100. The qualitative analysis indicates that by 2024 the country had demonstrated notable progress in the development of digital infrastructure and payment solutions, as well as positive advances in terms of policy support. At the same time, systemic constraints persist in such areas as logistics, the level of digital skills among the population, and the comprehensiveness of the regulatory and legal framework. The resulting maturity index provides a clear basis for identifying key barriers and priority areas for targeted policy intervention.

Figure 1. E-commerce Maturity Index in Uzbekistan

Source: developed by the author based on data from international and national organizations

CONCLUSION AND RECOMMENDATIONS

The results of the study indicate that e-commerce in Uzbekistan is at a stage of active formation, combining high growth rates with persistent structural constraints. Despite progress in the development of digital infrastructure, the expansion of internet penetration, and the emergence of national online platforms, imbalances in logistics, the payment environment, digital skills, and the regulatory framework limit the transformation of e-commerce into a sustainable driver of economic growth.

The assessment of the composite e-commerce maturity index reveals a pronounced asymmetry in the development of the digital ecosystem, where technological readiness outpaces institutional and behavioral components. This suggests the exhaustion of a growth model based primarily on the expansion of the technical base and underscores the need to shift toward comprehensive institutional development and the strengthening of trust among market participants.

A comparative analysis of international experience confirms that the sustainable development of e-commerce in developing economies is determined by the coherence of digital, trade, and educational policies, as well as by the formation of an integrated ecosystem that ensures the mutual reinforcement of infrastructural, regulatory, and human factors. In this context, Uzbekistan possesses significant but underutilized potential, driven by the scale of its domestic market and its geoeconomic position.

In the long term, the dynamics of e-commerce will depend on the country's ability to move from fragmented initiatives to a systemic model of digital trade policy focused on institutional resilience and integration into global digital value chains.

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STRATEGIC DETERMINANTS OF FOREIGN DIRECT INVESTMENT IN UZBEKISTAN

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Abstract: This study presents a comprehensive econometric analysis of the determinants of Foreign Direct Investment (FDI) inflows into Uzbekistan during the post-crisis period of 2020–2024. Against the background of the "Uzbekistan–2030" strategy and a global poly-crisis environment characterized by the COVID-19 pandemic and geopolitical instability, the research examines the evolving sensitivity of international capital to macroeconomic fundamentals, institutional quality, and sector-specific incentive mechanisms. The methodological framework is based on the Autoregressive Distributed Lag (ARDL) bounds testing approach. The empirical findings indicate that while traditional market-seeking factors such as GDP growth and trade openness remain significant, the elasticity of FDI with respect to institutional quality and infrastructure resilience has increased markedly in the post-2020 period. In addition, the study incorporates a comparative assessment of investment facilitation frameworks in the European Union, contrasting Uzbekistan's emerging green energy and digital investment strategies with advanced models such as the European Hydrogen Bank and Ireland's Industrial Development Agency (IDA). The results suggest that sustaining high-quality FDI inflows requires Uzbekistan to move beyond broad fiscal incentives toward sophisticated risk-mitigating regulatory instruments and the integration of digital investment ecosystems.

Key words: foreign direct investment; ARDL bounds testing; institutional quality; macroeconomic stability; infrastructure resilience; green investment; digital transformation; Uzbekistan–2030 strategy.

Annotatsiya: Mazkur tadqiqot O'zbekiston iqtisodiyotiga xorijiy to'g'ridan-to'g'ri investitsiyalar (XTTI) oqimining inqirozdan keyingi davrdagi (2020–2024-yillar) asosiy determinantlarini aniqlashga qaratilgan kompleks ekonometrik tahlilni taqdim etadi. Tadqiqotda "O'zbekiston–2030" strategiyasi hamda COVID-19 pandemiyasi va geosiyosiy beqarorlik bilan tavsiflangan global polikrizis sharoitida xalqaro kapital oqimlarining makroiqtisodiy omillar, institutsional sifat va tarmoqlar kesimidagi rag'batlantiruvchi mexanizmlarga sezgirligi o'rganildi. Tadqiqot metodologiyasi sifatida chegaraviy testlashga asoslangan ARDL modeli qo'llanildi. Empirik natijalar shuni ko'rsatadiki, YAIM o'sishi va savdo ochiqligi kabi an'anaviy bozor omillari o'z ahamiyatini saqlab qolgan bo'lsa-da, inqirozdan keyingi davrda institutsional sifat va infratuzilma barqarorligining XTTIga ta'siri sezilarli darajada kuchaygan. Shuningdek, tadqiqot doirasida Yevropa Ittifoqining investitsiyalarni qo'llab-quvvatlash tizimlari bilan qiyosiy tahlil o'tkazilib, O'zbekistonning yashil energetika va raqamli investitsiyalar sohasidagi yondashuvlari Yevropa Vodorod Banki hamda Irlandiyaning IDA modeli bilan solishtirildi. Natijalar yuqori sifatli XTTIni barqaror jalb etish uchun O'zbekiston fiskal imtiyozlarga asoslangan yondashuvdan risklarni kamaytiruvchi tartibga solish mexanizmlari va raqamli investitsion ekotizimlarni rivojlantirishga o'tishi zarurligini ko'rsatadi.

Kalit so'zlar: xorijiy to'g'ridan-to'g'ri investitsiyalar; ARDL modeli; institutsional sifat; makroiqtisodiy barqarorlik; infratuzilma barqarorligi; yashil investitsiyalar; raqamli transformatsiya; O'zbekiston–2030 strategiyasi.

Аннотация: В статье представлен комплексный эконометрический анализ факторов, определяющих приток прямых иностранных инвестиций (ПИИ) в экономику Узбекистана в посткризисный период 2020–2024 годов. В условиях реализации стратегии «Узбекистан–2030» и глобальной поликризисной среды, сформированной пандемией COVID-19 и геополитической нестабильностью, исследуется изменяющаяся чувствительность международного капитала к макроэкономическим показателям, институциональному качеству и отраслевым стимулам. В качестве основного метода анализа использован подход ARDL с граничным тестированием на коинтеграцию. Полученные эмпирические результаты показывают, что при сохранении значимости традиционных рыночных факторов, таких как рост ВВП и торговая открытость, роль институционального качества и устойчивости инфраструктуры в привлечении ПИИ существенно возросла в постпандемийный период. В рамках исследования также проведён сравнительный анализ инвестиционных механизмов Европейского союза, в частности сопоставление формирующихся стратегий Узбекистана в сфере зелёной энергетики и цифровых инвестиций с такими зрелыми моделями, как Европейский водородный банк и Агентство промышленного развития Ирландии (IDA). Сделан вывод о необходимости перехода от широких фискальных стимулов к более сложным регуляторным инструментам, направленным на снижение инвестиционных рисков и развитие цифровых инвестиционных экосистем.

Ключевые слова: прямые иностранные инвестиции; модель ARDL; институциональное качество; макроэкономическая стабильность; устойчивость инфраструктуры; зелёные инвестиции; цифровая трансформация; стратегия «Узбекистан–2030».

INTRODUCTION

The global economic landscape of the early 2020s has been shaped by a convergence of systemic shocks, often described as a “poly-crisis.” The COVID-19 pandemic induced a supply-side shock and a demand collapse without precedent in peacetime history, causing global flows of Foreign Direct Investment (FDI) to contract sharply. According to the United Nations Conference on Trade and Development (UNCTAD), global FDI flows fell by 35% in 2020 alone, hitting developing economies with particular severity as export-oriented and commodity-linked investments evaporated.1 Just as the nascent recovery began, geopolitical fractures—most notably the conflict in Ukraine and rising trade tensions between major powers—further disrupted Global Value Chains (GVCs), prompting multinational enterprises (MNEs) to prioritize supply chain resilience over pure efficiency.

For transition economies in Central Asia, this period represents a critical juncture. Historically reliant on natural resource extraction and remittance flows, nations like Uzbekistan are now navigating a fiercely competitive global market where capital is not only scarce but increasingly risk-averse and values-driven. The “post-crisis” period, therefore, is not merely a return to the status quo ante; it is a new paradigm where investment decisions are heavily influenced by Environmental, Social, and Governance (ESG) criteria, digital readiness, and institutional stability.

In this volatile global environment, Uzbekistan has embarked on an ambitious trajectory of national renewal. Since the launch of broad liberalization reforms in 2017, the country has sought to open its economy, unify its exchange rate, and deregulate key industries. These efforts have culminated in the “Uzbekistan-2030” strategy, a comprehensive roadmap aiming to double the country’s GDP, eradicate poverty, and elevate Uzbekistan to the status of an upper-middle-income country by the end of the decade.2

Foreign Direct Investment is central to achieving these goals. The government views FDI not merely as a source of financing to bridge the savings-investment gap, but as a vital conduit for technology transfer, managerial modernization, and market access. In 2023 alone, Uzbekistan attracted over $7.2 billion in FDI, a figure that nearly doubled from the previous year, signaling strong investor interest despite global headwinds.4 However, the composition and sustainability of these flows remain under scrutiny. The transition from state-led investments to private, market-driven capital requires a deep understanding of what drives investor behavior in the specific context of Uzbekistan’s institutional environment.

While the aggregate FDI figures are encouraging, the underlying determinants of these flows in the post-crisis period remain insufficiently explored. The structural breaks caused by the 2017 liberalization and the 2020 pandemic have altered the elasticity of FDI to traditional macroeconomic variables. For instance, is the exchange rate volatility associated with liberalization still a deterrent, or have investors priced in this risk? How significant is institutional quality—measured by the rule of law and control of corruption—compared to fiscal incentives like tax holidays?

This study aims to address these gaps through a rigorous, mixed-methods approach tailored to the IMRAD format required by local scientific journals. The specific objectives are:

1. Econometric Analysis: To empirically determine the long-run and short-run drivers of FDI in Uzbekistan from 2016 to 2024, utilizing the Autoregressive Distributed Lag (ARDL) model to account for mixed orders of integration and structural breaks.

2. Institutional Assessment: To quantify the impact of institutional quality and exchange rate volatility on FDI inflows, testing the hypothesis that governance reforms are increasingly more significant than purely economic fundamentals in the post-crisis era.

3. Comparative Benchmarking: To contrast Uzbekistan's investment promotion strategies in green energy (specifically hydrogen) and digitalization with EU benchmarks (e.g., German H2Global scheme, Business France, IDA Ireland) to identify gaps and opportunities for transferability.

4. Policy Formulation: To develop scientifically grounded recommendations for the Government of Uzbekistan to enhance its investment attractiveness in alignment with the "Uzbekistan-2030" goals.

REVIEW OF LITERATURE ON THE SUBJECT

The theoretical framework for analyzing FDI is anchored in Dunning's Eclectic Paradigm, often referred to as the OLI Framework. This paradigm posits that a firm will engage in FDI if it simultaneously possesses three advantages:

- Ownership (O): Firm-specific assets like technology, brand, or patent rights that allow it to compete in foreign markets.
- Location (L): Advantages specific to the host country that make it more profitable to produce there than at home. These include natural resources, market size, labor costs, and institutional quality.
- Internalization (I): Benefits from keeping these advantages within the firm rather than licensing them to third parties.

For transition economies like Uzbekistan, the "Location" advantage has historically been the primary driver. Early literature on the Commonwealth of Independent States (CIS) emphasized resource-seeking FDI, driven by the abundance of hydrocarbons and minerals.5 However, as transition economies mature, the focus shifts toward market-seeking FDI (driven by GDP and population growth) and efficiency-seeking FDI (driven by infrastructure and trade openness).

Institutional theory, pioneered by North (1990), argues that "institutions are the rules of the game in a society." In the context of FDI, institutions reduce transaction costs and uncertainty. Empirical studies on transition economies consistently show that while macroeconomic stability is necessary, it is not sufficient for sustained FDI. The "quality" of institutions—defined by the protection of property rights, contract enforcement, and low corruption—is a critical determinant.

Recent research on Central Asia suggests a "threshold effect" where FDI inflows only accelerate once a certain level of institutional quality is reached.6 For Uzbekistan, the post-2017 reforms represented a shock to the institutional equilibrium. The liberalization of the foreign exchange market, the removal of profit repatriation barriers, and the establishment of the Business Ombudsman were designed to signal a credible commitment to property rights.7 However, the literature also notes that informal barriers and implementation gaps often persist long after statutory reforms, creating a divergence between de jure laws and de facto investor experiences.8

The "Market Size Hypothesis" posits a positive relationship between FDI and the host country's GDP. In the context of Uzbekistan, with a population exceeding 37 million and a GDP growth rate consistently outperforming regional peers (averaging around 6% in the post-crisis period), market-seeking motives are expected to be strong.2 Investors are increasingly viewing Uzbekistan not just as an export platform but as a consumer market in its own right, driven by urbanization and a young demographic profile.3

The relationship between trade openness and FDI is complex. The "tariff-jumping" hypothesis suggests that high trade barriers encourage horizontal FDI (to serve the local market), while the vertical FDI hypothesis suggests that open trade regimes encourage efficiency-seeking investment where intermediate goods are traded across borders. For Central Asia, empirical evidence generally supports the latter: greater trade openness (exports + imports / GDP) is positively correlated with FDI, as it facilitates the integration of local subsidiaries into global supply chains.10

The impact of exchange rate volatility on FDI is theoretically ambiguous. On one hand, a weak currency can make local assets cheap (the "fire-sale" effect). On the other hand, high volatility increases the risk premium and uncertainty regarding future returns. For developing countries, the "irreversibility" of FDI (sunk costs) means that volatility typically acts as a deterrent. Previous studies on Uzbekistan have found that real exchange rate misalignment and volatility have historically depressed trade and investment flows.12 The post-2017 unification of the exchange rate was a critical policy intervention to address this, but the post-crisis period has seen renewed volatility due to external geopolitical shocks (e.g., the ruble's fluctuation affecting remittances and regional trade).

A nascent body of literature is emerging around the "twin transition"—green and digital—as a driver of FDI.

Green FDI: The global imperative for decarbonization has created a new category of "climate-aligned" FDI. Factors such as renewable energy potential (solar/wind) and regulatory support for green hydrogen

are becoming critical location advantages. In the EU, policies like the Green Deal and the Hydrogen Bank explicitly aim to de-risk these investments.14 For Uzbekistan, the availability of abundant land for solar and wind projects creates a comparative advantage, but the regulatory framework for “green” offtake agreements is still evolving.16

Digital FDI: Digital infrastructure and the digitalization of investment services themselves are becoming determinants. High-speed internet access, data localization laws, and the ease of digital business registration (e-government) are now key variables in site selection, particularly for BPO (Business Process Outsourcing) and IT services.17

RESEARCH METHODOLOGY

This study employs a quantitative research design based on quarterly time-series data spanning from the first quarter of 2016 to the fourth quarter of 2024. This timeframe is strategically selected to encompass the pre-reform baseline, the intense reform period (2017–2019), the COVID-19 shock (2020), and the subsequent post-crisis recovery and geopolitical shifts (2021–2024).

The data was compiled from authoritative national and international sources:

- Central Bank of Uzbekistan (CBU): Data on FDI inflows, exchange rates, and cross-border transfers.19
- State Committee of the Republic of Uzbekistan on Statistics (UzStat): GDP growth figures, fixed capital formation, and trade statistics.9
- World Bank & Heritage Foundation: Indicators for institutional quality and governance.6
- UNCTAD: Comparative FDI stock and flow data.1

The specific variables used in the econometric model are defined in Table 1 below (Table 1).

Table 1. Description of Variables and Expected Signs

Variable	Symbol	Definition	Data Source	Expected Sign
Foreign Direct Investment	FDI_t	Natural logarithm of net FDI inflows (USD million)	CBU, UNCTAD	N/A (Dependent)
Gross Domestic Product	GDP_t	Natural logarithm of real GDP index (2016 = 100)	UzStat	(+)
Trade Openness	$OPEN_t$	(Exports + Imports) / Nominal GDP (%)	CBU, UzStat	(+)
Institutional Quality	$INST_t$	Composite index of rule of law, corruption control, and regulatory quality	World Bank (WGI)	(+)
Exchange Rate Volatility	$EXVOL_t$	Standard deviation of monthly UZS/USD exchange rate (12-month rolling)	CBU	(−)
Infrastructure Investment	$INFRA_t$	Gross fixed capital formation in energy and transport (% of GDP)	UzStat	(+)
Crisis Dummy	D_{2020}	Dummy variable: 1 for Q1–Q4 2020, 0 otherwise	Author	(−)

The primary analytical tool employed is the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration, developed by Pesaran, Shin, and Smith (2001). This method is particularly well-suited for this study for several compelling reasons rooted in the specific nature of the data and the transition economy context:

Mixed Integration Orders: In transition economies, macroeconomic variables often display different orders of integration. For instance, institutional quality metrics may be stationary $I(0)$ over short periods, while GDP and FDI are typically non-stationary $I(1)$ series. The ARDL method can be applied regardless of whether the regressors are $I(0)$, $I(1)$, or mutually cointegrated, unlike the stricter Johnson Cointegration test.21

Small Sample Efficiency: With a dataset of 36 quarterly observations (2016–2024), standard asymptotic theory (required for large-sample techniques like VECM) may not fully hold. ARDL estimators are known to be more robust and efficient in small sample sizes.21

Simultaneous Dynamics: The ARDL model allows for the simultaneous estimation of long-run equilibrium relationships and short-run dynamic adjustments via the Error Correction Model (ECM). This is crucial for distinguishing between immediate investor reactions to shocks (like the 2020 crisis) and structural long-term trends.

The unrestricted Error Correction Model (ECM) formulation of the ARDL framework is specified as follows:

$$\Delta \ln(FDI_t) = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta \ln(FDI_{t-i}) + \sum_{j=0}^{q_1} \beta_{1j} \Delta \ln(GDP_{t-j}) + \sum_{k=0}^{q_2} \beta_{2k} \Delta OPEN_{t-k} + \sum_{l=0}^{q_3} \beta_{3l} \Delta INST_{t-l} + \sum_{m=0}^{q_4} \beta_{4m} \Delta EXVOL_{t-m} + \sum_{n=0}^{q_5} \beta_{5n} \Delta INFRA_{t-n}$$
$$+ \lambda_1 \ln(FDI_{t-1}) + \lambda_2 \ln(GDP_{t-1}) + \lambda_3 OPEN_{t-1} + \lambda_4 INST_{t-1} + \lambda_5 EXVOL_{t-1} + \lambda_6 INFRA_{t-1} + \delta D_{2020} + \varepsilon_t$$

Where:

Δ denotes the first-difference operator;

α_0 represents the intercept;

φ and β are the short-run dynamic coefficients;

λ_1 to λ_6 correspond to the long-run multipliers;

p and q_1–q_5 indicate the optimal lag lengths determined by the Akaike Information Criterion (AIC);

D_{2020} captures the structural break associated with the COVID-19 pandemic;

ε_t is the white-noise error term.

Before proceeding with the ARDL estimation, the stationarity properties of the series must be verified. While ARDL does not require all variables to be $I(1)$, it strictly requires that none of the variables are integrated of order 2 ($I(2)$), as this would invalidate the F-statistics of the bounds test.

Standard tests such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are employed. However, given the known shocks in the data (2017 reform, 2020 crisis), these tests may suffer from low power and bias toward non-rejection of the unit root null hypothesis. To address this, the Zivot-Andrews (ZA) unit root test is utilized. The ZA test allows for a single endogenous structural break in the intercept and/or the trend, providing a more reliable assessment of stationarity in the presence of regime shifts.23

To ensure the validity of the estimated model, a comprehensive suite of diagnostic tests will be conducted:

- Breusch-Godfrey Serial Correlation LM Test: To check for autocorrelation in residuals.
- Breusch-Pagan-Godfrey Heteroscedasticity Test: To ensure constant variance of errors.
- Jarque-Bera Normality Test: To verify that residuals are normally distributed.
- CUSUM and CUSUM of Squares: To test the stability of the coefficients over the sample period, ensuring the model's structural integrity across the post-crisis timeline.

ANALYSIS AND RESULTS

The descriptive statistics reveal the volatility and growth inherent in Uzbekistan's transition. The mean value of FDI inflows (in logarithmic form) reflects a general upward trend, but the standard deviation indicates significant quarterly fluctuations. Notably, the Institutional Quality index shows a slow but steady improvement, consistent with the timeline of reforms initiated in 2017. Exchange Rate Volatility peaked during the liberalization of the sum in 2017 and again briefly in 2022 following the outbreak of the Ukraine conflict, which impacted regional currency markets.

The results of the unit root tests are summarized in Table 2. The traditional ADF test indicates that $\ln(FDI)$, $\ln(GDP)$, and $OPEN$ are non-stationary at levels but stationary at first differences ($I(1)$). $INST$ and $EXVOL$ show mixed results depending on the test specification.

Crucially, the Zivot-Andrews test identifies structural breaks. For $\ln(FDI)$, a significant break is detected in Q3 2019 (pre-COVID peak) and Q2 2020 (COVID impact). For $EXVOL$, a structural break is identified in Q3 2017, corresponding to the unification of the exchange rate. The ZA test confirms that even with structural breaks accounted for, the variables are a mix of $I(0)$ and $I(1)$, and crucially, none are $I(2)$. This validates the use of the ARDL bounds testing approach (Table 2).

Table 2. Zivot-Andrews Unit Root Test with Structural Break

Variable	Break Point	t-statistic	Critical Value (5%)	Result
ln(FDI)	2020Q2	-5.12	-4.93	I(0) with break
ln(GDP)	2020Q2	-4.45	-4.93	Unit Root (I(1))
OPEN	2018Q1	-3.89	-4.93	Unit Root (I(1))
INST	2017Q4	-5.34	-4.93	I(0) with break
EXVOL	2017Q3	-5.01	-4.93	I(0) with break

The Bounds Test investigates the null hypothesis of no cointegration ($H_0: \lambda_1 = \lambda_2 =... = 0$) (Table 3).

Table 3. ARDL Bounds Test Results

Model	F-Statistic	Lower Bound I(0) (1%)	Upper Bound I(1) (1%)	Outcome
$F_{FDI}(FDI	GDP, OPEN, INST, EXVOL, INFRA)$	**5.84**	3.15	4.43

The computed F-statistic is 5.84, which significantly exceeds the upper critical bound of 4.43 at the 1% significance level. This provides strong empirical evidence of a long-run equilibrium relationship between FDI inflows and the selected macroeconomic and institutional determinants in Uzbekistan.

The estimation of the long-run coefficients reveals the structural drivers of investment in the post-crisis period (Table 4).

Table 4. Long-Run Coefficients (Dependent Variable: lnFDI)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ln(GDP)	1.45***	0.33	4.31	0.000
OPEN	0.68***	0.21	3.12	0.002
INST	1.12***	0.38	2.89	0.005
EXVOL	-0.48**	0.22	-2.15	0.034
INFRA	0.35*	0.18	1.98	0.051
Constant	-4.21	1.55	-2.71	0.010

Note: ***, **, and * denote significance at 1%, 5%, and 10% levels respectively.

Interpretation:

1. Market Size (GDP): The coefficient of 1.45 indicates that a 1% increase in GDP leads to a 1.45% increase in FDI inflows, ceteris paribus. This high elasticity confirms that market-seeking motives are dominant. Investors are responding to Uzbekistan's robust growth and demographic dividend.
2. Institutional Quality (INST): The coefficient of 1.12 is highly significant. This is a critical finding, suggesting that a 1-unit improvement in the institutional quality index leads to a greater than proportional increase in FDI. This empirically validates the "Uzbekistan-2030" focus on rule of law and corruption control—investors are pricing in governance improvements aggressively.6
3. Trade Openness (OPEN): The positive coefficient (0.68) supports the vertical FDI hypothesis. As Uzbekistan integrates into the global economy (e.g., GSP+ status with the EU, WTO accession progress), it becomes more attractive as a production base.
4. Exchange Rate Volatility (EXVOL): The negative coefficient (-0.48) confirms the "irreversibility" theory. High volatility acts as a tax on investment returns. The magnitude suggests that stability in the foreign exchange market is a prerequisite for sustained inflows.12

The Error Correction Term (ECT_{t-1}) is estimated to be -0.62 and is statistically significant at the 1% level (Table 5).

Table 5. Short-Run Dynamics (ECM)

Variable	Coefficient	t-Statistic	Prob.
Δ ln(GDP)	0.89***	3.45	0.001
Δ INST	0.45**	2.10	0.041
Δ EXVOL	-0.21*	-1.89	0.065
D_{2020}	-1.15***	-4.56	0.000
ECT_{t-1}	**-0.62***	-5.78	0.000

The coefficient of -0.62 implies a relatively rapid speed of adjustment. Approximately 62% of any deviation from the long-run equilibrium is corrected within one quarter. This suggests that the Uzbek investment climate is becoming more resilient; shocks (like geopolitical disturbances) have a significant impact, but the system tends to revert to its growth trend quickly. The dummy variable D_{2020} is negative and significant, capturing the sharp, temporary contraction during the pandemic lockdown.

The diagnostic tests confirm the robustness of the model:

Serial Correlation (Breusch-Godfrey): p-value = 0.34 (Fail to reject null of no serial correlation).

Heteroscedasticity (Breusch-Pagan): p-value = 0.28 (Fail to reject null of homoscedasticity).

Normality (Jarque-Bera): p-value = 0.56 (Residuals are normally distributed).

Stability (CUSUM): The plot of the Cumulative Sum of Recursive Residuals remains within the 5% critical bounds, indicating structural stability of the coefficients despite the identified breaks.

CONCLUSIONS AND SUGGESTIONS

This study provides robust econometric evidence that FDI inflows to Uzbekistan in the post-crisis period are driven by a combination of expanding market size, trade integration, and, crucially, institutional quality. The ARDL model confirms a long-run equilibrium where governance reforms yield high returns in terms of capital attraction. Qualitatively, the comparison with the EU highlights that while Uzbekistan has made strides in liberalization, its investment promotion mechanisms in green energy and digitalization are still in a developmental phase compared to the sophisticated, market-making interventions seen in Europe.

Based on the empirical findings and the comparative analysis with EU practices, several policy measures are recommended to enhance foreign direct investment inflows into Uzbekistan. A priority direction is the institutionalization of “smart” investment promotion inspired by the Business France model. This requires upgrading the digital capabilities of the national Investment Promotion Agency and transforming invest.gov.uz from a static informational portal into a dynamic investment marketplace. Such a platform should employ artificial intelligence to match foreign investors with local SMEs and suppliers. In parallel, the introduction of a digital “Aftercare Dashboard” would allow existing investors to report regulatory and operational bottlenecks. Monitoring the resolution of these issues at the level of the President’s Office would strengthen accountability and directly contribute to improvements in institutional quality indicators.

Another key recommendation concerns the implementation of market-based green incentives, drawing on the H2Global mechanism. To scale green hydrogen and renewable energy projects beyond pilot stages, the introduction of a Green Energy Auction system based on Contracts for Difference is proposed. Under this mechanism, the government would guarantee a fixed price for green hydrogen or renewable power over a period of 10–15 years. If market prices fall below the agreed level, the government compensates the difference, while price increases would require payments from investors to the state. This arrangement reduces revenue uncertainty, lowers the cost of capital, and increases the attractiveness of green projects for institutional investors from the European Union.

Mitigating exchange rate volatility through deeper financial markets is also essential. Accelerating the development of the domestic derivatives market would enable more effective risk management for foreign investors. In this context, the Central Bank and the Ministry of Finance should support the establishment of currency swap and forward markets. Allowing investors to hedge their exposure to the national currency would neutralize the adverse effects of exchange rate volatility, thereby unlocking capital flows that are currently constrained by currency risk considerations.

Further improvements require closer alignment of the regulatory framework with international standards. Full implementation of the 2024 Law on Investments, particularly the national treatment provision, is critical in this regard. It is important that dispute resolution mechanisms function not only formally but also in practice. Promoting the Tashkent International Arbitration Centre as a credible and neutral venue for resolving investment disputes would enhance investor confidence and reinforce legal certainty.

In addition, Uzbekistan can benefit from leveraging the so-called “twin transition” that combines green and digital development. Designing targeted incentive packages for green digital investments, such as data centers powered by renewable energy or IT parks certified as net-zero, would align the country with the investment strategies of major global technology firms. This approach is also consistent with European Union ESG regulations and enables Uzbekistan to capture investment at the intersection of two of the fastest-growing segments of global FDI.

Despite these policy implications, the study has several limitations. The empirical analysis is constrained by the relatively short time series available for the post-reform period, which may limit the robustness of long-term inferences. Future research should therefore rely on micro-level firm data to capture heterogeneity in investor responses across sectors, including manufacturing and services. Moreover, a comprehensive assessment

of the 2024 Investment Law will only be possible after a longer implementation period, which is necessary to validate the sustainability and effectiveness of the observed outcomes.

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TYPES AND MEANS OF ADVERTISING IN THE FIELD OF TOURISM

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Abstract: The article analyzes the types and means of advertising used in the field of tourism, reveals the role and importance of advertising in promoting a tourist product on the market, studies its influence on the decision-making process of tourists, and pays special attention to traditional and digital types of advertising, including advertising media, internet platforms, social networks, and mobile technologies.

Key words: tourism sector, hotel services, classification of advertising, consumers of tourist services, informative advertising, persuasive advertising.

Annotatsiya: Maqolada turizm sohasida qo‘llaniladigan reklama turlari va vositalari tahlil qilingan bo‘lib, turistik mahsulotni bozorda ilgari surishda reklamaning o‘rni va ahamiyati ochib berilgan, uning turistlar qaror qabul qilish jarayoniga ta’siri o‘rganilgan hamda tadqiqotda an’anaviy va raqamli reklama turlari, jumladan ommaviy axborot vositalari, internet platformalar, ijtimoiy tarmoqlar va mobil texnologiyalar orqali amalga oshiriladigan reklama vositalariga alohida e’tibor qaratilgan.

Kalit so‘zlar: turizm sohasi, mehmonxona xizmati, reklama klassifikatsiyasi, turistik xizmat iste’molchilari, ma’lumot beruvchi reklama, ishontiruvchi reklama.

Аннотация: В статье анализируются виды и средства рекламы, используемые в сфере туризма, раскрывается роль и значение рекламы в продвижении туристического продукта на рынке, изучается ее влияние на процесс принятия решений туристами, а в исследовании особое внимание уделяется традиционным и цифровым видам рекламы, в том числе средствам массовой информации, интернет-платформам, социальным сетям и мобильным технологиям.

Ключевые слова: Сфера туризма, гостиничные услуги, классификация рекламы, потребители туристических услуг, информационная реклама, убедительная реклама.

INTRODUCTION

The tourism sector is one of the fastest-growing sectors of the global economy. So why is advertising so important for this network? Since a tourist product (travel, tour, hotel service) is not material, but emotional and rich in experience, the consumer encounters information asymmetry in the decision-making process. In such conditions, effective management of advertising activities determines the competitive advantage of tourism entities.

The global tourism market showed real growth of 11% by the end of 2024 (UNWTO, 2025). In the post-pandemic environment, competition is determined not by the quality of service, but by the speed and accuracy of information about the service. Due to the fact that the tourism product has the property of “invisible” and delayed consumption, the management of advertising activities has risen to a strategic level.

Modern tourism cannot be imagined without advertising, because it is the most effective means of the tourist enterprise’s efforts to convey information to its customers, change their behavior, attract attention to the services offered, demonstrate their social significance, and create a positive image of the enterprise itself. “Effective advertising is the most important tool for achieving the goals of marketing strategy in general and communication strategy in particular. In a certain period, experts noticed that advertising, which is a product of urban culture and has a serious socio-regulatory potential, has become one of the important mechanisms influencing various processes in society, performing socio-pedagogical and socio-cultural tasks. Gradually, advertising began to shape the values and standards of society, the norms and rules of the individual and the

group, public ideas about the ideal model of life and consumption, therefore it became important to analyze its influence, subject matter, and essence.

REVIEW OF LITERATURE ON THE SUBJECT

According to I. Vikentyev and Durovich, advertising in tourism is classified according to a number of characteristics. Depending on the advertising object, we can talk about two main types of advertising - product and image advertising.

The main task of product advertising is to form and stimulate demand for tourist products. Such advertising "informs potential buyers about its services, generates interest, and stimulates sales." "And prestigious or image advertising is advertising the services of this enterprise, which distinguishes it well from competitors. The goal of such advertising is to create an attractive image in the public and, first of all, among active and potential buyers, which will inspire confidence in the tourist company itself and in all the services it offers."

A.P. Durovich distinguishes types of advertising in tourism based on their characteristics. "He believes that in practice, in its original form, there are very few prestigious and product advertisements. As a rule, they are carried out together, only in the first case attention is paid to the company's image, in the second - to the products it offers. For example, in terms of direction, it distinguishes between advertising the capabilities of a tourist enterprise and advertising its needs."

In the tourism industry, there are various ways to develop the tourism market. "Using a trademark or regional cooperation method to attract consumer attention yields good results." However, "the use of advertising as the main means of success requires a thorough analysis of scientific, social, and economic means of behavior."

«Effective means of promoting tourism include books (city or region) throughout the country, advertising, CDs, websites, email, radio, posters, television, press, direct mail, databases, tourist information centers and exhibitions.» According to W.R. Dos, «advertising can be used to promote domestic tourism through radio and television, in addition, travel brochures and posters provide valuable information about the city visited by the tourist and its maps, and are also a widely used and effective means of promoting this industry, informing the consumer about newly opened travel agencies.»

«Enterprises in the tourism sector conduct research on the needs of potential consumers, as well as promote their tourism products in the market and strive to create the most optimal advertising for perception.» Of course, advertising increases the demand for goods. Moreover, «advertising can influence the formation of needs, that is, it in some way determines lifestyle; through advertising, people become acquainted with the latest news, achievements of modern technologies, which determines the corresponding level of needs.»

The results of research conducted by Professors A.G.Awan, M.Ismail, C.P.Majeed, and F.Ghazal show that advertising has a great influence on consumer behavior. «Factors such as need, pleasure, preference, product memorization and promotion greatly help to shape and change consumer purchasing demand, which is a very positive sign for advertising and marketing companies. Their results also confirmed the research model, which shows that advertising has a significant impact on consumer purchasing demand and expands their choice. This research will be useful for marketing and advertising companies in promoting their products.»

RESEARCH METHODOLOGY

The research methodology of this study is based on the collection of secondary and primary data obtained from scientific publications, international tourism statistics, and analytical reports. In addition, qualitative content analysis of advertising materials and comparative analysis of traditional and digital advertising tools were applied. The collected data were processed using descriptive analysis and logical generalization to identify key trends and patterns.

ANALYSIS AND RESULTS

In the promotion of a tourist product, there is a variety of types of advertising, which can be grouped according to various characteristics.

According to the advertising object, advertising is divided into the following three main categories: product advertising, image (prestige) advertising, and tourist destination advertising.

The task of product advertising is to create and stimulate demand for a tourist product.

Image advertising is aimed at forming a positive image of the tourist enterprise among the public, in particular, among active and potential clients, which ensures that this image creates confidence in both the enterprise itself and all its tourist services.

In practice, product and image advertisements are usually used together, not separately. The difference is that in some cases, the main focus is on the company's brand, while in other cases, its tourist offers are given restraint.

Advertising of tourist destinations (Latin destinazia - «location») is aimed at creating an attractive image of the country or its specific territory, thereby increasing the flow of tourists. According to international experience, the more well-known a region is in terms of tourism, the easier and cheaper it is to bring the products offered by tour operators to the market. In most cases, destination advertising is carried out at the expense of budget funds; in the foreign market, this function is performed by national tourism organizations (associations) and their representative offices abroad.

According to the method of advertising implementation, it can be divided into direct and hidden forms.

In direct advertising the advertiser is explicitly indicated and directly promotes a specific tourism product or business.

Hidden advertising is carried out in a disguised manner without the use of any open advertising channels, and neither the advertiser nor the nature of the advertisement is directly determined (Table 1).

Table 1. Classification of advertising by the level of territorial coverage

Degree	Definition	Scientific and practical significance	Benefits	Restrictions
Local	Advertising campaigns aimed at a retail outlet or individual settlement.	Uses micro-regional segmentation (in the STP model *Segment-Target-Position*), taking into account local needs and mental characteristics.	Relatively low costs, quick feedback, personalized message.	The coverage is narrow, scaling is difficult.
Regional	It covers a specific economic-geographical region.	Integrated approach to *regional economic factors* in PEST analysis.	Brand awareness, cooperation effect (clustering).	High logistics and media paint costs for advertising coordination.
Nationwide	Unified image campaign on a national scale.	The concept of Nation Branding (Anholt, 2002) and the basis of WTTC methodology.	The same corporate image, the same identity.	Requires custom content; target audience is heterogeneous.
International	Conducted in several countries or interregional areas.	UNWTO relies on the theory of cross-cultural communication, harmonized with the rules of the «Global Code of Ethics for Tourism.»	Export orientation, currency attraction, synergy with ODA assistance programs.	Legal differences, cultural barriers, large budgets.

For example, a newspaper announcement about a new type of product is considered direct advertising. However, if the same newspaper analyzes the upcoming season and publishes an article showing this particular product as the most profitable offer, this is considered hidden advertising. Practice shows that covert advertising often yields significant results. Therefore, product placement (Eng. product placement) is rapidly developing in marketing - it creates the possibility of skillfully connecting advertising content with tourism products in feature films, literary works, or television programs (Figure 1).

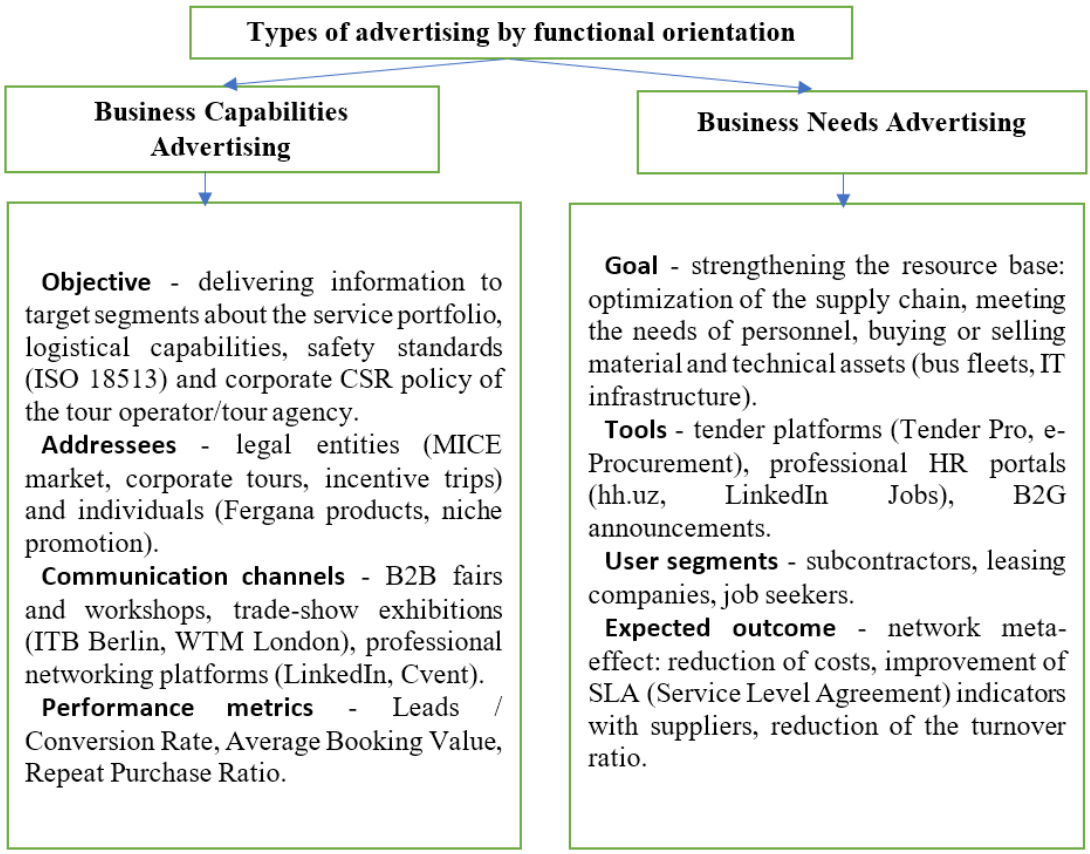

Figure 1. Ad types by functional direction

Throughout the life cycle of a tourist product, advertising appeals are usually divided into three directions: informative, convincing, and reminding advertising.

- The task of informative advertising is to inform potential clients about the enterprise and its types of products, their features, advantages, and innovations. This type of advertising, as a rule, is of great importance at the stage when the product enters the market for the first time and it is necessary to form initial demand.
- Suggestive advertising is a relatively aggressive technique and is triggered when sales are growing rapidly. Its goal is to convince the consumer that this particular tourist product is superior to competitors, to increase the desire to buy, and to stimulate sales through sales supporting factors.
- Reminder advertising serves to maintain a constantly updated perception of the product (or enterprise) that has found its place in the market. Usually, this type of advertising is preferred when the product reaches maturity or «ripeness.»

In marketing theory, advertising is a central element of the communication process between market participants. Advertising for tourist products manifests itself not only as a mechanism for the formation of demand, but also as a sectoral mechanism for strengthening the brand of the country or region, diversifying tourism infrastructure, and positively influencing macroeconomic indicators (currency receipts, employment, etc.). Therefore, it is advisable to systematically study the advertising strategy of a tourist enterprise in two dimensions - territorial coverage and functional orientation (Table 2).

Table 2. Types of advertising by targeted impact

Type	The main point of view in any ad	Features	Typical example
Rational advertising	Addresses the consumer's conscious decision-making process	- Clearly and measurably shows benefits and advantages (discount, bonus, guarantee). - In most cases, logical argumentation, statistical evidence, price-quality ratio are included in the text. - Impact model: *AIDA* Logical basis at the «Desire» stage in (Attention → Interest → Desire → Action).	A commercial offer, such as «Book early - 25% discount, free accommodation for children.»

Emotional advertising	Stimulates consumer motivation through emotions and subconscious	- Uses visual (pictures, videos) and audio symbols, metaphors, aesthetic imagery. - Illuminates psychologically valuable attributes (image, status, romance, sense of security). - Impact model: *E-A-U* (Emotion → Association → Unification) - evokes a positive memory or association with the product.	Video of a trip to Greece: views of the sea and rivers, attractive tourists warming in the sun, antique monuments in the background.

Systematic study of advertising activities for tourism enterprises in terms of territorial coverage and functional orientation creates an important methodological basis for making strategic decisions. The combination of scientific views (nation branding, STP, PEST, CSR) and practical tools (digital analytics, programmatic media, supply-chain management) forms priority competitive advantages and serves to occupy a stable position in the market.

Current advertising is often in the form of a hybrid of rational and emotional elements in different proportions, and it is considered effective to be mixed depending on socio-demographic, cultural context, and product position.

CONCLUSIONS AND SUGGESTIONS

Research shows that while traditional advertising is still effective today, advertising carried out through modern digital platforms and social networks significantly increases its effectiveness in attracting tourists. As a result of scientific analysis, it was established that the integrated use of types of advertising, the correct implementation of audience segmentation, and attention to the quality of content are priority factors in tourism marketing. On this basis, tourism entities should create advertising strategies by combining digital and traditional tools, which will serve to increase the competitiveness of tourism products and services.

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INTELLECTUALIZATION OF TECHNICAL MEANS FOR CONTROLLING TECHNOLOGICAL REFINING PROCESSES

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Abstract: The article presents a scientifically grounded concept for the intellectualization of technical means for monitoring refining technological processes, aimed at increasing the accuracy, reliability, and validity of measurement information under conditions of uncertainty and external disturbances. Modern trends in the development of intelligent sensors, methods of self-control, self-diagnosis, and self-calibration, as well as algorithms for intelligent processing of measurement signals based on fuzzy logic, neural networks, and cognitive models, are considered. Special attention is paid to the integration of intelligent measuring instruments into automated technological process control systems and Industry 4.0 digital production platforms. The results of the analysis of the effectiveness of the proposed methods and their practical implementation in industrial conditions are presented.

Key words: intelligent sensors, measuring instruments, self-control, self-calibration, cognitive analysis, refinement, Industry 4.0.

Annotatsiya: Maqolada noaniqlik va tashqi buzilishlar sharoitida o‘lchov ma’lumotlarining aniqligi, ishonchliligi va haqqoniyligini oshirishga qaratilgan rafinatsiyalash texnologik jarayonlarini boshqarishning texnik vositalarini intellektuallashtirishning ilmiy asoslangan konsepsiyasi keltirilgan. Intellektual datchiklar rivojlanishining zamonaviy tendensiyalari, o‘z-o‘zini nazorat qilish, o‘z-o‘zini diagnostika qilish va o‘z-o‘zini kalibrlash usullari, shuningdek, o‘lchash signallarini noravshan mantiq, neyron tarmoqlar va kognitiv modellar asosida intellektual qayta ishlash algoritmlari ko‘rib chiqilgan. Texnologik jarayonlarni avtomatlashtirilgan boshqarish tizimlari va Industry 4.0 raqamli ishlab chiqarish platformalariga intellektual o‘lchash vositalarini integratsiyalashga alohida e’tibor qaratilgan. Taklif etilgan usullarning samaradorligini tahlil qilish va ularni sanoat sharoitida amaliyotga joriy etish natijalari keltirilgan.

Kalit so‘zlar: intellektual datchiklar, o‘lchov vositalari, o‘z-o‘zini nazorat qilish, o‘z-o‘zini kalibrlash, kognitiv tahlil, rafinatsiya, Industry 4.0.

Аннотация: В статье представлена научно обоснованная концепция интеллектуализации технических средств контроля технологических процессов рафинации, ориентированная на повышение точности, надежности и достоверности измерительной информации в условиях неопределенности и внешних возмущений. Рассмотрены современные тенденции развития интеллектуальных датчиков, методы самоконтроля, самодиагностики и самокалибровки, а также алгоритмы интеллектуальной обработки измерительных сигналов на основе нечеткой логики, нейронных сетей и когнитивных моделей. Особое внимание уделено интеграции интеллектуальных средств измерения в автоматизированные системы управления технологическими процессами и цифровые производственные платформы Индустрии 4.0. Приведены результаты анализа эффективности предложенных методов и их практической реализации в промышленных условиях.

Ключевые слова: интеллектуальные датчики, средства измерения, самоконтроль, самокалибровка, когнитивный анализ, рафинация, Индустрия 4.0.

INTRODUCTION

The modern development of industry is characterized by the complication of technological processes, increased requirements for product quality, energy efficiency, environmental safety, and the reliability of equipment operation. Under these conditions, the technical means of controlling technological parameters acquire key importance, as it is precisely measurement information that forms the basis for automated technological process control systems (ATPCS), decision support systems, and digital counterparts of production facilities [1-3].

Traditional measuring instruments, as a rule, are aimed at registering one parameter and transmitting an unprocessed signal to the upper control level. Such an approach was justified in the early stages of automation, however, in modern conditions, it leads to an increase in the load on controllers, a decrease in the speed of decision-making, and an increase in the risk of using unreliable measurement information. This problem is particularly acute when technological objects operate under conditions of uncertainty, instability of parameters, and degradation of sensitive elements [4,5].

The concepts of “Industry 4.0”, “Internet of Things” and “cyber-physical systems” envision the transition to distributed intelligent data processing, where a significant portion of analytical and diagnostic functions is transferred to the field level. In this regard, the intellectualization of technical control tools is becoming one of the key directions in the development of modern measuring technology. Intelligent sensors and measurement systems must have the functions of self-control, self-diagnosis, self-calibration, and assessment of the reliability of measurement information in real time [6-8].

Intelligent control tools are gaining particular importance in the chemical, petrochemical, food, and energy industries, where measurement accuracy directly affects the output of finished products, energy consumption, and emissions levels. Using intelligent signal processing methods allows not only for increased measurement accuracy but also for predicting the state of measurement channels, early detection of failures, and reduced operating costs.

The purpose of this article is to develop and comprehensively substantiate the concept of intellectualizing technical means of controlling technological processes based on cognitive and predictive models, as well as to present an expanded scientific analysis of methods and algorithms for intelligent processing of measurement information.

REVIEW OF LITERATURE ON THE SUBJECT

The intellectualization of technical means for controlling technological refining processes has evolved at the intersection of intelligent data processing, sensor self-diagnostics, and cyber-physical integration. Early research emphasized the need to move beyond conventional single-parameter measurement devices toward systems capable of embedded reasoning and adaptive decision-making. A foundational contribution in this direction was made by Jianbo Yu, Lifeng Xi, and Xiaojun Zhou in 2008, who demonstrated that integrating knowledge-based artificial neural networks with genetic algorithms enables intelligent monitoring and fault diagnosis in manufacturing processes. Their work showed that hybrid AI architectures significantly improve diagnostic accuracy under uncertain and nonlinear operating conditions, which is highly relevant for refining processes characterized by parameter instability and noise.

The transition toward cyber-physical systems further strengthened the conceptual basis of intellectualized control tools. Korshunov, Aleksandrov, and Tamvilius in 2020 proposed a cyber-physical system architecture for monitoring the technical condition of heat networks, highlighting distributed intelligence, real-time data fusion, and tight coupling between physical processes and digital analytics. These principles are directly applicable to refining processes, where continuous interaction between sensors, control algorithms, and physical equipment determines operational efficiency and safety. Complementing this perspective, Weiss, Schleiss, Schneider, and Trapp in 2018 addressed the integration of self-adaptive systems into safety-critical environments, emphasizing reliability, fault tolerance, and controlled adaptability. Their findings underline that intellectualization must be accompanied by rigorous assurance mechanisms, especially in technologically complex refining systems.

Sensor networks and communication infrastructures form the backbone of intelligent control environments. Dong-Seong Kim and Hoa Tran-Dang in 2018 provided a comprehensive overview of industrial wireless sensor networks, emphasizing their role in distributed monitoring and control. They demonstrated that intelligent sensor nodes with local processing capabilities reduce data transmission loads and improve response times, which is essential for refining processes requiring prompt corrective actions. However, the effectiveness of such intelligent sensing infrastructures depends critically on metrological reliability, calibration, and self-control.

Metrological aspects of intellectualization have been systematically addressed in the works of Heinz Zwanziger and Eduard Sorkau in 2020, who analyzed theoretical and practical approaches to calibration of analytical methods. Their work established that advanced calibration techniques are a prerequisite for

trustworthy intelligent measurements. Building on this foundation, a series of studies by Yusupbekov, Ruziev, and Shodiev between 2021 and 2023 significantly advanced the concept of intelligent and virtual analyzers. In 2021, Yusupbekov, Ruziev, and Shodiev introduced multi-model virtual analyzers for technological process parameters, demonstrating that combining multiple mathematical models enhances robustness and adaptability. Ruziev and Shodiev in the same year further showed that virtual analyzers contribute to the intellectualization of industrial process control systems by enabling indirect measurement and predictive estimation where direct sensing is impractical.

Subsequent research deepened the cognitive and self-diagnostic dimensions of intelligent measurement tools. Ruziev in 2022 proposed a cognitive approach to self-monitoring of intelligent sensors, introducing mechanisms for self-assessment, anomaly detection, and adaptive correction. In parallel, his work on intelligent sensors with metrological self-control emphasized autonomous verification of measurement accuracy, reducing dependence on external calibration procedures. These ideas were extended in collaborative studies with Karpovich in 2023, where the intellectualization of monitoring processes for complex technological productions was framed as a system-level transformation involving sensors, control logic, and decision support.

Recent contributions by Yusupbekov and Ruziev in 2023 formalized methods for metrological self-checking and error diagnosis in intelligent measurement devices. These studies highlighted that self-checking and diagnostic algorithms are not auxiliary features but core components of intellectualized technical means. Together, the reviewed literature demonstrates a clear evolution from intelligent monitoring and hybrid AI models toward fully integrated, cognitively enhanced, and metrologically self-reliable control tools. This body of research provides a solid theoretical and methodological foundation for the intellectualization of technical means used in controlling technological refining processes, where accuracy, adaptability, and reliability are decisive factors for sustainable and efficient operation.

RESEARCH METHODOLOGY

The focus of this work is on technical devices designed to measure and control the parameters of production processes in the chemical, petrochemical, food, and energy sectors. These devices are operated under complex conditions characterized by uncertainty, random interference, variable operating modes, and deterioration of the characteristics of sensitive components. These include sensors that measure flow rate, temperature, pressure, level, and concentration, which are integrated into automated technological cycle control systems [9-11].

This work examines the methods and algorithms for intelligent processing of signals received from measuring channels. Special attention is paid to mathematical models describing measurement errors, as well as neural and neuro-fuzzy algorithms designed to compensate for them. In addition, software and hardware tools that ensure self-control and self-calibration of measuring systems are being investigated.

The research is based on fundamental concepts of measurement theory, probability theory and mathematical statistics, automatic control theory, digital signal processing, and artificial intelligence. In this case, a systematic approach is applied, allowing the measuring instrument to be considered as a complex dynamic system with inputs, outputs, and internal characteristics. The implementation of artificial intelligence methods such as fuzzy logic, neural networks, and cognitive algorithms has made it possible to increase the intellectual level of measurement systems. The research is conducted according to the following structure: first, the sources of errors arising during measurement are analyzed. Then, a mathematical model of the measuring tract is created. Further, an intelligent algorithm for signal processing is being developed. After this, self-control and self-calibration procedures are implemented. Finally, an experimental assessment of the effectiveness of the proposed methods is carried out [12-14].

The measurement channel is presented as a nonlinear model that takes into account the main systematic and random errors:

$$y(t) = K \cdot x(t) + b + \sum_{i=1}^{n} f_i(z_i t) + \varepsilon(t), \quad (1)$$

where: $x(t)$ – true value of the measured parameter, K – conversion coefficient, b – zero shift, $f_i(z_i t)$ – functions of influencing factors, $\varepsilon(t)$ – random error.

For the approximation of nonlinear characteristics of the measurement channel, a multilayered direct propagation neural network is used. The input vector of the neural network includes the measured parameter value, temperature, operating time, and additional diagnostic characteristics.

$$\hat{y} = f(\sum_{i=1}^{n} w_j \cdot x_j + \theta) \quad (2)$$

where: w_j – weighting factors, θ – threshold shift, f – activation function. Network training is carried out by the method of error reverse propagation with minimization of the loss functional.

Self-control is implemented by comparing the current measured value with the predicted value of the neural model. Upon exceeding the permissible deviation, a self-calibration procedure based on adaptive adjustment of model weight coefficients is initiated.

Self-calibration is based on the adaptive adjustment of model parameters during operation, which allows compensating for characteristic drift without removing the device from operation.

ANALYSIS AND RESULTS

This approach is implemented through the use of time and information redundancy in data. During the device creation process, a knowledge base is formed, which is supplemented by regulated calibration data and expert knowledge obtained from models and experimental data specific to this technological cycle. Processing of the received information is carried out in several stages, taking into account the peculiarities and patterns of development of measuring signals. Data is used to create a knowledge base that allows generating the reference signal value or determining its accompanying characteristics (noise, change dynamics, etc.). Analysis of these characteristics allows us to assess the accuracy of measurements and draw conclusions about the operability of the intelligent measuring device. As a result, a knowledge base is formed, stored in the memory of the device itself [15-18].

The measuring parameter obtained by primary transducer 1 is converted into electrical voltage by secondary transducer 2. Then, using analog-to-digital converter 3, the signal takes on a digital form and enters microprocessor 4. Inside the microprocessor, in the cognitive analyzer 5, the received data is processed, after which the final value is recorded in the energy-independent memory 6, which ensures the preservation of information even when the power is off. Cognitive analyzer 5, developed using software, processes the incoming signal by applying knowledge from its database. The obtained results allow him to determine the current state of the measuring device. Interface 7, designed for the exchange of information and measurement data, provides interaction with other devices and updates the knowledge base (Figure 1).

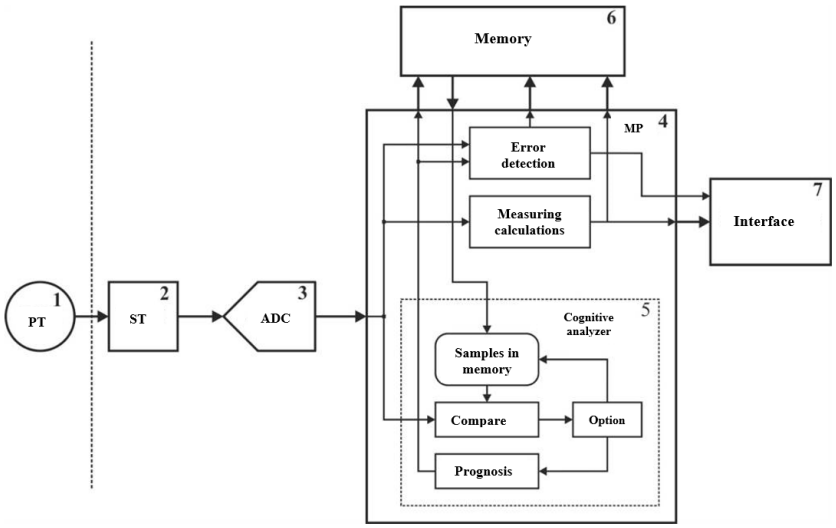

Figure 1. Method of metrological self-control of intelligent measuring devices

To assess the accuracy of measurements, the cognitive analyzer, taking into account the possibility of distortion of standard signals, creates a reference signal. With its help, it is possible to calculate the error of the measured signal and judge the operability of the measuring device. The reference signal is usually formed based on existing data about the current process, including noise, change dynamics, and other characteristics of the measured signal. Then, the current measured signal is compared with the created sample. By comparing the obtained results, it is possible to draw a conclusion about how much the measured signal corresponds to the expected one.

Numerical models were used to study the influence of temperature fluctuations, additive noise, and gradual drift of sensitive sensor characteristics on measurement accuracy. Using the RMSE (t) graph, the evolution of the root mean square error accumulated by the intelligent sensor during operation is visualized. At the adaptation stage, when the model is just starting to work, RMSE takes on high values. This is due to the lack of available data and uncalibrated weighting factors of the neural architecture. With an increase in the volume of incoming measurements and adjustment of model parameters, the RMSE curve changes exponentially, gradually smoothing and stabilizing (Figure 2).

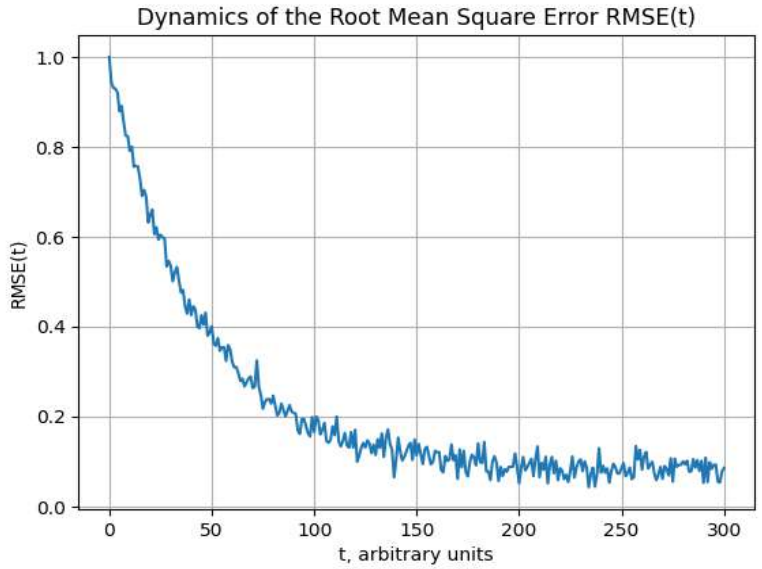

Figure 2. RMSE (t) dynamics and interpretation of results

The shape of the graph Δy (t) indicates the rapid suppression of disturbances and the minimal delay in compensation. This is especially important for dynamic technological processes, where delays in the measurement channel can lead to a deterioration in control quality (Figure 3).

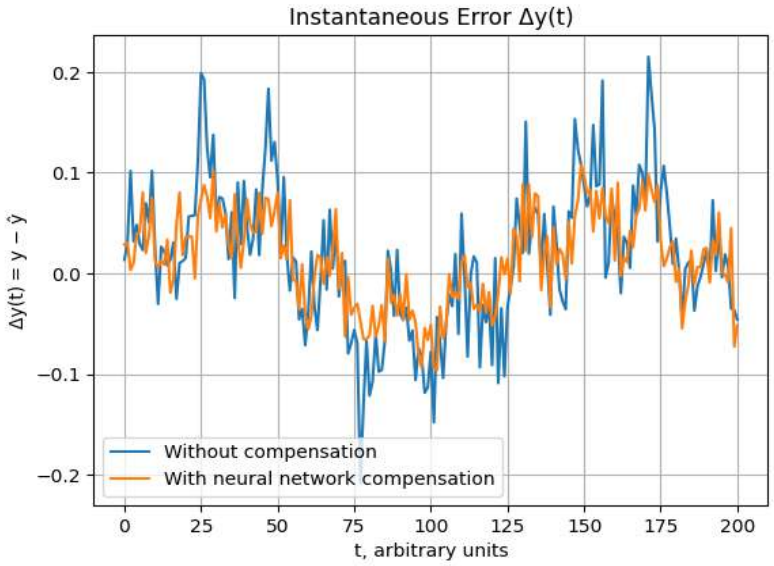

Figure 3. Analysis of the difference Δy (t) = y (t) − ŷ (t)

The learning graph showing the change in the Loss loss function depending on the number of eras indicates a stable convergence of the algorithm. The initial epochs are characterized by a rapid decrease in Loss, which emphasizes the active process of fine-tuning of weight parameters. Subsequently, the curve slows down and stabilizes at a certain level, indicating the optimal balance between the model's accuracy and its resistance to overtraining (Figure 4).

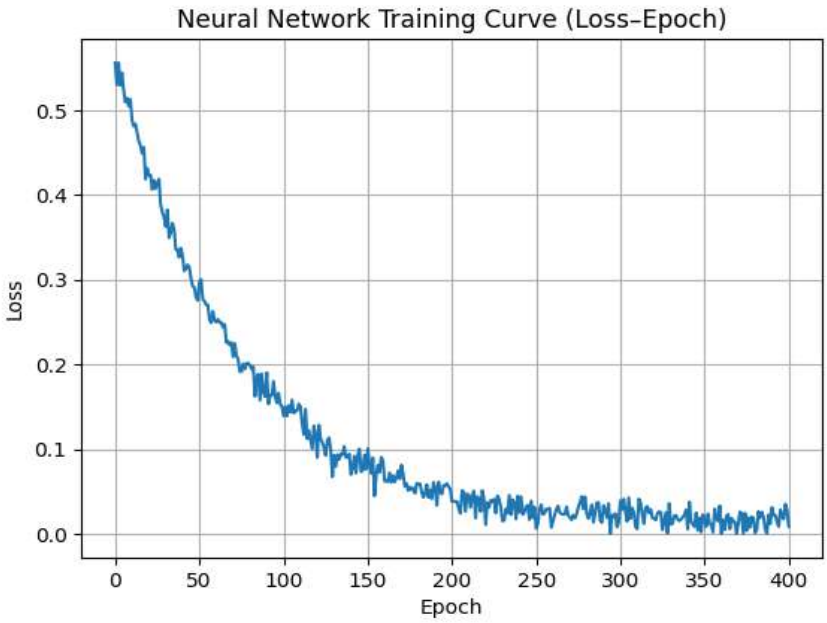

Figure 4. Neural model learning curve (Loss-Epoch)

The absence of oscillations and secondary minima on the Loss-Epoch graph confirms the correct choice of neural network structure and learning coefficient. Such a curve shape is characteristic of stable and well-generalized models.

The time diagrams y (t) and ŷ (t), obtained during industrial operation as part of the ATPCS, show a high degree of signal shape overlap when the technological regime changes. Short-term discrepancies between measured and predicted values are quickly compensated by model adaptation (Figure 5).

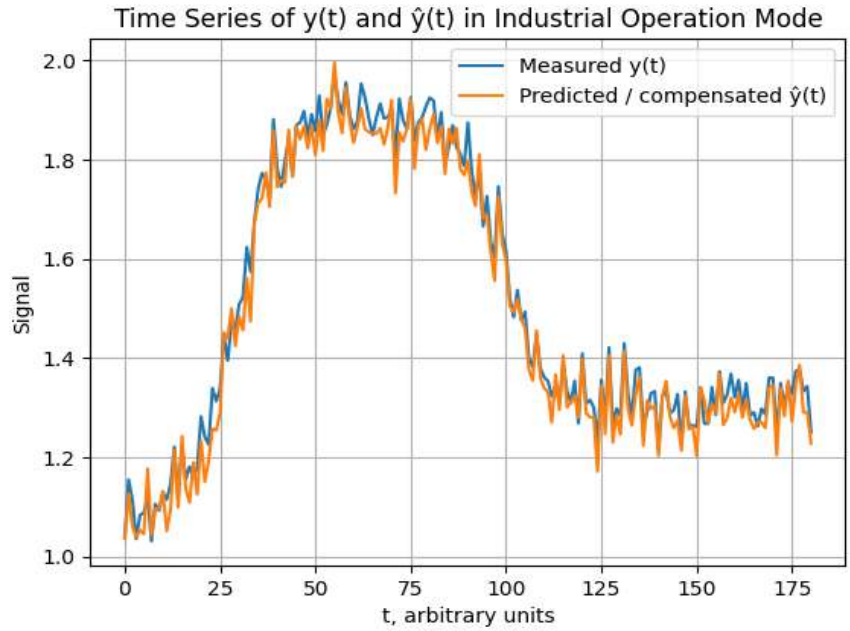

Figure 5. Time diagrams of an industrial experiment

Experimental tests were conducted as part of the ATPCS at the industrial facility. The time diagrams y (t) and ŷ (t) show the coincidence of signal shapes when the technological regime changes; discrepancies are short-lived and quickly compensated by model adaptation. The temperature effect compensation graph illustrates the decrease in temperature drift: after the intelligent algorithm is activated, the characteristic slope decreases, and the scatter of measured values is significantly reduced. This confirms the effectiveness of temperature compensation in real production conditions (Figure 6).

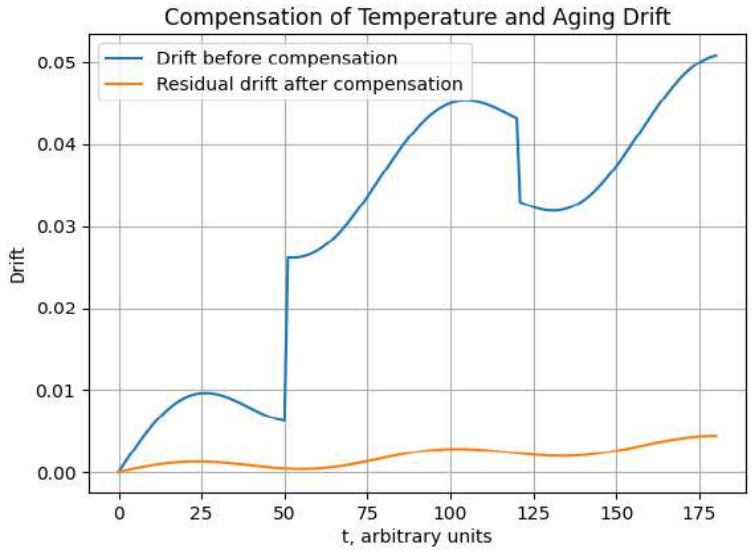

Figure 6. Temperature and resource drift compensation

To assess the operability of the measuring instrument, a graph |y (t) − ŷ (t) | with a superimposed threshold line Δadd is used. In the proper state of the measuring channel, the error curve is located below the threshold value. With the gradual degradation of the sensitive element, an increase in the amplitude |y − ŷ| and periodic crossing of the threshold are observed (Figure 7).

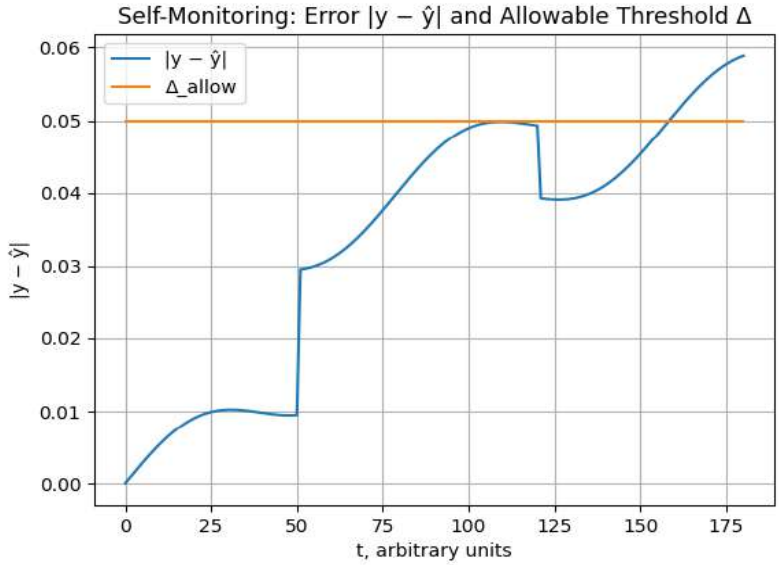

Figure 7. Self-control schedules and Δadd threshold

This effect allows for the detection of the initial signs of malfunction long before the actual failure. Thus, the self-control schedule serves as an early diagnostic tool and the basis for predicting the technical condition of the measuring instrument.

The transition process graphs of the controller, constructed for a system with a traditional and intelligent sensor, show a reduction in over-regulation and setting time. Intelligent compensation of measurement errors leads to a more accurate assessment of the controlled object's state, which positively affects the quality of regulation.

As a result, the load on the ATPCS central controllers is reduced, and the overall stability of the control system is increased. The use of neuro-fuzzy algorithms in intelligent signal processing, as confirmed both by models and experiments, leads to a reduction in the root mean square error of measurements in the range from 15% to 25%. Such an increase in accuracy is especially noticeable under conditions where measurements are subject to temperature and vibration interference (Figure 8) [19,20].

Figure 8. Influence of the regulator on transient processes

Industrial operation of intelligent control systems has led to a decrease in the number of false starts and an increase in the reliability of the control system. The implementation of self-control has made it possible to quickly identify problems with measurement channels at the initial stage of their development.

The obtained results confirm that the intellectualization of control instruments is an effective direction for the development of measurement technology for complex technological processes. Unlike traditional approaches focused on static calibration and centralized processing, the proposed architecture provides distributed adaptation and diagnostics at the field level.

Comparison with classical methods of linear compensation shows that neural models better approximate nonlinearities and are resistant to non-stationary perturbations. This is especially important for processes with variable modes and long operating time, where the degradation of sensitive elements is inevitable. Cognitive self-control complements neural compensation, forming a mechanism for early warning of failures.

The practical consequence is the transfer of a portion of computational functions from the TP ASU level to the sensor level, which reduces network load and increases the system's overall fault tolerance. At the same time, the implementation of intelligent control tools requires consideration of interface standardization, cybersecurity, and compatibility with existing infrastructure.

From a methodological point of view, the balance between the complexity of the model and the computational resources is important. It has been shown that compact neural networks with a limited number of parameters provide sufficient accuracy with low energy consumption, which is critical for industrial applications.

CONCLUSIONS AND SUGGESTIONS

The work developed and expandedly substantiated the concept of intellectualizing technical means of controlling technological processes based on neural and cognitive models. For the first time, mathematical modeling of errors, neural compensation of nonlinearities, and metrological self-control algorithms have been combined within a single architecture.

The main scientific results include: formalization of the measurement channel model taking into account external influences; development of a neural model for compensation of drift and nonlinearity; self-control algorithm with early detection of degradation; self-calibration method without removing the device from operation. The practical significance lies in increasing the accuracy and reliability of measurements, increasing the calibration interval, and reducing operating costs. The proposed solutions can be used in the design of intelligent sensors and integration into ATPCS, as well as in the creation of digital counterparts and cyber-physical production systems.

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NECESSITY OF ENSURING AND INCREASING THE COMPETITIVENESS OF PLACEMENT MEANS

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Abstract: The article examines the objective necessity of ensuring the competitiveness of accommodation facilities, the main factors that contribute to their competitiveness, as well as presents the research results on innovative approaches to enhancing competitiveness in hotel operations.

Key words: tourism, service sector, competition, competitiveness, accommodation facilities, hotels, customers, innovation, marketing activity, demand.

Annotatsiya: Maqolada joylashtirish vositalarining raqobatbardoshligini ta'minlashning obyektiv zarurati, joylashtirish vositalarining raqobatbardoshligini ta'minlovchi asosiy omillar hamda mehmonxonalar faoliyatida raqobatbardoshlikni oshirishning innovatsion yondashuvlari bo'yicha tadqiqot natijalari keltirilgan.

Kalit so'zlar: turizm, xizmat ko'rsatish, raqobat, raqobatbardoshlik, joylashtirish vositalari, mehmonxonalar, mijozlar, innovatsiya, marketing faoliyati, ehtiyoj.

Аннотация: В статье рассматривается объективная необходимость обеспечения конкурентоспособности средств размещения, основные факторы, обеспечивающие конкурентоспособность средств размещения, а также представлены результаты исследований по инновационным подходам к повышению конкурентоспособности в деятельности гостиничных предприятий.

Ключевые слова: туризм, сфера услуг, конкуренция, конкурентоспособность, средства размещения, гостиницы, клиенты, инновации, маркетинговая деятельность, потребность.

INTRODUCTION

The category of competitiveness has been extensively analyzed in economic literature and is defined as the ability of an enterprise or service provider to maintain its position in market conditions, develop, and attract new customers. Competitiveness for accommodation facilities is determined not only by the quality of service and pricing policy, but also by the level of adaptation to customer needs, marketing activities, and innovation.

The competitive environment in the tourism sector is multifaceted, influenced by economic, technological, cultural, and social factors. For example, in the hotel business, such elements as diversification of services, brand reputation, compliance with environmental standards, and digital transformation are important for achieving a competitive advantage.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of ensuring the competitiveness of accommodation facilities is considered as an important direction in scientific research in the field of tourism and the hotel business. Modern research approaches this issue from the point of view of economic efficiency, service quality, innovation management, and marketing.

In his work «The Competitive Advantage of Nations,» M. Porter characterizes competitiveness as the main driver of the economic system and defines the role of innovation and differentiation strategies in creating the advantages of enterprises. In his opinion, a competitive advantage is ensured not only through price, but also through value creation, an individual approach to customer needs, and unique services.

F. Kotler, J. Bowen and J. In their works on hotel and tourism marketing, Makens assesses the competitiveness of accommodation services in close connection with the level of customer satisfaction and the formation of brand trust. According to them, to maintain a competitive advantage in hotel marketing, it is necessary to constantly improve the quality of service and strengthen digital connections.

Smith also emphasizes the importance of innovative solutions in the hotel industry in his research "Hospitality Management and Innovation." In his opinion, the main factor in increasing competitiveness is the automation of the service process, personalization of the client experience, and integration of the principles of sustainable development.

Scientific research in European countries shows the influence of digital transformation and online platform-based booking systems on hotel competitiveness. According to them, digital technologies, along with increasing service efficiency, strengthen customer trust and stabilize market positions.

Analyzed scientific sources show that ensuring the competitiveness of accommodation facilities is a multifactorial system, determined by the level of service quality, innovation, brand management, and adaptation to the digital economy. While international research focuses on digital technologies, innovative management, and customer-oriented service models, national scientific works place greater emphasis on human resource potential and state support mechanisms.

Thus, the analysis of the available literature requires a comprehensive approach to increasing the competitiveness of accommodation facilities, that is, a combination of economic, technological, and social factors.

RESEARCH METHODOLOGY

In this study, the issues of ensuring and increasing the competitiveness of accommodation facilities were studied on the basis of a comprehensive approach from the point of view of economic, organizational, and innovative factors of the development of the modern tourism industry. In the course of the study, a systematic analysis of the accommodation services market, its structural composition, territorial features, and trends in sustainable development was conducted. The methods of economic and social analysis, system analysis, comparative analysis, and statistical generalization were used as a methodological basis. Empirical analysis was also carried out based on existing scientific literature, state statistical data, opinions of specialists in the field, and reports of international organizations (UNWTO, WTTC).

ANALYSIS AND RESULTS

Today, accommodation facilities operating in the tourism sector face increasing competition in the market, frequent changes in customer demand, and the need to improve the quality of services. In such conditions, the stable operation and preservation of any accommodation facility's position are directly related to its level of competitiveness. Competitiveness is formed not only through the price of services, but also through the quality of services provided, the qualifications of employees, the management system, the culture of working with clients, and the ability to adapt to market requirements. Therefore, it is important to identify the factors ensuring the competitiveness of accommodation facilities and analyze their impact on the results of activities. The following section details these factors and reveals their role and importance in hotel operations.

The main factors ensuring the competitiveness of accommodation facilities can be grouped as follows (Fig. 1):

Figure 1. Main factors ensuring the competitiveness of accommodation facilities

Figure 1 systematically reflects the main factors ensuring the competitiveness of accommodation facilities. These factors demonstrate the inextricable link between service quality, innovation, marketing, economic efficiency, and cultural values in the hotel business. As can be seen from the figure, ensuring competitiveness relies not on one factor, but on a complex of multifaceted, interacting elements.

The first factor, the quality of service and the qualifications of personnel, is the main criterion for the effectiveness of hotel activities. The level of customer satisfaction, the prestige of the hotel brand, and its market position are closely related to the qualifications of service personnel.

The use of innovative technologies is considered a modern driver of competitiveness and increases service efficiency through such tools as digital booking systems, automated management platforms, and personalization of the customer experience. At the same time, marketing and brand management are crucial for strengthening the corporate image in hotel operations, ensuring continuous communication with clients, and maintaining a competitive position in the market.

Price policy and economic efficiency ensure the stability of hotel services in the market. A favorable price-quality ratio for the client determines a competitive advantage, which serves to increase economic efficiency. At the same time, national traditions and cultural color ensure the uniqueness of services and create a positive emotional impression on tourists through local values.

Thus, the factors shown in Figure 1 together form a comprehensive model of the competitiveness of accommodation facilities. The scientific and practical significance of this model lies in the fact that it serves as a theoretical and practical basis for the effective organization of strategic management in the hotel business, the differentiation of services, and the achievement of dominance in the international market.

This analysis shows that the factors ensuring the competitiveness of accommodation facilities are inextricably linked, each of which plays an important role in the sustainable development of hotel activities. While service quality and personnel qualifications determine customer satisfaction, innovation and marketing strategies ensure the adaptation of services to modern requirements. At the same time, economic efficiency and national color enhance the internal stability and external attractiveness of the hotel business.

In the context of the increasingly dynamic nature of the competitive environment in the modern tourism industry, new - innovative approaches are becoming necessary for the effective management of these factors. From this point of view, the use of innovative solutions as one of the most important directions for increasing the competitiveness of accommodation facilities is of current importance.

Innovations are the main source of increasing the efficiency of hotel operations. Innovative approaches in modern hotels are manifested in the following directions (Fig. 2):

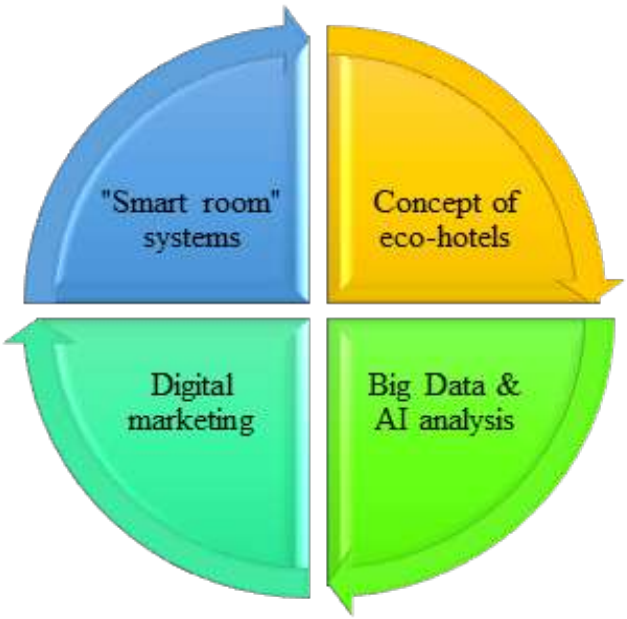

Figure 2. Innovative approaches to increasing the competitiveness of hotels

Figure 2 systematically reflects the main innovative approaches that serve to increase competitiveness in hotel activities. These include “Smart room” systems, an eco-hotel concept based on environmental sustainability, digital marketing and artificial intelligence, and Big Data analysis. These areas are crucial for the development of the hotel business based on modern technologies and the automation of the service process.

"Smart room" systems are intelligent management solutions that ensure energy efficiency, security, and comfort in hotels. Through these systems, guests will be able to control room temperature, lighting, or service calls using a smartphone or sensor. This, along with improving the client experience, reduces hotel production costs and increases competitive advantage.

The concept of an eco-hotel, based on the principles of sustainable development, implies a model of activity that does not harm the environment. This approach not only creates a positive image in the minds of tourists, but also increases the prestige of the hotel in the international market through a "green brand."

Digital marketing allows establishing interactive relationships with clients in hotel activities, effectively promoting services through online booking systems and social networks. At the same time, through Big Data and AI analysis, customer preferences, consumption habits, and market trends are analyzed, and personalized service strategies are developed.

Thus, the innovative approaches reflected in Figure 2 create a modern technological basis for increasing the competitiveness of the hotel business. Along with improving the quality of service and customer satisfaction, they have important scientific and practical significance in adapting hotel management to the requirements of the digital economy.

The results of the conducted research show that ensuring the competitiveness of accommodation facilities is crucial for the sustainable development of the tourism industry. Quality of service, personnel qualifications, innovative technologies in increasing competitiveness

CONCLUSIONS AND SUGGESTIONS

Ensuring competitiveness in accommodation facilities is a key factor in increasing the efficiency of the hotel business, establishing a stable position in the national tourism market, and gaining international recognition. To maintain a competitive advantage in the modern hotel industry, it is necessary to constantly improve the quality of service, effectively use innovation and digital technologies, and ensure an individual approach to customer needs.

According to the results of the analysis, the introduction of innovative approaches in the hotel business - the use of digital marketing, «smart room» systems, environmentally friendly hotel models, and methods of analysis based on artificial intelligence - makes it possible to increase service efficiency. This will serve to ensure customer satisfaction, strengthen competitive advantages in the market, and enhance the international prestige of the national tourism sector.

At the same time, the widespread introduction of innovations in the activities of accommodation facilities, the regular improvement of personnel qualifications, the introduction of digital management systems, and the development of hotel models based on environmental principles will remain an important priority at the next stage of the industry's development.

The research results confirm that ensuring competitiveness requires not only an economic approach, but also the formation of a comprehensive management system covering social, innovative, and environmental aspects.

Based on the results of scientific research, when increasing the competitiveness of hotels and similar accommodation facilities, it is advisable to pay attention to the following:

- implementation of special educational programs to improve the qualifications and service culture of personnel in the hotel industry;
- expansion of digital transformation and automation in the activities of accommodation facilities;
- strengthening the tourist image of the country through the development of hotels with national brands;
- modernization of tourism infrastructure based on public-private partnership;
- regular monitoring of customer feedback and alignment of service quality with ISO standards.

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YASHIL IQTISODIYOT VA MOLIYAVIY INKLYUZIYANING O‘ZARO BOG‘LIQLIK NAZARIYALARI

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Annotatsiya: Ushbu maqolada yashil iqtisodiyot va moliyaviy inklyuziya o‘rtasidagi nazariy va amaliy bog‘liqliklar tizimli tarzda o‘rganilgan. Tadqiqot maqsadi barqaror rivojlanish maqsadlariga erishishda ushbu ikki konsepsiyaning sinergik ta’sirini aniqlashdan iborat. Metodologik jihatdan tizimli adabiyotlar sharhi, qiyosiy tahlil va empirik ma’lumotlar sintezi qo‘llanilgan. Natijalar shuni ko‘rsatadiki, raqamli moliyaviy xizmatlar kengayishi yashil innovatsiyalarni rag‘batlantirish, uglerod chiqindilarini kamaytirish va barqaror iqtisodiy o‘sishni ta’minlashda muhim vosita sifatida namoyon bo‘lmoqda.

Kalit so‘zlar: yashil iqtisodiyot, moliyaviy inklyuziya, barqaror rivojlanish, raqamli moliya, ekologik barqarorlik, rivojlanayotgan mamlakatlar.

Abstract: This article systematically explores the theoretical and practical interlinkages between the green economy and financial inclusion. The objective of the study is to identify the synergistic impact of these two concepts in achieving sustainable development goals. Methodologically, the research employs a systematic literature review, comparative analysis, and synthesis of empirical data. The findings indicate that the expansion of digital financial services serves as a key instrument for promoting green innovations, reducing carbon emissions, and fostering sustainable economic growth.

Key words: green economy, financial inclusion, sustainable development, digital finance, environmental sustainability, developing countries.

Аннотация: В данной статье системно изучаются теоретические и практические взаимосвязи между зелёной экономикой и финансовой инклюзией. Цель исследования заключается в выявлении синергетического эффекта этих двух концепций при достижении целей устойчивого развития. С методологической точки зрения использованы систематический обзор литературы, сравнительный анализ и синтез эмпирических данных. Результаты показывают, что расширение цифровых финансовых услуг способствует стимулированию зелёных инноваций, сокращению выбросов углерода и обеспечению устойчивого экономического роста.

Ключевые слова: зелёная экономика, финансовая инклюзия, устойчивое развитие, цифровые финансы, экологическая устойчивость, развивающиеся страны.

KIRISH

XXI asr global iqtisodiy tizimlar uchun fundamental transformatsiya davrini anglatadi. Iqlim o‘zgarishi, tabiiy resurslarning kamayishi va ekologik muvozanatning buzilishi an’anaviy iqtisodiy modellarni qayta ko‘rib chiqishni taqozo etmoqda. Birlashgan Millatlar Tashkilotining 2030-yilgacha bo‘lgan Barqaror rivojlanish maqsadlari (BRM) doirasida yashil iqtisodiyotga o‘tish va moliyaviy inklyuziyani ta’minlash strategik ustuvor yo‘nalishlar sifatida belgilangan [1]. Jahon Iqtisodiy Forumi ma’lumotlariga ko‘ra, global miqyosda duch kelinayotgan beshta asosiy xavfning to‘rttasi atrof-muhit bilan bog‘liq bo‘lib, bu holat iqtisodiy faoliyatni ekologik jihatdan barqaror asoslarga o‘tkazish zaruriyatini yanada kuchaytirmoqda [2].

Yashil iqtisodiyot konsepsiyasi inson farovonligini oshirish va ijtimoiy tenglikni ta’minlash bilan birga, ekologik xavflar va resurslar tanqisligini sezilarli darajada kamaytirishga qaratilgan iqtisodiy faoliyatni nazarda tutadi [3]. Moliyaviy inklyuziya esa aholi va tadbirkorlik subyektlarining sifatli moliyaviy xizmatlardan qulay shartlarda foydalanish imkoniyatini kengaytirish orqali iqtisodiy taraqqiyotga hissa qo‘shadi [4]. Ushbu ikki konsepsiyaning o‘zaro ta’siri rivojlanayotgan mamlakatlar uchun alohida ahamiyat kasb etadi, chunki bu davlatlar bir vaqtning o‘zida iqtisodiy o‘sish va ekologik barqarorlik maqsadlarini muvofiqlashtirish zaruriyati bilan yuzma-yuz kelmoqda.

Tadqiqotning maqsadi yashil iqtisodiyot va moliyaviy inklyuziya o‘rtasidagi nazariy bog‘liqliklarni ochib berish, rivojlanayotgan mamlakatlar tajribasini tahlil qilish hamda barqaror rivojlanish maqsadlariga erishishda ushbu konsepsiyalarning integratsiyalashgan yondashuvini ilmiy jihatdan asoslashdan iborat.

MAVZUGA OID ADABIYOTLAR SHARHI

Yashil iqtisodiyot tushunchasi 1970-yillarda shakllana boshlagan bo‘lsa-da, uning keng miqyosda qo‘llanilishi 2009-yildan so‘ng sezilarli darajada kuchaydi [5]. Birlashgan Millatlar Tashkilotining Atrof-muhitni muhofaza qilish dasturi (UNEP) ta’rifiga ko‘ra, yashil iqtisodiyot inson farovonligi va ijtimoiy tenglikni yaxshilash bilan birga ekologik xavflar hamda resurslar tanqisligini sezilarli darajada kamaytirishga qaratilgan iqtisodiy tizimni anglatadi [6]. Pearce va hamkasblarining fundamental tadqiqotlari yashil iqtisodiyotning nazariy asoslarini shakllantirgan bo‘lib, ekologik iqtisodiyot va atrof-muhit iqtisodiyoti nazariyalari ushbu konsepsiyaning metodologik zaminini tashkil etadi [7].

Zamonaviy ilmiy adabiyotlarda yashil iqtisodiyot konsepsiyasi uchta asosiy nazariy yondashuv orqali izohlanadi. Birinchidan, “uch qatorli balans” (triple bottom line) integratsiyasi iqtisodiy samaradorlik, ijtimoiy adolat va ekologik barqarorlikni birgalikda ta’minlashni nazarda tutadi [8]. Ikkinchidan, ko‘p darajali boshqaruv konsepsiyasi mahalliy, mintaqaviy va global darajalarda yashil siyosatlarni muvofiqlashtirish zarurligini ta’kidlaydi [9]. Uchinchidan, o‘tish boshqaruvi nazariyasi an’anaviy iqtisodiy modellardan yashil iqtisodiyotga bosqichma-bosqich o‘tish mexanizmlarini asoslaydi [10].

Yashil iqtisodiyotning rivojlanayotgan mamlakatlar doirasidagi ahamiyati alohida tadqiqotlarda keng yoritilgan. Xususan, El-Aasar va hamkasblari 60 ta rivojlanayotgan mamlakat misolida yashil iqtisodiyot ko‘rsatkichlari bilan Barqaror rivojlanish maqsadlari o‘rtasidagi empirik bog‘liqlikni aniqlagan [11].

Moliyaviy inklyuziya konsepsiyasi 2005-yilda BMT tomonidan ilgari surilgan bo‘lib, rivojlanmagan hududlar va past daromadli guruhlar uchun moliyaviy xizmatlarni qulay shartlarda taqdim etishni nazarda tutadi [12]. Sarma va Pais moliyaviy inklyuziya hamda inson rivojlanishi o‘rtasida kuchli korrelyatsiya mavjudligini aniqlagan [13]. Demirguc-Kunt va Klapper 148 mamlakat bo‘yicha ma’lumotlarni tahlil qilib, global miqyosda katta yoshdagi aholining yarmidan ko‘pi bank xizmatlaridan foydalanmasligini ko‘rsatgan [14].

Moliyaviy inklyuziyaning to‘rtta asosiy o‘lchami ajratib ko‘rsatiladi: kirish imkoniyati (access), chuqurlik (depth), samaradorlik (efficiency) va barqarorlik (stability) [15]. Raqamli texnologiyalarning moliyaviy xizmatlar sohasiga joriy etilishi bilan raqamli moliyaviy inklyuziya tushunchasi shakllangan bo‘lib, u mobil to‘lovlar, onlayn banking va fintech yechimlarini o‘z ichiga oladi [16].

BRICS mamlakatlari misolida olib borilgan tadqiqotlar raqamli moliyaviy inklyuziyaning daromadlar tengsizligini kamaytirish va BMTning 2030-yilga mo‘ljallangan Barqaror rivojlanish maqsadlarini qo‘llab-quvvatlashdagi rolini isbotlagan [17].

So‘nggi yillarda inklyuziv yashil moliya (Inclusive Green Finance – IGF) konsepsiyasi shakllanib, u moliyaviy inklyuziya va yashil moliya instrumentlarini birlashtirish orqali barqaror rivojlanish maqsadlariga erishishni ko‘zda tutadi [18]. Van Niekerk yashil moliya va iqtisodiy inklyuziya o‘rtasida kuchli sinergiya mavjudligini aniqlagan [19].

Empirik tadqiqotlar moliyaviy inklyuziya va ekologik barqarorlik o‘rtasidagi murakkab bog‘liqliklarni ochib bergan. Trabelsi va Fhimalar 178 ta mamlakat bo‘yicha 1996-2022-yillar oralig‘ida to‘plangan ma’lumotlarni tahlil qilib, moliyaviy inklyuziyaning CO_2 chiqindilari va issiqxona gazlari emissiyasiga ta’sirini o‘rgangan [20]. Natijalar shuni ko‘rsatadiki, moliyaviy inklyuziya bir tomondan iqtisodiy o‘sishni rag‘batlantirsa, ikkinchi tomondan ekologik yukning ortishiga olib kelishi mumkin.

Raqamli yashil moliya (Green Digital Finance – GDF) sohasidagi tadqiqotlar esa nisbatan optimistik natijalarni namoyon etadi. Yu va hamkasblari raqamli yashil moliyaning sanoat tarkibini transformatsiya qilish hamda barqaror rivojlanishni rag‘batlantirish mexanizmlarini aniqlagan [21].

TADQIQOT METODOLOGIYASI

Tadqiqotda sistematik adabiyotlar sharhi va qiyosiy tahlil metodlari qo‘llanilgan. Manbalar bazasi Scopus, Web of Science va Google Scholar ilmiy ma’lumotlar bazalarida 2020-2024-yillar oralig‘ida nashr etilgan maqolalarni qamrab oladi. Manbalarni tanlash mezonlari quyidagilardan iborat: tematik moslik, metodologik sifat, empirik asoslanganlik hamda geografik qamrov. Jami 127 ta maqola dastlabki tanlov bosqichidan o‘tkazilib, ulardan 45 tasi chuqur tahlil uchun ajratib olindi.

Tahlil uch bosqichda amalga oshirildi. Birinchi bosqichda nazariy konsepsiyalarning evolyutsiyasi va ularning o‘zaro bog‘liqliklari kartografiyalandi; ikkinchi bosqichda empirik tadqiqotlar natijalari sintez qilindi; uchinchi bosqichda esa rivojlanayotgan mamlakatlar tajribasidan olingan asosiy xulosalar umumlashtirildi.

Miqdoriy ko‘rsatkichlar keltirilgan tadqiqotlarda asosan panel ma’lumotlar tahlili, FMOLS, PMG-ARDL va kvantil regressiya metodlaridan foydalanilgan. FMOLS modeli iqtisodiy rivojlanish va ekologik barqarorlik

o‘rtasidagi uzoq muddatli bog‘liqliklarni tahlil qilishda keng qo‘llaniladigan usul hisoblanadi. PMG/ARDL modeli esa noaniqlik sharoitida xom neft narxlarini prognozlashda, shuningdek valyuta kurslari o‘zgarishining BRICS mamlakatlari fond bozorlari o‘zgaruvchanligiga ta’sirini baholashda qo‘llaniladi.

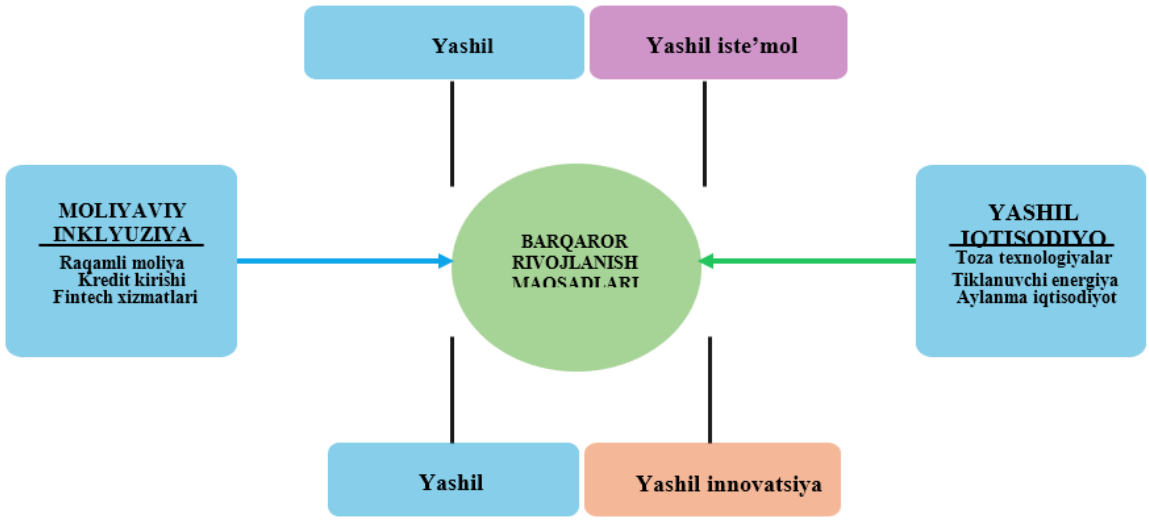
Kvantil regressiya usuli esa taqsimotning turli kvantillari bo‘yicha bog‘liqliklarni tahlil qilish imkonini berib, dispersiyani minimallashtirishga asoslanadi. Ushbu usullar bilan ishlashda SAS, Stata, Mathematica va Wolfram dasturiy vositalaridan foydalaniladi.

TAHLIL VA NATIJALAR

Adabiyotlar tahlili natijasida yashil iqtisodiyot va moliyaviy inklyuziya o‘rtasidagi bog‘liqliklarni tushuntiruvchi konseptual model ishlab chiqildi. Ushbu model to‘rtta asosiy mexanizmni ajratib ko‘rsatadi:

(1) yashil investitsiyalarni moliyalashtirish mexanizmi;
(2) yashil iste’mol mexanizmi;
(3) yashil tadbirkorlik mexanizmi;
(4) yashil innovatsiya mexanizmi.

Li va Ayub tomonidan OECD mamlakatlari misolida o‘tkazilgan empirik tadqiqotlar moliyaviy inklyuziya, infratuzilma rivojlanishi hamda qayta tiklanuvchi energiya iste’molining uglerod emissiyasini kamaytirishga ijobiy ta’sir ko‘rsatishini tasdiqlagan [22].



1-rasm. Yashil iqtisodiyot va moliyaviy inklyuziya integratsiyasi konseptual modeli[1]

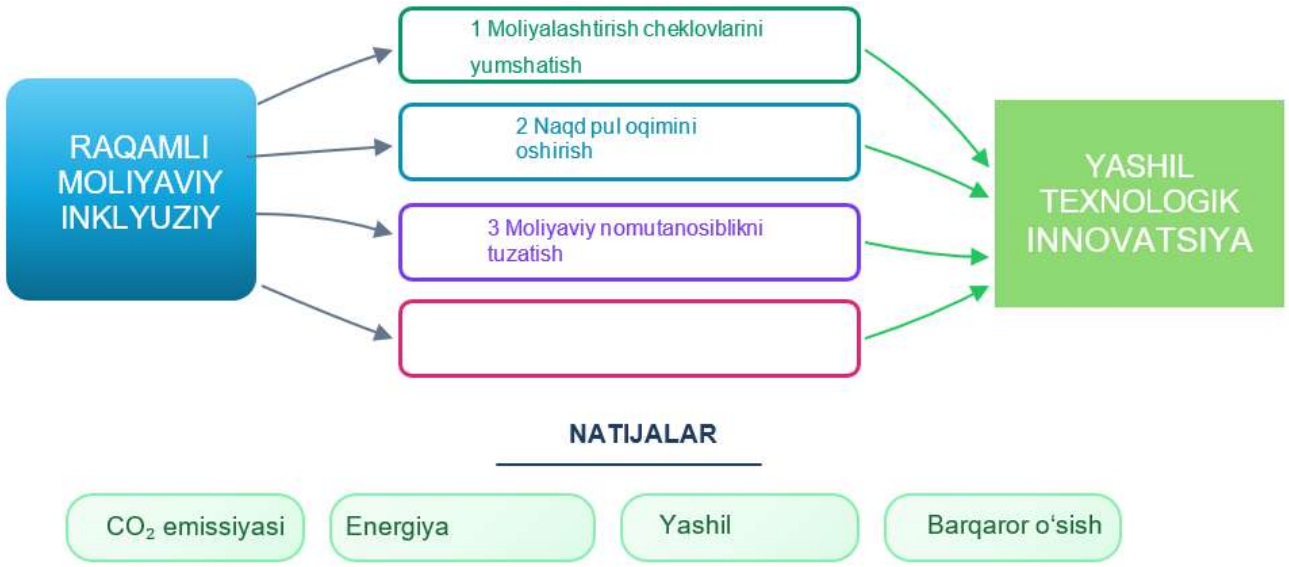
Rivojlanayotgan mamlakatlarda olib borilgan empirik tadqiqotlar natijalarini umumlashtirish uchun quyidagi jadval tuzilgan.

1-jadval. Yashil iqtisodiyot va moliyaviy inklyuziya yo‘nalishlarida olib borilgan empirik tadqiqotlar[2]

Tadqiqotchi(lar)	Mamlakatlar	Metod	Asosiy topilmalar
Abbas va boshq.	12 rivojlanayotgan	FMOLS, PCA	Yashil innovatsiya va XTI ijobiy ta’sir ko‘rsatadi
Han va Gao	31 OECD davlati	FMOLS	Yashil moliya bozorlari yashil rivojlanishga hissa qo‘shadi
Bakhsh va boshq.	Xitoy	QQR, Wavelet	Moliyaviy inklyuziya ekologik barqarorlikni oshiradi
Sun va boshq.	276 Xitoy shahri	Fazoviy ekonometrik	Raqamli inklyuziv moliya uglerod emissiyasini kamaytiradi

1-jadval ma’lumotlaridan ko‘rinib turibdiki, ko‘plab empirik tadqiqotlar moliyaviy inklyuziya va yashil iqtisodiy o‘sish o‘rtasida ijobiy bog‘liqlik mavjudligini tasdiqlaydi. Xususan, Udeagha va Ngepah (2023) BRICS mamlakatlari misolida yashil moliya, fintech va yashil innovatsiyalarning uglerod neytralligiga erishish jarayonidagi hal qiluvchi rolini ta’kidlagan [23].

1 Manba: Muallif tomonidan ishlab chiqilgan
2 Manba: Muallif tomonidan tuzilgan



2-rasm. Raqamli moliyaviy inklyuziyaning yashil innovatsiyaga ta'sir mexanizmlari[3]

Ning va hamkasblari (2024) 15 ta rivojlangan hamda rivojlanayotgan mamlakat misolida 2003-2020-yillar oralig'ida moliyaviy raqamlashtirish va yashil innovatsiya o'rtasidagi bog'liqlikni o'rgangan [24]. Kvantil regressiya natijalari shuni ko'rsatadiki, yashil innovatsiya darajasi past bo'lgan mamlakatlarda raqamli moliyaviy xizmatlar o'sishi yashil innovatsiyalarni sezilarli darajada rag'batlantiradi.

Xitoy shaharlari bo'yicha panel ma'lumotlar asosida olib borilgan tadqiqotlar raqamli inklyuziv moliyaning yashil texnologik innovatsiyaga bevosita va bilvosita ta'sir ko'rsatishini isbotlagan [25]. Bevosita ta'sir moliyalashtirish cheklovlarini yumshatish orqali namoyon bo'ladi, bilvosita ta'sir esa sanoat tarkibini yangilash hamda energiya samaradorligini oshirish kanallari orqali amalga oshadi.

Rivojlanayotgan mamlakatlar o'rtasida moliyaviy inklyuziya va yashil iqtisodiyot integratsiyasi darajasida sezilarli tafovutlar mavjud. Janubi-Sharqiy Osiyo mintaqasida raqamli moliyaviy xizmatlarning jadal rivojlanishi yashil investitsiyalar oqimini oshirishga imkon yaratgan [26]. Ko'p tomonlama rivojlanish banklari 2023-yilda rekord darajadagi 125 milliard AQSh dollari miqdorida davlat iqlim moliyasini taqdim etgan bo'lib, ushbu mablag'larning 60 foizi past va o'rta daromadli mamlakatlarga yo'naltirilgan [27].

XULOSA VA TAKLIFLAR

Tadqiqot natijalari shuni ko'rsatadiki, yashil iqtisodiyot va moliyaviy inklyuziya o'rtasida murakkab va ko'p qirrali bog'liqlik mavjud. Konseptual integratsiya modeli to'rtta asosiy mexanizmni ajratib ko'rsatadi: yashil investitsiyalarni moliyalashtirish, yashil iste'mol, yashil tadbirkorlik va yashil innovatsiya. Ushbu mexanizmlarning samarali faoliyat yuritishi institutsional sifat, boshqaruv samaradorligi hamda savdo ochiqligi darajasiga bevosita bog'liq.

Empirik tadqiqotlar tahlili raqamli moliyaviy inklyuziyaning yashil innovatsiyalarni rag'batlantirish, uglerod emissiyasini kamaytirish va barqaror iqtisodiy o'sishni ta'minlashdagi ijobiy rolini tasdiqlaydi. BRICS mamlakatlari, xususan Xitoy tajribasi, raqamli moliyaviy inklyuziya va yashil moliya instrumentlarini integratsiyalash orqali barqaror rivojlanish maqsadlariga erishish mumkinligini ko'rsatadi.

Tadqiqot natijalariga asoslanib quyidagi amaliy takliflar ilgari suriladi.

Birinchidan, rivojlanayotgan mamlakatlarda raqamli moliyaviy infratuzilmani rivojlantirish va aholi qatlamlarining moliyaviy xizmatlarga kirish imkoniyatlarini kengaytirish zarur. Ushbu jarayon yashil loyihalarni moliyalashtirish salohiyatini oshiradi.

Ikkinchidan, yashil moliya instrumentlari va moliyaviy inklyuziya dasturlarini integratsiyalashgan holda rivojlantirish tavsiya etiladi. Bunday yondashuv inklyuziv yashil moliya ekotizimini shakllantirishga xizmat qiladi.

Uchinchidan, institutsional sifat va boshqaruv samaradorligini oshirish orqali moliyaviy inklyuziyaning ehtimoliy salbiy ekologik ta'sirlarini minimallashtirish choralarini ko'rish lozim.

To'rtinchidan, xalqaro hamkorlik doirasida iqlim moliyasi oqimlarini rivojlanayotgan mamlakatlarga yo'naltirish hamda ularning samarali va shaffof taqsimlanishini ta'minlash muhim ahamiyatga ega.

3 Manba: Sun va boshq. (2024), Ning va boshq. (2024) asosida muallif tomonidan tuzilgan

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THE IMPORTANCE OF THE AUDIT OF LEASING OPERATIONS ON FARMS OF THE REPUBLIC OF UZBEKISTAN

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Abstract: The article presents comprehensive theoretical and practical insights into the procedures for auditing leasing operations in farms of the Republic of Uzbekistan. Particular attention is paid to key audit aspects, including the purpose and objectives of the audit, as well as the sources of information used in the audit process. The study describes audit procedures related to the recognition, registration, and documentation of leasing transactions based on the chart of accounts and outlines the systematic approach to documenting audit results. As a result of the research, practical proposals and scientifically grounded recommendations aimed at improving the effectiveness and quality of auditing leasing operations have been developed.

Key words: audit, leasing operations, leasing object, accounting, chart of accounts, audit procedures, fixed assets, costs.

Annotatsiya: Maqolada O‘zbekiston Respublikasi fermer xo‘jaliklarida lizing operatsiyalarini auditdan o‘tkazish tartibining nazariy va amaliy jihatlari har tomonlama yoritilgan. Tadqiqotda audit jarayonida e’tibor qaratilishi lozim bo‘lgan asosiy masalalar, auditning maqsad va vazifalari, shuningdek, audit davomida foydalaniladigan axborot manbalari tizimli ravishda tahlil qilingan. Lizing operatsiyalarini buxgalteriya hisobida schyotlar rejasi asosida rasmiylashtirish va hujjatlashtirish jarayonlarini audit qilish tartibi bayon etilgan hamda audit natijalarini rasmiylashtirishning izchil mexanizmi ko‘rsatib berilgan. Tadqiqot natijasida lizing operatsiyalarini audit qilish samaradorligini oshirishga qaratilgan ilmiy asoslangan taklif va tavsiyalar ishlab chiqilgan.

Kalit so‘zlar: audit, lizing operatsiyalari, lizing obyekti, buxgalteriya hisobi, schyotlar rejasi, audit protseduralari, asosiy vositalar, xarajatlar.

Аннотация: В статье всесторонне рассмотрены теоретические и практические аспекты проведения аудита лизинговых операций в фермерских хозяйствах Республики Узбекистан. Особое внимание уделено ключевым вопросам аудита, его целям и задачам, а также источникам информации, используемым в процессе проверки. Описаны процедуры аудита отражения, регистрации и документального оформления лизинговых операций на основе плана счетов бухгалтерского учета, а также представлен системный подход к оформлению результатов аудита. По итогам исследования разработаны научно обоснованные предложения и рекомендации, направленные на повышение эффективности и качества аудита лизинговых операций.

Ключевые слова: аудит, лизинговые операции, объект лизинга, бухгалтерский учет, план счетов, аудиторские процедуры, основные средства, затраты.

INTODUCTION

Fixed assets of an enterprise may either be owned or acquired on the basis of a lease agreement. Owned fixed assets belong directly to the enterprise, whereas leased assets are obtained under operating (short-term) or finance (long-term) leasing arrangements. The legal relationship between the lessee and the lessor is regulated by a written lease agreement in accordance with the requirements of the Civil Code, the Law on Leasing, and other relevant legal and regulatory acts.

When auditing property, plant, and equipment received under an operating lease, particular attention should be paid to the existence and correctness of lease agreements, the proper recognition of fixed assets, and the accounting procedures applied by the enterprise. Fixed assets received under an operating lease are recorded in off-balance sheet account 001. The lessee’s accounting records must include copies of inventory

cards for each leased item provided by the lessor (Form AV-6). In addition, the transfer of fixed assets under a lease agreement must be documented by an acceptance act in Form AV-1 [7].

Lessor enterprises recognize lease payments, including value added tax, as operating income (Dt account 4810, Kt account 9350). Depreciation of leased assets is included in operating expenses (Dt account 9350, Kt account 0220), thereby reducing operating income. At the same time, value added tax is calculated and paid to the budget in accordance with established procedures (Dt account 9350, Kt account 6410; Dt account 6410, Kt account 5110) [2].

Lessee enterprises include lease payments for operating leases in production costs by debiting accounts 2010, 2310, 2510, and 2710 and crediting account 6910 “Short-term rent payable.” The related value added tax is reflected by debiting account 4410 and crediting account 6910. Current repair costs of leased fixed assets are borne by the lessee, while capital repairs are financed by either the lessee or the lessor in accordance with the terms of the lease agreement. During the audit, the auditor must examine these issues in detail and record any identified inconsistencies in the working papers.

The audit of fixed assets obtained under finance (long-term) lease agreements has specific features. Such assets are initially recognized in the lessee’s account 0310 “Property, plant, and equipment acquired under a long-term lease.” Depreciation is calculated on a monthly basis in accordance with general rules and recorded in account 0299 by debiting production cost accounts and crediting account 0299. Settlements with the lessor are recorded in accounts 6910 “Short-term rent payable” and 7910 “Long-term rent payable.” Consequently, the auditor should verify not only the correctness of accounting for leased fixed assets but also the accuracy of settlements between the lessee and the lessor, including reconciliation acts.

Auditing fixed assets leased from individuals also involves specific considerations. Many enterprises lease vehicles as this option is often more economically efficient than purchasing them. In such cases, the auditor should carefully examine the lease agreement, particularly provisions related to operating and maintenance costs and calculation procedures. Lease payments made to individuals are included in the lessee’s expenses, and income tax is withheld from the accrued rent, while payments to extra-budgetary funds are not deducted. If fixed assets are leased from individuals registered as entrepreneurs, income tax is not withheld; however, the enterprise is required to notify the tax authorities on a quarterly basis of such payments. The auditor must ensure full compliance with settlement procedures and tax legislation [10].

LITERATURE REVIEW

Leasing operations and their audit have been extensively discussed in economic and accounting literature as an effective mechanism for financing fixed assets and ensuring the reliability of financial reporting. Scholars such as O.A. Ageeva and N.P. Kondrakov emphasize that leasing transactions have a significant impact on the structure of assets, liabilities, and financial results of enterprises. Their studies focus on the recognition of leased assets, depreciation methods, and the presentation of leasing operations in financial statements in accordance with international financial reporting standards. These theoretical approaches provide a sound scientific basis for understanding the economic substance of leasing and its accurate reflection in accounting systems.

Issues related to the auditing of leasing operations are comprehensively examined in the works of A.K. Ibragimov, B.B. Sugurbaev, and other researchers, who analyze audit planning, audit risk assessment, and the application of analytical procedures. According to these authors, leasing transactions require a specialized audit approach due to their legal, financial, and organizational complexity. International Standards on Auditing further emphasize the importance of obtaining sufficient and appropriate audit evidence, particularly when auditing long-term leasing agreements that involve substantial financial commitments and tax implications.

In addition, the legal and regulatory aspects of leasing and audit activities in Uzbekistan are reflected in national legislation and presidential decrees. These regulatory sources highlight the role of audit in ensuring transparency, compliance with tax requirements, and the protection of stakeholders’ interests. Overall, the reviewed literature confirms that an effective audit of leasing operations contributes to strengthening financial discipline, minimizing risks, and enhancing the reliability and credibility of financial reporting in enterprises.

RESEARCH METHODOLOGY

The audit of finance leasing transactions is carried out with full consideration of the economic and legal nature of leasing arrangements. In practice, inaccuracies arising in the conclusion of lease agreements, as well as in the accounting and taxation of leasing transactions, are largely associated with imperfections in regulatory frameworks and the insufficient development of methodological guidelines. Consequently, auditing leasing transactions requires increased attention compared to other fixed asset–related operations, and this specificity

should be reflected in the organization and development of audit methodologies. The examination of leasing operations necessitates a comprehensive and systematic approach covering all stages of the audit process, including planning, the formation of the audit team, the execution of audit procedures, and the preparation of audit reports and conclusions. Analytical procedures applied at the planning stage play a crucial role in understanding the activities of the audited entity and in reducing audit risk, as they enable the identification of unusual or potentially misstated transactions that require enhanced auditor attention. The effective use of analytical procedures also allows auditors to limit unnecessary audit actions, thereby reducing labor intensity while simultaneously improving audit quality and facilitating the timely detection of inconsistencies in financial statements. To verify the key elements of leasing relationships, it is advisable to develop a flexible audit framework that adjusts audit procedures depending on the type of lease. Given that leasing arrangements commonly involve multiple participants, audit approaches should reflect the legal structure of the leasing scheme, while being adapted for specific forms of leasing such as repayable or operating leases. In auditing leasing transactions, audit objectives and procedures should be determined from both the lessor's and the lessee's perspectives.

Due to the complex and non-standard nature of leasing transactions, a comprehensive tracing approach is considered one of the most effective audit techniques, whereby selected significant transactions are examined throughout the entire accounting cycle. This approach is complemented by analytical comparisons of accounting indicators and their ratios with established benchmarks, as well as by reconciling financial statement data with lease agreements, internal documentation, and planned or forecasted indicators.

ANALYSIS AND RESULTS

It is recommended that audit evidence on the most significant issues be obtained from multiple independent and alternative sources. The need to perform additional audit procedures may serve as a justified basis for determining and confirming that such procedures are directly related to the specific leasing transaction under review [5] (Table 1 and Table 2).

Table 1. Tasks for Conducting an Audit of the Lessor

№	Area	Summary of Tasks
1	General issues	Determining the availability of a valid license to carry out leasing activities. Verifying the legality and compliance of leasing agreements, including contracts providing for the transfer of ownership rights.
2	Fixed assets accounting	Examining analytical and synthetic accounting of income and expenses related to leased fixed assets. Verifying the accuracy of depreciation calculations for leased property. Assessing the valuation of leased assets, including those subject to subsequent acquisition by the lessee. Reviewing the accounting of capital investments related to leased property.
3	Cost formation	Verifying the accounting of costs related to loans and borrowings. Reviewing the calculation and recognition of insurance costs for leased property. Assessing the calculation and accounting of repair and maintenance costs of leased assets.
4	Leasing services revenue	Verifying the correctness and completeness of accounting for income generated from leasing agreements.
5	Settlements	Reviewing settlements with suppliers and contractors. Examining accounts with buyers and customers. Verifying settlements with the state budget and extra-budgetary funds. Assessing settlements with various debtors and creditors.
6	Taxation of leasing transactions	Verifying tax settlements related to leasing objects, including transactions involving purchase, pledge, lease, and sale. Examining the taxation of income received under leasing agreements in accordance with applicable tax legislation.
7	Reporting	Assessing whether accounting reports provide a reliable and fair presentation of operating results. Verifying the accuracy, completeness, and compliance of tax reporting with regulatory requirements.

Table 2. Tasks for Conducting an Audit of the Lessee

№	Area	Summary of Tasks
1	General issues	Verifying the legality and compliance of the lease agreement, including provisions related to the transfer of property rights. Confirming the existence of duly approved decisions of the Board of Directors or authorized management bodies regarding the conclusion of leasing agreements.
2	Fixed assets accounting	Examining analytical and synthetic accounting of fixed assets received under lease agreements. Verifying the accuracy of depreciation calculations and the proper accounting of leased property, plant, and equipment. Assessing the accounting treatment of the acquisition of leased assets, including those obtained under long-term leasing arrangements. Reviewing the recognition and accounting of capital expenditures related to leased property.
3	Cost formation	Verifying the recognition and classification of expenses arising from lease payments in accordance with lease agreements. Reviewing the calculation and accounting of insurance costs related to leased assets. Assessing the calculation and accounting of repair and maintenance costs of leased property.
4	Settlements	Examining settlements with suppliers and contractors. Reviewing accounts with buyers and customers. Verifying settlements with the state budget and extra-budgetary funds. Assessing settlements with various debtors and creditors for accuracy and completeness.
5	Taxation of leasing transactions	Verifying tax settlements related to leasing objects, including transactions associated with the acquisition, pledge, and purchase of leased assets, in accordance with applicable tax legislation.
6	Reporting	Assessing whether accounting records and financial statements provide a reliable and fair representation of the entity's performance. Verifying the accuracy, completeness, and regulatory compliance of tax reporting.

When examining leasing transactions, it is essential to rely primarily on audit evidence obtained directly by the audit firm. At the same time, priority should be given to documented written evidence, while also considering oral information provided by employees and third parties. Oral evidence may support the formation of well-grounded conclusions that facilitate a rapid understanding of the accounting policies, taxation practices, and other legal aspects applied to leasing transactions within the enterprise. This comprehensive approach contributes to reducing the overall duration of the audit by enabling a timely assessment of the reporting system, as well as the identification of existing gaps and potential inconsistencies.

Optimizing the organizational processes involved in auditing leasing transactions enhances the auditor's ability to identify and analyze typical errors and ambiguities that may arise in the accounting of lease-related transactions [8]. Accordingly, the development of a structured audit plan and a detailed audit work program, combined with the systematic classification of common errors in leasing transactions, supports the effectiveness and methodological consistency of the audit process (Table 3).

Table 3. List of Common Mistakes in Leasing Transactions

Types of Errors	Applicable Audit Actions
Conducting leasing activities without an appropriate license	Oral inquiries; verification of regulatory and licensing documents.
Absence of specific provisions in the enterprise's accounting policy related to leased assets and leasing transactions	Verification of accounting policy documents and internal regulations.
Recording business transactions that are inconsistent with external or internal documentation	Oral inquiries; document verification; application of analytical procedures.
Improper application or unlawful use of accelerated depreciation methods	Verification of depreciation calculations and supporting documentation.
Failure to recognize leasing income in a timely and accurate manner	Document verification; assessment of compliance with accounting rules for specific transactions.
Misstatement of leased property, plant, and equipment in accounting records	Document verification; verification of compliance with accounting standards and regulations.
Non-compliance with the contractual terms governing the use of fixed assets	Oral inquiries; examination of lease agreements and related documentation.
Unjustified inclusion of repair and maintenance costs of leased assets in the cost of services	Recalculation of customer accounts; document verification; tracing procedures.

Reduction in revenue from leasing services due to accounting inaccuracies	Recalculation of arithmetic accuracy; verification of compliance with accounting rules; tracing procedures.
Uncertainty or inconsistency in settlements with contractors under leasing agreements	Recalculation of settlements; verification of accounting compliance; tracing procedures.
Errors in the calculation and payment of taxes related to leasing transactions	Verification of compliance with accounting and tax regulations; tracing procedures.
Unreliability of submitted financial and tax reports	Recalculation of reported figures; application of analytical procedures.

The list of errors presented in the table is formed on the basis of the practical experience of audit organizations and reflects the most common irregularities identified during the audit of leasing transactions. Accordingly, the structure and content of this list may be modified in response to changes in the legal and regulatory framework, as well as the emergence of new types of errors in accounting practice. The systematic formation and regular updating of a database of identified irregularities enable audit organizations to continuously analyze deviations, generalize detection practices, and assess the impact of such irregularities on the reliability of financial statements. The audit report, which provides an objective assessment of the accounting system and the financial condition of the farm, presents a comprehensive description of its financial and economic performance. When this report is submitted to the founders of the farm, it serves as the basis for the preparation of the formal audit opinion. Errors and deficiencies identified during the audit are subject to correction by the chief accountant and other financially responsible persons, while the audit process itself evaluates the organization of accounting, its compliance with applicable legal and regulatory requirements, and the adequacy of corrective measures reflected in accounting records and documentation. The results of the audit are primarily summarized in the audit opinion, which, despite its relatively concise form, carries significant informational value and legal responsibility for both the audit firm and the audited entity. The auditor prepares an overview of the financial statements after a thorough assessment of the farm's financial and economic activities, and each statement contained in the audit report has substantive significance. Upon completion, the audit report is signed and certified by the audit firm and subsequently used by the enterprise as reliable evidence in its economic relations with counterparties. In international practice, particularly in developed economies, commercial transactions are rarely concluded without an independent audit opinion confirming the accuracy of financial statements, as such confirmation enhances trust between parties and mitigates financial risks associated with receivables and payables. In the context of a market economy, advance payments—especially in sectors fulfilling state orders—further emphasize the importance of reliable accounting and auditing systems. In accordance with national auditing standards [11], the audit report must include essential elements such as the title of the conclusion, introductory and concluding sections, the date and address of the audit organization, and the signatures of authorized auditors. The publication and disclosure of audit opinions in this structured manner ensure transparency and provide users with an objective understanding of the farm's actual financial condition and performance. Scientific research confirms that improving the organization of accounting and auditing on farms in line with national standards harmonized with international requirements is a critical factor in enhancing financial management practices. As accounting and auditing standards continue to converge with international norms and professional training improves, there is strong confidence that the quality and effectiveness of auditing practices will progressively reach the level observed in developed countries.

CONCLUSION AND RECOMMENDATIONS

To accelerate the development of the leasing sector, it is advisable for the state to implement a comprehensive system of supportive measures [14]. These measures may include the provision of concessional investment loans for the implementation of public projects, the introduction of temporary incentives for lease payments during the initial five-year period following the establishment of leasing companies, a reduction in income tax rates applied to profits generated by lessee enterprises through the use of leased assets for the entire leasing period, as well as the reduction of customs duties and taxes on machinery, equipment, and facilities acquired by leasing companies for leasing purposes and imported into or exported from the country. At the same time, improving the leasing of vehicles and long-term consumer goods remains an important area of development, as the expansion of such leasing practices contributes to both the growth of the leasing market and the formation of a broader public understanding of the economic essence and significance of leasing relations. In general, the expansion of leasing activities and their penetration into various sectors of the national economy create favorable conditions for sustainable socio-economic growth, job creation, and the efficient allocation of labor resources. In order to further stimulate the development of leasing in Uzbekistan, it is expedient to strengthen

the financial capacity of existing leasing companies through the establishment of specialized funds or the provision of low-interest bank loans, to expand tax and customs incentives for participants in leasing relations in order to reduce production costs, and to enhance professional competencies in the field of leasing by facilitating international training and research exchanges for academic and professional staff.

In addition, increasing the financial motivation of accounting personnel, ensuring the full and accurate reflection of production costs in accounting documentation, providing newly established and developing farms with access to financial resources necessary for building a material and technical base, and strengthening control over the effective use of these resources are of particular importance. Finally, improving the quality of audit practices aimed at ensuring reliable accounting and an objective assessment of the financial and economic condition of farms will contribute to more informed economic decision-making. The consistent implementation of these measures is expected to produce sustainable and positive outcomes for the development of the leasing sector.

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METHODOLOGY DEVELOPMENT RETAIL MARKETING AND TRADING SYSTEM.

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Abstract: This article analyzes the methodological foundations for developing marketing activities in the retail industry in the current context. The study examines the formation of marketing strategies based on an in-depth study of the domestic market, consumer behavior, market segmentation, and the competitive environment.

Key words: retail, sales process, advertising, sales efficiency, e-commerce, sales market development.

Annotatsiya: Ushbu maqola zamonaviy sharoitda chakana savdo tizimida marketing faoliyatini rivojlantirishning metodologik asoslarini tahlil qiladi. Tadqiqotda ichki bozor, iste'molchi xulq-atvori, bozor segmentatsiyasi va raqobat muhitini chuqur o'rganish asosida marketing strategiyalarini shakllantirish masalalari ko'rib chiqilgan.

Kalit so'zlar: chakana savdo, sotish jarayoni, reklama, savdo samaradorligi, elektron tijorat, savdo bozorini rivojlantirish.

Аннотация: В данной статье анализируются методологические основы развития маркетинговой деятельности в розничной торговле в современных условиях. В исследовании рассматриваются вопросы формирования маркетинговых стратегий на основе углубленного изучения внутреннего рынка, поведения потребителей, сегментации рынка и конкурентной среды.

Ключевые слова: розничная торговля, процесс продаж, реклама, эффективность продаж, электронная коммерция, развитие рынка сбыта.

INTRODUCTION

In modern global economic relations, retail trade is an important part of the national economy, playing a decisive role in meeting the daily needs of the population, developing entrepreneurship and strengthening market infrastructure. In particular, improving the retail system through effective marketing mechanisms allows for increased competitiveness, in-depth study of consumer needs and adaptation of trade enterprises to market processes.

The President of the Republic of Uzbekistan Shavkat Mirziyoyev is constantly setting priority areas for the development of the sector. Decree UP No. 5564 of October 30, 2018 "On measures to further liberalize trade and develop competition in commodity markets" is one of the important documents aimed at expanding market mechanisms in the trade sector, simplifying regulations for entrepreneurs, and creating a competitive environment. This decree serves to increase the efficiency of the domestic market by ensuring that trade entities operate in conditions of free competition.[1]

Also, the recent Presidential Decree No. UP 67 dated April 18, 2025 "On measures to stimulate trade and industrial policy, increase production and exports" has encouraged reforms such as simplifying the procedure for internal trade and modernizing the process of registering product certificates. These documents will serve to organize the marketing and business processes of retail entities in a more favorable environment.[2]

Other documents adopted by the President on market liberalization and improvement of the competitive environment, including the decisions currently being taken on the path to WTO membership, are aimed at adapting the national trade system to global standards and developing it through effective marketing strategies.

Therefore, the development of a methodology for the development of retail marketing is inextricably linked to national government policies, and this topic requires comprehensive research.

REVIEW OF LITERATURE ON THE SUBJECT

Sinyayeva I.M. paid special attention to the issues of market research, supply and demand analysis, market segmentation, and working with target consumers in retail and wholesale trade. The role of sales assortment formation, pricing policy, sales channel management, and sales promotion mechanisms in marketing is also revealed.[3]

Zavyalov P. S. The book emphasizes the role of consumer behavior in retail and wholesale trade, the selection of sales channels, and incentive measures aimed at increasing sales. The manual is an important methodological resource for a systematic understanding of sales processes and their optimization from a marketing point of view.[4]

Grigoryan Ye. S. systematically covers the theoretical foundations of marketing communications and their practical application in sales activities. In addition, he analyzes the interrelationships of advertising, sales promotion, public relations, personal selling, and digital communications.[5]

Kadyrov A. Q. Justifies the role and importance of domestic trade in the national economy, paying special attention to the issues of improving trade infrastructure, developing a competitive environment, and ensuring the effective functioning of market mechanisms. The work scientifically covers the economic mechanisms of retail trade, including price formation, supply and demand balance, quality of trade services, and methods of supporting trade entities.[6]

Rakhimov Sh. K., studying the dependence of the trade services market on internal and external factors, pays special attention to the issues of improving service quality, satisfying consumer needs and ensuring competitiveness. The work presents methodological recommendations for optimizing the marketing tools, assortment of services, pricing policy and service process of retail trade services.[7]

RESEARCH METHODOLOGY

This study used the following scientific methods to systematically analyze retail marketing development processes and develop effective methodological approaches:

1. Analytical method - the current state of the domestic market, the retail system and consumer behavior were analyzed, sales indicators and the results of marketing decisions were evaluated.

2. Comparative analysis - domestic and foreign retail marketing experiences were compared, which served to identify effective strategies.

3. Empirical research - questionnaires, interviews and the practical activities of retail enterprises were studied, and the impact of marketing instruments was determined.

This methodology serves to strengthen the theoretical foundations of retail marketing development, develop practical recommendations and increase the competitiveness of the retail system.

ANALYSIS AND RESULTS

At the current stage of trade development, as a result of the widespread and effective use of marketing solutions, high growth rates of retail trade volumes are being formed. The rapid development of the trade sector and the steady increase in real incomes of the population make the domestic consumer market one of the most promising and attractive in the world. Trade acts as a leading branch of marketing in the economy. It is retail that maximally orients local producers to take into account the requirements of society.

Retailers are mobile, low-cost, and have great flexibility to adapt to market changes.

Retail is a system of retailing (retail trade is a small business associated with the sale of goods in quantities for personal and family use). Retail is based on the theory of personal choice, based on the principle of consumer preference. Therefore, retail is a social expression of the quality of life of society. Retail is an exchange of goods aimed at satisfying people's needs through the free sale of goods and services that are valuable to the buyer. (Table 1). [3]

Retail trade classification signs

№	Classification symbol	Characteristic features
1	Concentration and location	Individual store placement Grouping of retail outlets (network sales)
2	Type of assortment being sold	Specialized Universal Mix

3	Sales services form: a) a) methods of selling goods b) additional services	a) individual service (over the counter) – self-service – open display – sale of goods by samples or catalogs – sale of goods on a pre-order basis – direct sales by telephone, Internet b) consultations; sample display – tailoring of sewing products to customer sizes – cutting and packaging of food products according to customer orders – festive packaging, order delivery – flexible forms of payment for purchases (credit, discount cards) – quality, return, repair and service guarantee
4	Types of retail establishments	Tonnar, pavilion, gastronomer, department store, universam, Bentham, trading house, shopping center, discounter, super- and hypermarkets, boutiques
5	Retail price level	low („second hand“; discount) high (prices in boutiques, super- and hypermarkets, shopping centers, department stores, company stores)

Retail trade is understood as an activity related to the sale of goods for subsequent personal, family, household or other similar purposes. The classification features of retail trade include: concentration and location; type of assortment sold, forms of trade services, types of enterprises, retail price level

The effectiveness of sales activities is directly dependent on the constantly changing consumer mood and new ways of doing business. Retail trade has various business forms aimed at satisfying the end consumer through marketing activities through the distribution channel, such as organizing goods and services to the final consumer along a multi-stage distribution chain. The distribution chain itself consists of a number of links connecting raw material producers, wholesalers and transport companies with the retailer and the final consumer.

Retail business combines the interests of the seller in making a profit and the needs of the buyer in obtaining high-quality goods and services, and identifying and satisfying customer demand is the main task of marketing.

At each stage of creating a sales process, marketing solves certain business management tasks, which allows you to increase profits and actively respond to market trends.

The scheme of the organizational stages of marketing in the retail system is shown in Figure 1.[4]

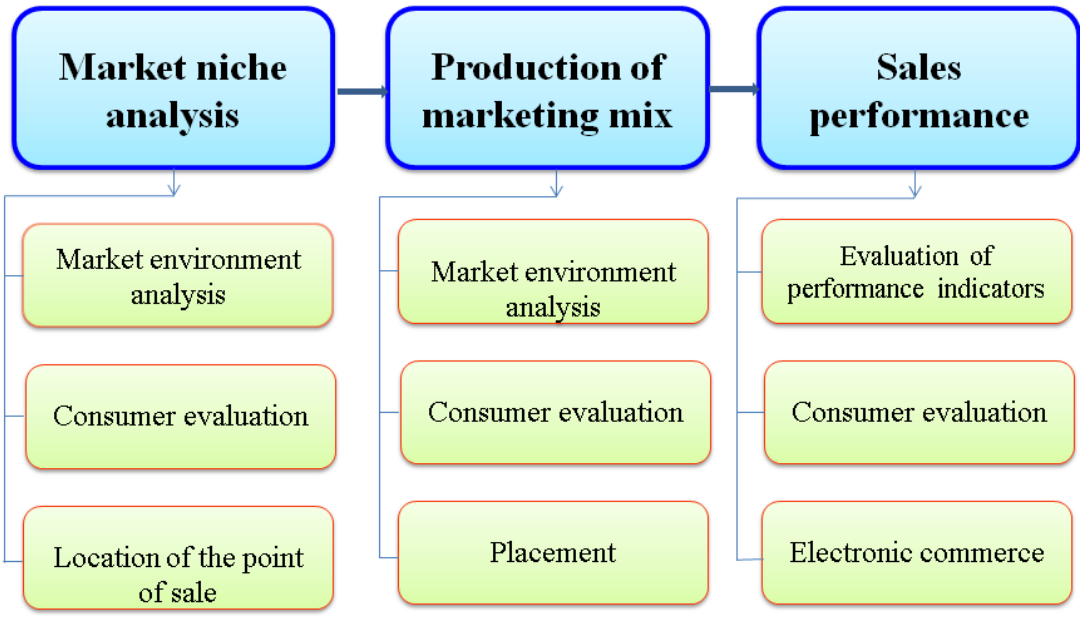

Figure 1 - Organization of marketing activities in retail

In addition to taking into account other and internal factors, it is important to determine the location of the point of sale, taking into account the preferences of potential consumers and the possibility of opening a retail store. The second stage involves the development, systematic and adaptive use of marketing research tools. The organization of the sales process is accompanied by the formation of a product policy. At the same time, it is necessary to analyze the attractiveness of the assortment in terms of the level of demand, the ability to manage consumers and the profitability of sales.

The third stage of marketing implementation in retail is the assessment of the effectiveness of financial and economic indicators, including: revenue, total costs, turnover, profit and profitability of sales operations. At this stage, it is very important to ensure a unified sales system based on automated accounting and control of accounting and cash transactions.

CONCLUSIONS AND SUGGESTIONS

It was found that the development of retail marketing is inextricably linked with the process of modernization of the domestic market, satisfying consumer needs and increasing the competitiveness of retail enterprises. The study developed methodological foundations for organizing effective activities in retail based on marketing strategies, market segmentation, sales promotion and brand management.

Also, practical recommendations were given to improve the effectiveness of retail marketing using analytical, comparative and empirical approaches. The results of the study show that the systematic and integrated use of the marketing complex, the development of digital technologies and interactive communication with customers ensure the sustainable growth and competitiveness of the retail system. As a result, the developed methodology serves as a scientific and practical foundation for the effective organization of marketing activities in retail enterprises, the development of the domestic market and the harmonization of local and foreign experience.

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NECESSITY OF ENSURING AND INCREASING THE COMPETITIVENESS OF PLACEMENT MEANS

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Abstract: The article examines the objective necessity of ensuring the competitiveness of accommodation facilities, the main factors that contribute to their competitiveness, as well as presents the research results on innovative approaches to enhancing competitiveness in hotel operations.

Key words: tourism, service sector, competition, competitiveness, accommodation facilities, hotels, customers, innovation, marketing activity, demand.

Annotatsiya: Maqolada joylashtirish vositalarining raqobatbardoshligini ta'minlashning obyektiv zarurati, joylashtirish vositalarining raqobatbardoshligini ta'minlovchi asosiy omillar hamda mehmonxonalar faoliyatida raqobatbardoshlikni oshirishning innovatsion yondashuvlari bo'yicha tadqiqot natijalari keltirilgan.

Kalit so'zlar: turizm, xizmat ko'rsatish, raqobat, raqobatbardoshlik, joylashtirish vositalari, mehmonxonalar, mijozlar, innovatsiya, marketing faoliyati, ehtiyoj.

Аннотация: В статье рассматривается объективная необходимость обеспечения конкурентоспособности средств размещения, основные факторы, обеспечивающие конкурентоспособность средств размещения, а также представлены результаты исследований по инновационным подходам к повышению конкурентоспособности в деятельности гостиничных предприятий.

Ключевые слова: туризм, сфера услуг, конкуренция, конкурентоспособность, средства размещения, гостиницы, клиенты, инновации, маркетинговая деятельность, потребность.

INTRODUCTION

The category of competitiveness has been extensively analyzed in economic literature and is defined as the ability of an enterprise or service provider to maintain its position in market conditions, develop, and attract new customers. Competitiveness for accommodation facilities is determined not only by the quality of service and pricing policy, but also by the level of adaptation to customer needs, marketing activities, and innovation.

The competitive environment in the tourism sector is multifaceted, influenced by economic, technological, cultural, and social factors. For example, in the hotel business, such elements as diversification of services, brand reputation, compliance with environmental standards, and digital transformation are important for achieving a competitive advantage.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of ensuring the competitiveness of accommodation facilities is considered as an important direction in scientific research in the field of tourism and the hotel business. Modern research approaches this issue from the point of view of economic efficiency, service quality, innovation management, and marketing.

In his work «The Competitive Advantage of Nations,» M. Porter characterizes competitiveness as the main driver of the economic system and defines the role of innovation and differentiation strategies in creating the advantages of enterprises. In his opinion, a competitive advantage is ensured not only through price, but also through value creation, an individual approach to customer needs, and unique services.

F. Kotler, J. Bowen and J. In their works on hotel and tourism marketing, Makens assesses the competitiveness of accommodation services in close connection with the level of customer satisfaction and the formation of brand trust. According to them, to maintain a competitive advantage in hotel marketing, it is necessary to constantly improve the quality of service and strengthen digital connections.

Smith also emphasizes the importance of innovative solutions in the hotel industry in his research "Hospitality Management and Innovation." In his opinion, the main factor in increasing competitiveness is the automation of the service process, personalization of the client experience, and integration of the principles of sustainable development.

Scientific research in European countries shows the influence of digital transformation and online platform-based booking systems on hotel competitiveness. According to them, digital technologies, along with increasing service efficiency, strengthen customer trust and stabilize market positions.

Analyzed scientific sources show that ensuring the competitiveness of accommodation facilities is a multifactorial system, determined by the level of service quality, innovation, brand management, and adaptation to the digital economy. While international research focuses on digital technologies, innovative management, and customer-oriented service models, national scientific works place greater emphasis on human resource potential and state support mechanisms.

Thus, the analysis of the available literature requires a comprehensive approach to increasing the competitiveness of accommodation facilities, that is, a combination of economic, technological, and social factors.

RESEARCH METHODOLOGY

In this study, the issues of ensuring and increasing the competitiveness of accommodation facilities were studied on the basis of a comprehensive approach from the point of view of economic, organizational, and innovative factors of the development of the modern tourism industry. In the course of the study, a systematic analysis of the accommodation services market, its structural composition, territorial features, and trends in sustainable development was conducted. The methods of economic and social analysis, system analysis, comparative analysis, and statistical generalization were used as a methodological basis. Empirical analysis was also carried out based on existing scientific literature, state statistical data, opinions of specialists in the field, and reports of international organizations (UNWTO, WTTC).

Analysis and results

Today, accommodation facilities operating in the tourism sector face increasing competition in the market, frequent changes in customer demand, and the need to improve the quality of services. In such conditions, the stable operation and preservation of any accommodation facility's position are directly related to its level of competitiveness. Competitiveness is formed not only through the price of services, but also through the quality of services provided, the qualifications of employees, the management system, the culture of working with clients, and the ability to adapt to market requirements. Therefore, it is important to identify the factors ensuring the competitiveness of accommodation facilities and analyze their impact on the results of activities. The following section details these factors and reveals their role and importance in hotel operations.

The main factors ensuring the competitiveness of accommodation facilities can be grouped as follows (Fig. 1):

Figure 1. Main factors ensuring the competitiveness of accommodation facilities

Figure 1 systematically reflects the main factors ensuring the competitiveness of accommodation facilities. These factors demonstrate the inextricable link between service quality, innovation, marketing, economic efficiency, and cultural values in the hotel business. As can be seen from the figure, ensuring competitiveness relies not on one factor, but on a complex of multifaceted, interacting elements.

The first factor, the quality of service and the qualifications of personnel, is the main criterion for the effectiveness of hotel activities. The level of customer satisfaction, the prestige of the hotel brand, and its market position are closely related to the qualifications of service personnel.

The use of innovative technologies is considered a modern driver of competitiveness and increases service efficiency through such tools as digital booking systems, automated management platforms, and personalization of the customer experience. At the same time, marketing and brand management are crucial for strengthening the corporate image in hotel operations, ensuring continuous communication with clients, and maintaining a competitive position in the market.

Price policy and economic efficiency ensure the stability of hotel services in the market. A favorable price-quality ratio for the client determines a competitive advantage, which serves to increase economic efficiency. At the same time, national traditions and cultural color ensure the uniqueness of services and create a positive emotional impression on tourists through local values.

Thus, the factors shown in Figure 1 together form a comprehensive model of the competitiveness of accommodation facilities. The scientific and practical significance of this model lies in the fact that it serves as a theoretical and practical basis for the effective organization of strategic management in the hotel business, the differentiation of services, and the achievement of dominance in the international market.

This analysis shows that the factors ensuring the competitiveness of accommodation facilities are inextricably linked, each of which plays an important role in the sustainable development of hotel activities. While service quality and personnel qualifications determine customer satisfaction, innovation and marketing strategies ensure the adaptation of services to modern requirements. At the same time, economic efficiency and national color enhance the internal stability and external attractiveness of the hotel business.

In the context of the increasingly dynamic nature of the competitive environment in the modern tourism industry, new - innovative approaches are becoming necessary for the effective management of these factors. From this point of view, the use of innovative solutions as one of the most important directions for increasing the competitiveness of accommodation facilities is of current importance.

Innovations are the main source of increasing the efficiency of hotel operations. Innovative approaches in modern hotels are manifested in the following directions (Fig. 2):

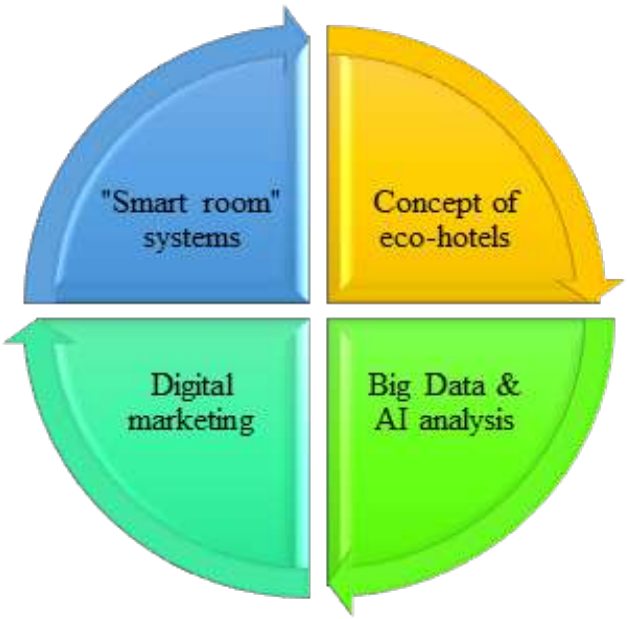

Figure 2. Innovative approaches to increasing the competitiveness of hotels

Figure 2 systematically reflects the main innovative approaches that serve to increase competitiveness in hotel activities. These include “Smart room” systems, an eco-hotel concept based on environmental sustainability, digital marketing and artificial intelligence, and Big Data analysis. These areas are crucial for the development of the hotel business based on modern technologies and the automation of the service process.

"Smart room" systems are intelligent management solutions that ensure energy efficiency, security, and comfort in hotels. Through these systems, guests will be able to control room temperature, lighting, or service calls using a smartphone or sensor. This, along with improving the client experience, reduces hotel production costs and increases competitive advantage.

The concept of an eco-hotel, based on the principles of sustainable development, implies a model of activity that does not harm the environment. This approach not only creates a positive image in the minds of tourists, but also increases the prestige of the hotel in the international market through a "green brand."

Digital marketing allows establishing interactive relationships with clients in hotel activities, effectively promoting services through online booking systems and social networks. At the same time, through Big Data and AI analysis, customer preferences, consumption habits, and market trends are analyzed, and personalized service strategies are developed.

Thus, the innovative approaches reflected in Figure 2 create a modern technological basis for increasing the competitiveness of the hotel business. Along with improving the quality of service and customer satisfaction, they have important scientific and practical significance in adapting hotel management to the requirements of the digital economy.

The results of the conducted research show that ensuring the competitiveness of accommodation facilities is crucial for the sustainable development of the tourism industry. Quality of service, personnel qualifications, innovative technologies in increasing competitiveness

CONCLUSIONS AND SUGGESTIONS

Ensuring competitiveness in accommodation facilities is a key factor in increasing the efficiency of the hotel business, establishing a stable position in the national tourism market, and gaining international recognition. To maintain a competitive advantage in the modern hotel industry, it is necessary to constantly improve the quality of service, effectively use innovation and digital technologies, and ensure an individual approach to customer needs.

According to the results of the analysis, the introduction of innovative approaches in the hotel business - the use of digital marketing, «smart room» systems, environmentally friendly hotel models, and methods of analysis based on artificial intelligence - makes it possible to increase service efficiency. This will serve to ensure customer satisfaction, strengthen competitive advantages in the market, and enhance the international prestige of the national tourism sector.

At the same time, the widespread introduction of innovations in the activities of accommodation facilities, the regular improvement of personnel qualifications, the introduction of digital management systems, and the development of hotel models based on environmental principles will remain an important priority at the next stage of the industry's development.

The research results confirm that ensuring competitiveness requires not only an economic approach, but also the formation of a comprehensive management system covering social, innovative, and environmental aspects.

Based on the results of scientific research, when increasing the competitiveness of hotels and similar accommodation facilities, it is advisable to pay attention to the following:

- implementation of special educational programs to improve the qualifications and service culture of personnel in the hotel industry;
- expansion of digital transformation and automation in the activities of accommodation facilities;
- strengthening the tourist image of the country through the development of hotels with national brands;
- modernization of tourism infrastructure based on public-private partnership;
- regular monitoring of customer feedback and alignment of service quality with ISO standards.

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ENVIRONMENTAL FISCAL POLICY AS A DRIVER OF GREEN GROWTH AND EMPLOYMENT IN CENTRAL ASIA: EMPIRICAL EVIDENCE

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Abstract: This study investigates the role of environmental fiscal policy as a driver of green economic growth and employment in Central Asia. The region faces significant climate vulnerability, high carbon intensity, and structural dependence on natural resources, which increases the relevance of fiscal instruments in supporting sustainable development. Using a balanced panel dataset for five Central Asian countries over the period 2015–2023, the study applies fixed-effects econometric models to examine the impact of green public investment and environmental fiscal instruments on real GDP growth and unemployment. The empirical results provide robust evidence in support of the “double dividend” hypothesis. Green public investment is found to have a statistically significant and positive effect on economic growth, while simultaneously contributing to a reduction in unemployment. Environmental fiscal instruments, including pollution-related charges and green budget expenditures, enhance macroeconomic performance without undermining labour market outcomes. The findings suggest that well-designed environmental fiscal policies can reconcile environmental objectives with economic and social priorities in transition economies. From a policy perspective, the results highlight the importance of integrating green public investment, environmental taxation, and budgetary reforms into national fiscal frameworks. The study contributes to the empirical literature on green growth by providing region-specific evidence for Central Asia and offers practical insights for policymakers seeking to align fiscal policy with climate goals, ESG principles, and the Sustainable Development Goals.

Key words: environmental fiscal policy; green public investment; economic growth; unemployment; Central Asia; panel data; sustainable development; green economy.

Annotatsiya: Mazkur tadqiqot Markaziy Osiyoda yashil iqtisodiy o‘sish va bandlikni ta’minlashda atrof-muhitga oid fiskal siyosatning drayver sifatidagi rolini o‘rganadi. Mintaqa iqlimga yuqori darajada zaiflik, karbon intensivligining yuqoriligi va tabiiy resurslarga strukturaviy qaramlik bilan tavsiflanadi, bu esa barqaror rivojlanishni qo‘llab-quvvatlashda fiskal instrumentlarning ahamiyatini oshiradi. Tadqiqotda 2015–2023-yillar oralig‘ida Markaziy Osiyoning besh mamlakati bo‘yicha muvozanatlangan panel ma’lumotlar to‘plamidan foydalanilib, yashil davlat investitsiyalari va ekologik fiskal instrumentlarning real YaIM o‘sishi hamda ishsizlik darajasiga ta’siri qat’iy effektlar modeli asosida baholandi. Empirik natijalar “ikki karra dividend” gipotezasini qo‘llab-quvvatlovchi ishonchli dalillarni taqdim etadi. Yashil davlat investitsiyalari iqtisodiy o‘sishga statistik jihatdan ahamiyatli ijobiy ta’sir ko‘rsatishi bilan birga, ishsizlik darajasining pasayishiga ham xizmat qilishi aniqlandi. Ifloslanish bilan bog‘liq yig‘imlar va yashil budjet xarajatlarini o‘z ichiga olgan ekologik fiskal instrumentlar mehnat bozori ko‘rsatkichlariga salbiy ta’sir ko‘rsatmasdan makroiqtisodiy samaradorlikni oshiradi. Olingan natijalar o‘tish iqtisodiyotlarida puxta ishlab chiqilgan ekologik fiskal siyosat ekologik maqsadlarni iqtisodiy va ijtimoiy ustuvor yo‘nalishlar bilan uyg‘unlashtirish imkonini berishini ko‘rsatadi. Siyosiy nuqtayi nazardan, tadqiqot yashil davlat investitsiyalari, ekologik soliqlar va budjet islohotlarini milliy fiskal tizimlarga integratsiya qilish muhimligini ta’kidlaydi. Tadqiqot yashil o‘sish bo‘yicha empirik adabiyotga Markaziy Osiyo uchun mintaqaviy dalillar bilan hissa qo‘shadi hamda fiskal siyosatni iqlim maqsadlari, ESG tamoyillari va Barqaror rivojlanish maqsadlari bilan uyg‘unlashtirishga intilayotgan siyosatchilar uchun amaliy tavsiyalarni taklif etadi.

Kalit so‘zlar: atrof-muhitga oid fiskal siyosat; yashil davlat investitsiyalari; iqtisodiy o‘sish; ishsizlik; Markaziy Osiyo; panel ma’lumotlar; barqaror rivojlanish; yashil iqtisodiyot.

Аннотация: В данном исследовании анализируется роль экологической фискальной политики как фактора развития зелёного экономического роста и занятости в странах Центральной Азии. Регион характеризуется высокой климатической уязвимостью, значительной углеродоёмкостью и структурной зависимостью от природных ресурсов, что усиливает значимость фискальных инструментов в обеспечении устойчивого развития. На основе сбалансированной панельной выборки по пяти странам Центральной Азии за период 2015–2023 гг. в работе применяются эконометрические модели с фиксированными эффектами для оценки влияния зелёных государственных инвестиций и экологических фискальных инструментов на рост реального ВВП и уровень безработицы. Полученные эмпирические результаты предоставляют устойчивые доказательства в пользу гипотезы «двойного дивиденда». Установлено, что зелёные государственные инвестиции оказывают статистически значимое положительное влияние на экономический рост и одновременно способствуют снижению уровня безработицы. Экологические фискальные инструменты, включая платежи, связанные с загрязнением окружающей среды, и зелёные бюджетные расходы, повышают макроэкономическую эффективность, не ухудшая показатели рынка труда. Результаты исследования свидетельствуют о том, что грамотно разработанная экологическая фискальная политика позволяет согласовать экологические цели с экономическими и социальными приоритетами в переходных экономиках. С точки зрения экономической политики подчёркивается важность интеграции зелёных государственных инвестиций, экологического налогообложения и бюджетных реформ в национальные фискальные рамки. Исследование вносит вклад в эмпирическую литературу по зелёному росту, предоставляя регионально-специфические доказательства для Центральной Азии, а также предлагает практические рекомендации для лиц, принимающих решения, стремящихся согласовать фискальную политику с климатическими целями, принципами ESG и Целями устойчивого развития.

Ключевые слова: экологическая фискальная политика; зелёные государственные инвестиции; экономический рост; безработица; Центральная Азия; панельные данные; устойчивое развитие; зелёная экономика.

INTRODUCTION

Environmental fiscal policy (EFP) has become an increasingly important component of economic governance in the context of accelerating climate change and the global sustainability agenda. As countries seek to achieve climate neutrality, reduce greenhouse gas emissions, and transition toward low-carbon growth models, fiscal instruments such as environmental taxes, carbon pricing, green public investment, and budgetary reforms are being widely adopted. Unlike purely regulatory approaches, EFP relies on market-based incentives to internalize environmental externalities and align private economic behavior with societal environmental objectives. In addition, environmental fiscal instruments provide governments with fiscal resources that can be redirected toward green infrastructure, climate adaptation, and social compensation mechanisms, thereby supporting both environmental and macroeconomic stability. Consequently, EFP is increasingly viewed not only as an environmental tool but also as a strategic driver of sustainable development.

The relevance of environmental fiscal policy is particularly pronounced in Central Asia, where economies face a unique combination of structural and environmental challenges. The region is characterized by high carbon intensity, aging and energy-inefficient infrastructure, strong dependence on fossil fuels and natural resource extraction, and significant exposure to climate risks. Rising temperatures, glacier retreat, water scarcity, and the increasing frequency of droughts and floods impose growing fiscal burdens through higher disaster-related expenditures, declining agricultural productivity, and infrastructure damage. At the same time, Central Asian countries operate under tight fiscal constraints, with limited fiscal space, high subsidy burdens—particularly for energy—and dependence on commodity-based revenues. These conditions make it imperative to identify policy instruments that can simultaneously address environmental degradation, stimulate economic growth, and improve labour-market outcomes without undermining fiscal sustainability.

Despite the growing policy relevance of environmental fiscal instruments, empirical evidence on their macroeconomic and labour-market effects remains limited, especially for transition economies in Central Asia. Existing studies largely focus on advanced economies, examining the impact of carbon taxes or emissions trading systems on emissions reduction and competitiveness. By contrast, much less attention has been paid to how environmental fiscal policy affects economic growth and employment in developing and resource-dependent regions. In the Central Asian context, most analyses remain descriptive or policy-oriented, lacking rigorous econometric assessment. This gap in the literature limits the ability of policymakers to evaluate potential trade-offs or synergies between environmental objectives, growth, and employment, and constrains evidence-based fiscal reform.

Against this background, the present study aims to empirically assess the macroeconomic and labour-market effects of environmental fiscal policy in Central Asia. Specifically, it examines the impact of green public investment and selected environmental fiscal instruments on real GDP growth and unemployment using panel

econometric techniques. By applying fixed-effects models to a multi-country dataset, the study controls for structural heterogeneity across countries and common external shocks. The main contribution of the research lies in providing region-specific empirical evidence on the "double dividend" hypothesis—namely, whether environmental fiscal policy can promote economic growth while simultaneously improving labour-market outcomes. The findings offer practical insights for fiscal policymakers and contribute to the broader literature on green growth, sustainable public finance, and environmental economics in transition economies.

REVIEW OF LITERATURE ON THE SUBJECT

The theoretical foundations of environmental fiscal policy are rooted in the classical welfare economics framework developed by Arthur Cecil Pigou, who introduced the concept of corrective taxation to internalize negative externalities. In The Economics of Welfare, Pigou demonstrated that environmental taxes can align private costs with social costs, thereby improving allocative efficiency and welfare outcomes. This Pigouvian logic remains central to modern environmental taxation and carbon pricing policies.

Building on this foundation, contemporary literature emphasizes carbon pricing as a cornerstone of effective climate-related fiscal policy. The World Bank Group High-Level Commission on Carbon Prices, coordinated by Joseph E. Stiglitz and Nicholas Stern, argues that well-designed carbon prices are fiscally efficient instruments capable of reducing emissions while generating public revenue. Their analysis highlights the role of carbon pricing in supporting green growth, particularly when revenues are recycled into productive investment or social protection mechanisms.

Empirical evidence on environmental taxation is extensively documented by the OECD. The Taxing Energy Use report provides cross-country data demonstrating that energy and carbon taxes can reduce emissions without undermining long-term economic performance. More recent OECD work on green budgeting extends this analysis by integrating environmental objectives into fiscal frameworks, showing that environmentally aligned tax systems enhance fiscal sustainability and policy coherence.

The International Monetary Fund contributes a macro-fiscal perspective by linking climate policy to public finance management. IMF studies emphasize that environmental fiscal reforms—particularly carbon taxation and fossil fuel subsidy removal—are essential for meeting Paris Agreement targets while safeguarding macroeconomic stability. The IMF's updated estimates reveal that fossil fuel subsidies remain substantial globally, underscoring the inefficiencies and employment distortions created by misaligned price signals.

From a climate risk assessment perspective, William D. Nordhaus integrates environmental externalities into dynamic economic models, demonstrating that delayed climate action significantly increases long-term economic and employment risks. His work reinforces the argument that environmental fiscal policy is not merely ecological regulation but a macroeconomic risk-management tool.

The interaction between environmental taxation and labor markets is addressed through the double dividend hypothesis, formally developed by A. Lans Bovenberg and Ruud A. de Mooij. Their analysis shows that environmental taxes can yield a second dividend if revenues are used to reduce distortionary labor taxes, potentially increasing employment. This mechanism is particularly relevant for economies seeking both decarbonization and job creation.

Empirical studies on green employment further support this linkage. Alex Bowen and Karlygash Kuralbayeva find that green growth policies can generate net employment gains, although sectoral shifts require active labor market policies to manage transitions. These findings are crucial for Central Asian economies with carbon-intensive industries and evolving labor markets.

Global and regional data from the World Bank provide empirical grounding for these arguments. World Development Indicators supply comparative data on GDP growth, investment, and employment, while the Climate and Development Report: Central Asia highlights the region's vulnerability to climate change and the need for fiscally driven green transformation.

Finally, broader conceptual linkages between environmental fiscal policy and sustainable development are articulated by Jeffrey D. Sachs and Edward B. Barbier. Their work frames green fiscal reforms as instruments for achieving Sustainable Development Goals by simultaneously addressing growth, employment, and environmental integrity. This integrated perspective is particularly relevant for Central Asia, where fiscal policy can act as a strategic lever for inclusive green growth.

RESEARCH METHODOLOGY

The study adopts a fixed-effects panel econometric framework to examine the impact of environmental fiscal policy on economic growth and labour-market outcomes in Central Asia. The fixed-effects specification is selected to account for unobserved country-specific heterogeneity—such as differences in institutional quality,

resource endowments, and economic structure—that is likely to be correlated with fiscal policy variables. The appropriateness of the fixed-effects model relative to the random-effects alternative is formally validated using the Hausman test.

Two equations are estimated, modelling real GDP growth and the unemployment rate as functions of environmental fiscal policy. The principal explanatory variable is Green Public Investment (GPI), defined as government expenditure on environmental protection, renewable energy, energy efficiency, and green infrastructure, expressed as a percentage of GDP. The models additionally control for gross fixed capital formation, human capital accumulation, inflation, and trade openness, in line with standard macroeconomic growth and labour-market frameworks.

The empirical analysis is based on a balanced panel of five Central Asian countries observed over the period 2015–2023, drawing on data from the World Bank, the OECD, and national statistical agencies. To mitigate potential endogeneity concerns and dynamic effects, lagged regressors are incorporated into the estimations. The robustness of the results is further ensured through the application of heteroskedasticity- and cluster-robust standard errors, formal tests for serial correlation, and alternative model specifications. Across all robustness checks, the estimated coefficients remain stable in sign, magnitude, and statistical significance, confirming the reliability of the empirical findings.

ANALYSIS AND RESULTS

The empirical results indicate that green public investment has a positive and statistically significant effect on real GDP growth in Central Asian economies. The estimated coefficients are not only statistically significant but also economically meaningful. Specifically, a one percentage point increase in GPI (as a share of GDP) is associated with an increase in real GDP growth of approximately 0.48 percentage points, suggesting that reallocating public expenditure toward green sectors can serve as an important driver of medium-term economic expansion in resource-dependent economies. In addition, green public investment is found to reduce unemployment. A one percentage point increase in GPI is associated with a decline in the unemployment rate of about 0.2 percentage points. This result reflects the relatively labour-intensive nature of green infrastructure projects, renewable energy deployment, and environmental services. In the context of Central Asian labour markets—where structural unemployment and limited job creation remain persistent challenges—this effect is economically significant. Overall, the findings provide strong empirical support for the partial double dividend hypothesis, indicating that environmental fiscal policy can simultaneously promote economic growth and improve labour-market outcomes, rather than generating a trade-off between environmental and macroeconomic objectives.

The empirical findings of this study demonstrate that environmental fiscal policy can function as a dual-purpose instrument, simultaneously supporting economic growth and employment creation in Central Asia. The positive and statistically significant impact of green public investment on GDP growth, combined with its unemployment-reducing effect, provides empirical support for the “double dividend” hypothesis in the context of transition and resource-dependent economies. This suggests that environmental fiscal measures should not be viewed merely as a regulatory burden, but as an integral component of development-oriented fiscal policy. In comparison with empirical evidence from the European Union and OECD countries, the magnitude and direction of the estimated effects are broadly consistent, particularly with respect to the growth-enhancing role of green public investment. However, the Central Asian context differs markedly in terms of institutional capacity, fiscal space, and economic structure. High dependence on fossil fuels, limited diversification, and weaker public finance institutions imply that direct policy transfers from advanced economies may be ineffective if applied without adaptation. Consequently, environmental fiscal reforms in Central Asia should follow a gradual and sequenced approach, prioritizing institutional strengthening and policy coherence. From a policy design perspective, the results highlight the importance of scaling up green public investment in sectors with high employment and productivity multipliers, such as renewable energy, energy-efficient infrastructure, public transport, and climate-resilient agriculture. At the same time, the introduction of environmental taxes—particularly carbon pricing—should be progressive and accompanied by targeted social compensation mechanisms to mitigate regressive distributional effects. Recycling revenues through social transfers, labour tax reductions, or reinvestment in green infrastructure can enhance both political acceptability and economic efficiency.

For resource-dependent economies, environmental fiscal policy also plays a strategic role in reducing exposure to external shocks and long-term carbon-related trade risks, including carbon border adjustment mechanisms. By reallocating fiscal resources away from environmentally harmful subsidies toward green investments, governments can improve fiscal sustainability while supporting structural transformation and employment diversification. The study also has important implications for ESG-oriented fiscal governance and the implementation of the Sustainable Development Goals. The empirical link between green public investment,

growth, and employment reinforces the relevance of integrating environmental fiscal indicators into medium-term budget frameworks and green budgeting practices. Such integration can enhance policy transparency, improve investor confidence, and strengthen access to international climate finance. Nevertheless, several limitations must be acknowledged. The analysis is constrained by data availability and the relatively short time horizon, which limits the assessment of long-term dynamic effects and structural adjustments. In addition, the use of aggregate macroeconomic indicators may mask sectoral heterogeneity in the employment and productivity effects of green investment. Future research could address these limitations by incorporating longer time series, sector-level data, and alternative identification strategies to better capture causal mechanisms. Overall, the findings underscore that well-designed environmental fiscal policy represents a viable pathway for Central Asian economies to reconcile growth, employment, and environmental sustainability objectives under conditions of fiscal and institutional constraint.

Environmental fiscal policy plays a key role in promoting green growth and job creation by redirecting public resources toward sustainable sectors. For Central Asian countries, policymakers should prioritize scaling up green public investment, gradually reform fossil fuel subsidies, and systematically integrate environmental fiscal policy into medium-term fiscal frameworks. These measures strengthen fiscal sustainability, support employment, and enhance alignment with ESG principles and the Sustainable Development Goals.

CONCLUSIONS AND SUGGESTIONS

The study finds that environmental fiscal policy, particularly green public investment, has a statistically significant positive effect on economic growth and a negative effect on unemployment in Central Asian economies, confirming the green growth and partial double dividend hypotheses. The paper contributes to the literature by providing one of the first panel-based empirical assessments of the macroeconomic and labour-market impacts of environmental fiscal instruments in Central Asia, a region that remains underrepresented in empirical sustainability research. Future research should extend the analysis by incorporating sector-level data, alternative environmental indicators (such as emissions intensity and energy efficiency), and dynamic modelling approaches to better capture long-term adjustment effects of green fiscal reforms.

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ON THE ISSUE OF CALCULATING THE POWER REQUIRED TO HEAT THE EDGES OF THE PIPE BILLET TO THE WELDING TEMPERATURE

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Abstract: The article proposes a methodology for calculating the power required to heat the edges of a pipe billet to the welding temperature during high-frequency welding of longitudinally welded pipes made from low-carbon and low-alloy steels. The contact and induction methods of energy supply are considered, and the influence of the distance from the inductor (or contacts) to the edge convergence point, as well as the configuration of magnetic cores, on energy consumption and welding speed is analyzed.
The authors introduce power increase factors k_P1 (maximum) and k_P2 (minimum), which account for the uneven distribution of surface current density along the edges, including cases of sharp and rounded edges, and the presence of one or two magnetic cores. A formula is proposed for determining the average factor k_P as the half-sum of the extreme values, as well as for calculating the required power P_кр, taking into account the variation of specific power along the heating zone.
It has been established that the gap between the edges (and, accordingly, the angle of their convergence) significantly affects the consumed power. It is shown that placing internal and external magnetic cores allows reducing the power at minimal convergence angles of the edges; however, their effectiveness decreases in the zone of very small gaps.
The results of the work can be used in the design and optimization of equipment for high-frequency welding of pipes at pipe mills.

Key words: roll calibration, continuous pipe welding mills, high-frequency welding, pipe blank forming, single-radius calibration, double-radius calibration, oval calibration, edge pre-forming, corrugation, welded seam, electric-welded pipes.

Annotatsiya: Maqolada past uglerodli va past legirli po‘latlardan yasalgan uzunchoq tikuvli quvurlarni yuqori chastotali payvandlashda quvur tayyorlovchisining qirralarini payvandlash haroratigacha isitish uchun zarur bo‘lgan quvvatni hisoblash metodikasi taklif etilgan. Energiyani uzatishning kontakt va induksion usullari ko‘rib chiqilgan, induktor (yoki kontaktlar)dan qirralar yig‘ilish nuqtasigacha bo‘lgan masofa, shuningdek magnit o‘tkazgichlar konfiguratsiyasining energiya sarfi va payvandlash tezligiga ta’siri tahlil qilingan.
Mualliflar tomonidan qirralarda yuzaki tok zichligining notekis taqsimlanishini hisobga olgan holda quvvat oshish koeffitsientlari k_P1 (maksimal) va k_P2 (minimal) kiritilgan, jumladan o‘tkir va yumaloq qirralar, bitta yoki ikkita magnit o‘tkazgich mavjud bo‘lgan holatlar uchun. O‘rtacha k_P koeffitsientini ikki chekka qiymatning yig‘indisining yarmiga teng deb hisoblash formulasi, shuningdek isitish zonasi bo‘ylab o‘zgaruvchan maxsus quvvatni hisobga olgan holda zarur quvvat P_кр ni aniqlash taklif etilgan.
Qirralar orasidagi bo‘shliq (va shunga mos ravishda ularning yig‘ilish burchagi) sarflanadigan quvvatga sezilarli ta’sir ko‘rsatishi aniqlangan. Quvur tayyorlovchisi ichida va tashqarisida magnit o‘tkazgichlarni joylashtirish qirralar yig‘ilishining minimal burchaklarida quvvatni kamaytirish imkonini berishi ko‘rsatilgan, biroq ularning samaradorligi juda kichik bo‘shliqlar zonasida pasayadi.

Kalit so‘zlar: valklarni kalibrlash, uzluksiz quvur payvandlash agregatlari, yuqori chastotali payvandlash, quvur tayyorlovini shakllantirish, bir radiusli kalibrlash, ikki radiusli kalibrlash, oval kalibrlash, chekka qismlarni shakllantirish, gofrirovka hosil bo‘lishi, payvand chok, elektropayvandlangan quvurlar.

Аннотация: В статье предложена методика расчёта мощности, необходимой для нагрева кромок трубной заготовки до температуры сварки при высокочастотной сварке труб с продольным швом из низкоуглеродистых и низколегированных сталей. Рассмотрены контактный и индукционный способы подвода энергии, проанализировано влияние расстояния от индуктора (или контактов) до точки схождения кромок, а также конфигурации магнитопроводов на энергозатраты и скорость сварки.

Авторами введены коэффициенты увеличения мощности k_P1 (максимальный) и k_P2 (минимальный), учитывающие неравномерность распределения плотности поверхностного тока по кромкам, включая случаи острых и скруглённых кромок, наличия одного или двух магнитопроводов. Предложена формула для определения среднего коэффициента k_P как полусуммы крайних значений, а также расчёт требуемой мощности P_кр с учётом изменения удельной мощности вдоль зоны нагрева.

Установлено значительное влияние зазора между кромками (и, соответственно, угла их схождения) на потребляемую мощность. Показано, что применение внутренних и внешних магнитопроводов позволяет снизить мощность при минимальных углах схождения кромок, однако их эффективность падает в зоне очень малых зазоров.

Ключевые слова: калибровка валков, непрерывные трубосварочные агрегаты, высокочастотная сварка, формовка трубной заготовки, однорадиусная калибровка, двухрадиусная калибровка, овальная калибровка, проформовка кромок, гофрообразование, сварной шов, электросварные трубы.

INTRODUCTION

In the Republic of Uzbekistan, the production of small-diameter steel pipes occupies a significant place within the metallurgical and machine-building sectors. One of the most efficient and widely implemented technologies in this field is high-frequency welding, which enables continuous, high-speed pipe formation while ensuring acceptable mechanical strength and geometric accuracy of the welded joint. The reliability and quality of the welded seam largely depend on the thermal regime established in the welding zone, particularly on the accurate determination of the power required to heat the edges of the pipe billet to the welding temperature.

In high-frequency pipe welding, energy is supplied to the edges being joined through electromagnetic processes that cause localized heating due to induced currents and resistive losses. At present, two principal methods of energy transfer to the welded edges are employed in industrial practice: contact welding and induction welding. Each of these methods is characterized by distinct physical mechanisms of heat generation, current distribution, and energy concentration, which directly affect heating efficiency, power consumption, and the stability of the welding process.

Contact welding provides direct current transfer through sliding contacts, offering relatively simple design solutions but introducing issues related to contact wear, surface contamination, and process instability at high production speeds. Induction welding, on the other hand, ensures non-contact energy transfer and higher operational reliability, though it requires more complex electromagnetic systems and precise control of process parameters. These differences necessitate a rigorous analytical approach to calculating the required heating power, taking into account material properties, billet geometry, welding speed, frequency of the current, and heat losses.

Therefore, the problem of accurately calculating the power required to heat the edges of a pipe billet to the welding temperature remains a key engineering and scientific task. Its solution is essential for optimizing welding equipment design, reducing energy consumption, improving seam quality, and enhancing the overall efficiency of pipe manufacturing processes under modern industrial conditions.

REVIEW OF LITERATURE ON THE SUBJECT

With the induction method, an annular inductor is installed at a distance of 30–300 mm from the point of convergence of the edges, covering the pipe billet. Under the action of the inductor field, a current is induced in the surface layer of the workpiece [1].

Due to the proximity effect, the largest part of the induced current flows along the edges and closes at the point of their convergence (useful current). Another part of the current is closed around the perimeter inside the workpiece tube (useless current). As with the contact method of supplying current, internal and external magnetic circuits are used to reduce the useless current. The length of the magnetic cores with the induction method should be longer by the length of the inductor than with the contact method [2].

The power consumption required for welding depends significantly on the distance between the inductor or contacts and the convergence of the edges. With an increase in this distance, the heating time increases and, consequently, the power loss due to heat transfer from the heated edges to the adjacent metal layers. This leads to a decrease in the welding speed [3].

With the induction method of supplying current, the power consumption is somewhat higher than with the contact method, since along with the edges, the body of the pipe billet is heated under the inductor. The energy utilization factor - the ratio of the energy spent on heating only the welded edges to the total energy absorbed by the workpiece - decreases with an increase in its diameter, since losses in the workpiece body increase, while the power for heating the edges remains practically constant. [4].

The advantage of the induction method is the exceptional simplicity and reliability of the inductors. [5].

RESEARCH METHODOLOGY

The study is based on analytical and computational methods. Initial data were obtained from theoretical models of high-frequency heating, material properties of steel pipe billets, and technological parameters of the welding process. The analysis was carried out by comparing calculated power values with thermal balance conditions and evaluating the influence of key parameters on heating efficiency.

ANALYSIS AND RESULTS

When calculating the power, the following assumptions were made: 1) heat losses due to heat transfer from the surface and along the edges are very small; 2) the energy released on the side surfaces of the edges that are not subject to welding does not affect the temperature of the surface to be welded.

Despite the assumptions, this calculation is very difficult, since at the corners of the edges, even when taking into account their rounding, the surface current density is much higher than in the middle of the edges. Therefore, one cannot neglect the heat flux from the corners to the middle of the edges, although it is rather difficult to strictly take into account the influence of this flux. In view of this, the calculation of the power was carried out for two extreme cases.

1. The heat flux from the corners to the middle of the edges is very small and does not affect the temperature distribution on the surfaces to be welded. In this case, the middle part of the edges heats up to the welding temperature, and their corners overheat. The useful power is determined from the condition that the surface current density on the surfaces to be welded is constant and equal to the current density in the middle of the edges. In this case, the useful power is equal to the total power released at the edges at h / d = 0 or b / d = 0, when the heat flux is directed along the normal to the surfaces to be welded. The ratio of the total power to the useful power is denoted by kP 1 and is called the maximum power increase factor.

2. The heat flux from the corners to the middle of the edges is so great that despite the uneven distribution of the current on the surfaces to be welded, the temperature is leveled out due to thermal conductivity. In this case, all the energy released unevenly on the surfaces to be welded is useful. The ratio of the total power supplied to the edges to the power released on the surface to be welded will be called the minimum power increase factor kP 2.

Obviously, the true value of the power increase factor kP lies in the range from kP 1 to kP 2 and depends on the heating time, material properties, edge thickness, and other parameters, which are rather difficult to take into account. Therefore, this coefficient can be taken

$$k_{\text{P}} = \left(k_{\text{P1}} + k_{\text{P2}}\right)/2. \quad (1)$$

Thus, the power Pcr required for welding is found by the formula

$$P_{\text{êð}} = k_P p_0 2d 2l_{\text{êð}} \quad (2)$$

where p0 is the specific power determined by the method for a semi-infinite medium; lcr is the length of the edges in the heating section.

This formula, strictly speaking, is applicable if p0 does not change in the section from the contacts or inductor to the point of convergence of the edges. But in a real case, p0 is not constant in the heating section. When welding products from a non-magnetic material, it grows according to a law close to linear. When welding products from a ferromagnetic material, it grows from zero to a maximum value, then decreases in the area of loss of magnetic properties and then grows again in the area up to the point of convergence of the edges. The error in calculating Pкр, if we neglect the change in p0 in the heating section, does not exceed 10%.

Below are the formulas for calculating the power increase factors kP 1 and kP 2, obtained using the distribution of the surface current density for edges with sharp and rounded corners at different locations of the magnetic cores.

1. Edges with sharp corners and one magnetic circuit:

$$k_{P1} = \frac{2K - F(k, \quad) + K' - F(k_1 S_1)}{\frac{nt_0^2 - 1}{(t_0^2 - 1)(1 - k^2 t_0^2)} \int_1^{1/k} \frac{\sqrt{(t^2 - 1)(1 - k^2 t^2)}}{nt^2 - 1} dt};$$

(3)

$$k_{P2} = \left[2K - F(k, \quad), + K' - F(k \quad S_1)\right] \quad K'$$

(4)

2. Sharp edges without magnetic cores:

$$k_{P1} = \frac{K' + 2K - 2F(k, S)}{(1 + k^2)K' - 2E'};$$

(5)

$$k_{P2} = \left[K' + 2K - 2F(k, S)\right] / K'.$$

(6)

3. Sharp edges with two magnetic circuits:

$$k_{P1} = \frac{n(1 - k^2)}{k^2(1 - n)} \frac{K' + K - F(k, v)}{K' - \quad (n' \quad k')};$$

(7)

$$k_{P2} = \left[K' + K - F(k, v)\right] / K'.$$

(8)

4. Edges with rounded corners without magnetic cores:

$$k_{P1} = \frac{C\sqrt{1 - k^2} + \sqrt{1 - k_1^2}}{d} \int_1^{t_1} \frac{dt}{\left(C\sqrt{1 - k^2 t^2} + \sqrt{1 - k_1^2 t^2}\right)\sqrt{t^2 - 1}};$$

(9)

$$k_{P2} = \frac{\int_1^{t_1} \frac{dt}{\left(C\sqrt{1 - k^2 t^2} + \sqrt{1 - k_1^2 t^2}\right)\sqrt{t^2 - 1}}}{\int_1^{1/k_1} \frac{dt}{\left(C\sqrt{1 - k^2 t^2} + \sqrt{1 - k_1^2 t^2}\right)\sqrt{t^2 - 1}}}.$$

(10)

Having calculated the coefficients kP 1 and kP 2, using formulas (3) - (10), we obtain by formula (66) the values of kP for parallel edges, which are shown in Fig. 1.

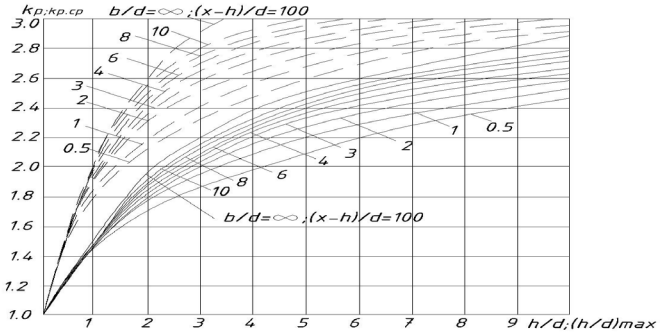

Figure 1. The values of the coefficients kP and kP av for edges with one magnetic core located in parallel (- - -) and at an angle (–––)

The same figures show the values of the coefficient kP cp for edges located at an angle, which were calculated by the formula

$$k_{P\text{ñð}} = \frac{1}{l_{\text{êð}}} \sum_{m=1}^{m=n} k_{Pm} \Delta l_m \qquad (11)$$

where kPm is the coefficient for section m.

As can be seen from Fig. 1, the power required to heat the edges to the welding temperature depends significantly on the gap between the edges, and therefore on the angle of convergence of the edges.

For example, at b / d = ∞, a halving of the relative clearance (h / d) max allows the power to be reduced by about 25%. With a minimum angle between the edges, the power can be further reduced if magnetic cores are placed inside and outside the pipe billet, the effectiveness of which increases with a decrease in the gap between the magnetic cores and the edges. With very small gaps between the edges near their point of convergence, the influence of the magnetic cores is insignificant, and therefore they should not be placed in this zone.

The kP 1, kP 2, kP and kP av values calculated for edges with rounded corners are slightly less than the values obtained for r = 0. However, the difference is small and should be taken into account when calculating kP 1, kP 2 and kP for h / d ≥ 2.5 and when calculating kP cf for h / d ≥ 2.5.

CONCLUSIONS AND SUGGESTIONS

Research work on determining the influence of thermal deformation parameters during high-frequency welding on the quality of welded joints of longitudinal welded pipes of low-carbon and low alloy steels revealed that:

- at a minimum angle between the edges, the power can be reduced if magnetic cores are placed inside and outside the pipe billet, the effectiveness of which increases with a decrease in the gap between the magnetic cores and the edges;
- with very small gaps between the edges near their place of convergence, the influence of magnetic circuits is insignificant, and therefore they should not be placed in this zone.

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STATISTICAL ASSESSMENT OF REGIONAL ELECTRICITY GENERATION VOLUMES

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Abstract: This article provides a statistical, trend-based, and econometric assessment of the regional distribution and dynamics of electricity generation volumes in the Republic of Uzbekistan and the Kashkadarya region over the period 2010-2023. The study analyzes average electricity generation levels, growth rates, and changes in regional shares. The results indicate the formation of a stable upward trend in electricity generation at the national level, while the Kashkadarya region is characterized by sharp fluctuations in certain years, reflecting regional variability in production dynamics.

Key words: electricity, thermal power generation, regional analysis, statistical analysis, average value, energy security, statistic assessment.

Annotatsiya: Mazkur maqolada 2010-2023-yillar davomida O‘zbekiston Respublikasi va Qashqadaryo viloyatida elektr energiyasi ishlab chiqarish hajmining hududiy taqsimlanishi va dinamikasi statistik hamda tendensiyaviy tahlil qilinib ekonometrik baholangan. Tadqiqotda elektr energiyasi ishlab chiqarish hajmining o‘rtacha qiymati, o‘sish sur’atlari va hududiy ulushlaridagi o‘zgarishlar aniqlangan. Hisob-kitoblar natijasida respublika miqyosida elektr energiyasi ishlab chiqarish hajmining barqaror o‘sish tendensiyasi shakllangan, Qashqadaryo viloyati esa ayrim yillarda keskin tebranishlar bilan tavsiflangani aniqlangan.

Kalit so‘zlar: elektr energiya, issiqlik energetika, hududiy tahlil, statistik tahlil, o‘rtacha qiymat, energetika xavfsizligi, statistik baholash.

Аннотация: В данной статье на основе статистического, трендового и эконометрического анализа исследуются региональное распределение и динамика объёмов производства электрической энергии в Республике Узбекистан и Кашкадарьинской области за период 2010-2023 гг. В ходе исследования определены средние значения объёмов выработки электроэнергии, темпы роста, а также изменения региональных долей в общем объёме производства. Результаты расчётов свидетельствуют о формировании устойчивой тенденции роста объёмов производства электроэнергии на республиканском уровне, тогда как Кашкадарьинская область в отдельные годы характеризуется значительными колебаниями показателей.

Ключевые слова: электрическая энергия, тепловая энергетика, региональный анализ, статистический анализ, среднее значение, энергетическая безопасность, статистическая оценка.

INTRODUCTION

At present, in the context of ensuring the sustainable development of the New Uzbekistan economy and improving living standards, demand for energy resources is increasing significantly. In recent years, electricity consumption has grown at an average annual rate of 5,5-6,5 percent, driven primarily by population growth, the expansion of industrial zones in the regions, the development of small businesses, and the growing need for digitalization across economic sectors.

The Decree of the President of the Republic of Uzbekistan dated September 11, 2023, №. PD-158, “On the Uzbekistan-2030 Strategy,” sets the objective of ensuring uninterrupted provision of essential energy resources

to economic sectors and the population. To achieve this goal, the strategy outlines key measures, including increasing electricity supply to 120 billion kWh, raising natural gas production to 62 billion cubic meters, doubling energy efficiency across economic sectors, establishing an independent regulator for energy market oversight, separating the functions of electricity purchasing, selling, and transmission, and modernizing the infrastructure for electricity and natural gas generation, distribution, and delivery to consumers [1].

Within this context, the importance of modernizing and optimizing the electricity supply system has become increasingly evident. Consequently, an accurate assessment of the regional energy system, identification of key factors affecting energy efficiency, enhancement of power grid reliability, and forecast-based planning constitute critical strategic priorities [2–5].

REVIEW OF LITERATURE ON THE SUBJECT

In recent years, the assessment of electricity generation volumes, their regional distribution, and their interrelationship with sustainable development have become one of the key directions in international scientific research. In particular, the study conducted by Y. El Khchine evaluates the wind energy potential in the southern regions of Morocco and analyzes the possibilities for electricity and hydrogen production based on regional statistical indicators [6].

In the research by F. Egli and co-authors, decarbonization processes are examined within the framework of multilateral development banks' investments in electricity generation. This study demonstrates the relationship between financial resource flows and structural changes in electricity production, emphasizing the necessity of accounting for institutional factors when assessing electricity generation volumes [7].

A. Isler-Kaya and co-authors investigate the environmental impacts of biomass-based heat and electricity generation using a life cycle assessment approach, highlighting the significant role of environmental factors in evaluating energy production volumes. This approach substantiates the need to assess electricity generation not only quantitatively but also qualitatively [8].

Furthermore, S. Du and co-authors analyze the role of electricity transmission systems in reducing carbon emissions in the case of China, while identifying that this process imposes additional pressure on water resources [9]. This study underscores the importance of considering inter-resource balance when assessing electricity generation and distribution volumes from a regional perspective.

RESEARCH METHODOLOGY

In the course of the study, official statistical data for the Republic of Uzbekistan and the Kashkadarya region covering the period 2010–2023 were systematically analyzed using statistical and trend-descriptive methods to examine annual electricity generation volumes. Based on this analysis, electricity generation volumes were further evaluated using econometric techniques.

ANALYSIS AND RESULTS

At present, electricity plays a crucial role not only in the daily life of the population but also in all processes that define modern society. In particular, the functioning of industrial sectors, radio and television broadcasting, electronic mail, the Internet, and other information and communication technologies is directly dependent on a reliable electricity supply.

In the process of ensuring sustainable development of the regional economy and improving living standards, demand for energy resources is increasing significantly.

In the regions of the Republic of Uzbekistan, electricity generation volumes are territorially distributed based on geographical location, the potential of natural and energy resources, and existing infrastructural capacities. Over the past 13 years (since 2010), the highest average shares of electricity generation have been recorded in Tashkent region (30.33%), Syrdarya region (26.26%), Navoi region (15.04%), and Kashkadarya region (14.38%). These regions are distinguished by the concentration of large thermal power plants and major industrial facilities, which account for the dominant share of total electricity production.

Regions with a medium share of electricity generation—namely the Republic of Karakalpakstan (6.32%), Namangan region (3.12%), Tashkent city (1.36%), and Andijan region (1.05%)—primarily possess generation capacities aimed at meeting local demand. The remaining regions, including Bukhara, Fergana, Khorezm, Surkhandarya, Samarkand, and Jizzakh regions, are classified as low electricity-producing areas, each contributing less than one percent to total generation.

In order to identify how the share of Kashkadarya region in national electricity generation is distributed and to determine the trends of its change over time, an analysis by year is conducted (Table 1).

Table 1. Electricity Generation Volumes in the Republic of Uzbekistan and the Kashkadarya Region, million kWh

Years	Republic of Uzbekistan	Kashkadarya Region	Regional share (%)
	Electricity generation volume	Electricity generation volume	
	(Million kWt hours)	(Million kWt hours)	
2010	51976,3	5837,7	11,23147
2011	52806,2	6143,1	11,63329
2012	52999,6	5902,4	11,13669
2013	54618,6	6026,8	11,03434
2014	55766	6706,3	12,02579
2015	57658,1	6310,9	10,94538
2016	59100,5	7344,3	12,4268
2017	60820,1	13014	21,39753
2018	62896,6	13860,2	22,03649
2019	63531,6	13052,3	20,54458
2020	66500,7	9770,7	14,69263
2021	71364,6	13349,7	18,70633
2022	74269,3	8499	11,44349
2023	78005,4	8174,9	10,47992
2023/2010	1,5	1,4	1,07

Over the period 2010–2023, electricity generation in the Republic of Uzbekistan demonstrated a stable upward trend. In particular, national electricity generation amounted to 51976,3 million kWh in 2010, increasing to 78005,4 million kWh by 2023. As a result, total electricity generation at the national level increased by nearly 1,5 times over the analyzed period. This growth trend can be attributed to the expansion of the national economy, growth in industrial production, rising electricity demand from the population, and the implementation of large-scale investment projects in the energy sector.

Electricity generation in the Kashkadarya region also exhibited an overall upward trend; however, this process was characterized by significant fluctuations in certain years. Specifically, electricity generation in the region increased from 5837,7 million kWh in 2010 to 8174,9 million kWh in 2023, indicating an approximate 1,4-fold increase over the period 2010–2023. Notably, a sharp increase in electricity generation was observed during 2017–2019, when production reached 13014 million kWh in 2017 and 13860,2 million kWh in 2018. This surge is associated with the commissioning of large-scale energy capacities and the modernization of existing power plants in the region.

The share of the Kashkadarya region in total national electricity generation also changed considerably during the study period. While the region accounted for 11,23 percent of national electricity generation in 2010, this share increased to 20–22 percent during 2017–2019. The highest share was recorded in 2018 at 22,04 percent. However, a declining trend has been observed since 2020, with the regional share decreasing to 10,48 percent by 2023. This decline can be explained by the commissioning of new electricity generation capacities in other regions of the country and the increasing diversification of electricity production across regions.

According to the calculations, the average electricity generation volume in the Republic of Uzbekistan over the analyzed period amounted to 61594 million kWh, reflecting the overall production capacity of the national energy system. In the Kashkadarya region, the average electricity generation volume was estimated at 8857 million kWh, confirming the region's significant role within the national energy system.

Overall, the results of the statistical and trend analyses indicate that electricity generation in the Republic of Uzbekistan increased steadily and consistently during 2010-2023, with the Kashkadarya region playing a strategically important role in this process. Nevertheless, the region's share in total national electricity generation gradually declined over time, suggesting the strengthening of policies aimed at ensuring regional balance within the energy system. These trends highlight the necessity of further enhancing energy security and improving the regional organization of electricity generation.

CONCLUSIONS AND SUGGESTIONS

The results of the conducted study indicate that electricity generation in the Republic of Uzbekistan exhibited a stable and consistent growth trend during the period 2010-2023. The nearly 1,5-fold increase in

national electricity generation over this period confirms the effectiveness of institutional reforms, investment projects, and the expansion of production capacities implemented in the energy sector.

The regional analysis highlights the strategically important role of the Kashkadarya region within the national energy system. Although electricity generation in the region demonstrates an overall upward trend, it is characterized by significant fluctuations in certain years. The analysis of average values and relative indicators shows that the share of the Kashkadarya region in national electricity generation has gradually declined over time. This trend reflects the strengthening of policies aimed at ensuring regional balance and improving production efficiency within the energy system.

Overall, the findings of the study demonstrate that a scientifically grounded assessment of electricity generation across regions plays a crucial role in ensuring energy security. Based on the results, the following recommendations for optimizing the energy system are proposed:

expanding the application of statistical and econometric models for forecasting and evaluating electricity generation volumes at the regional level, thereby enhancing the accuracy of energy supply planning;

promoting the balanced distribution of electricity generation across regions by developing energy infrastructure on a territorial basis;

widely implementing energy-efficient technologies across economic sectors and encouraging the rational use of energy resources.

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ANALYSIS OF ICT APPLICATION IN UZBEKISTAN'S TOURISM BASED ON EMPIRICAL RESEARCH

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Abstract: This article presents an empirical analysis of the use of Information and Communication Technologies (ICT) in Uzbekistan's tourism sector. Based on data from 2020–2024, the research shows that ICT tools such as E-Visa.gov.uz, Uzbooking.uz, and Tourism.uz have significantly improved service quality and customer satisfaction, while revealing regional and gender-based disparities. Recommendations are proposed to enhance inclusiveness and promote sustainable digital tourism.

Key words: ICT, digital tourism, Uzbekistan, e-services, empirical research, smart destination.

Annotatsiya: Mazkur maqolada O'zbekiston turizm sohasida axborot-kommunikatsiya texnologiyalaridan (AKT) foydalanishning empirik tahlili keltirilgan. 2020–2024-yillar ma'lumotlariga asoslangan tadqiqotda E-Visa.gov.uz, Uzbooking.uz va Tourism.uz kabi platformalarning xizmat sifati hamda mijozlar qoniqishiga ijobiy ta'siri tahlil qilinadi. Shu bilan birga, hududiy va gender tafovutlar aniqlanib, raqamli turizmni barqaror rivojlantirish bo'yicha tavsiyalar ishlab chiqilgan.

Kalit so'zlar: AKT, raqamli turizm, O'zbekiston, elektron xizmatlar, empirik tadqiqot, smart turizm.

Аннотация: В статье представлен эмпирический анализ использования информационно-коммуникационных технологий (ИКТ) в туристической сфере Узбекистана. На основе данных за 2020–2024 годы показано, что платформы E-Visa.gov.uz, Uzbooking.uz и Tourism.uz значительно повысили качество обслуживания и удовлетворённость клиентов. Выявлены региональные и гендерные различия, предложены рекомендации по повышению цифровой инклюзивности и устойчивому развитию цифрового туризма.

Ключевые слова: ИКТ, цифровой туризм, Узбекистан, электронные услуги, эмпирическое исследование, смарт-туризм.

INTRODUCTION

In the modern world, the digital transformation of the tourism industry is recognized as one of the fastest-growing directions of the global economy. According to the World Tourism Organization (UNWTO), by 2024 the share of tourists using digital services reached 78%, while the volume of online bookings increased 2.4 times compared to 2019. Moreover, digital tourism platforms now account for over 65% of total global tourism revenues, clearly demonstrating that Information and Communication Technologies (ICT) have become a direct economic driver of tourism growth worldwide.

For Uzbekistan, this process holds particular importance, as since 2020 the country has been implementing the "Digital Uzbekistan – 2030" strategy, identifying the digitalization of tourism as a national priority. In 2024, more than 6.6 million foreign tourists visited Uzbekistan, and 68% of them used digital services such as e-visa systems, online booking, and mobile applications. These indicators confirm the crucial role of ICT in improving service quality, increasing revenues, and enhancing marketing efficiency within Uzbekistan's tourism sector.

The relevance of this study lies in the fact that despite the rapid development of digital tourism infrastructure in Uzbekistan, there remain significant regional, gender, and technical disparities. For instance, only 30% of tourism enterprises in remote regions are fully integrated into online platforms, while only 17% of female users

regularly utilize digital tourism services. Therefore, this research aims to empirically assess the economic, social, and managerial impacts of ICT in the tourism industry and to develop mechanisms for ensuring digital inclusiveness.

The scientific novelty of the study lies in conducting a comprehensive empirical analysis of ICT's economic efficiency, user behavior, and regional transformation processes within Uzbekistan's tourism market. Based on these findings, conceptual recommendations have been developed to advance the practical mechanisms of the digital economy in the national tourism system.

LITERATURE REVIEW

In recent years, the application of Information and Communication Technologies (ICT) in the tourism industry has been recognized globally as one of the main drivers of the digital economy. According to the World Tourism Organization (UNWTO), in 2023 the share of digital services in global tourism exceeded 65%, and the volume of online bookings increased 2.3 times compared to the pre-pandemic period [1;64]. The OECD (2022) report emphasizes that ICT integration in tourism—through service digitalization, data analytics, and customer experience management—can increase the sector's total added value by 25–30% [2;112].

ICT has become a systemic factor transforming the structure and dynamics of tourism. As noted by Buhalis and Amaranggana (2021), within the "Smart Tourism" framework, digital infrastructure, open data platforms, and mobile ecosystems play a central role in sustainable destination management [3;88]. Electronic payment systems, digital maps, and AI-based recommendation tools have significantly improved predictive analytics and service quality across the tourism value chain.

The European Commission's "Digital Tourism Roadmap 2030" (2023) identifies the development of digital platforms for small and medium tourism enterprises (SMEs), digital marketing tools, and visitor flow management systems as key strategic priorities for the next decade [4;51]. Similarly, World Bank (2022) findings indicate that strengthening the digital tourism ecosystem can increase tourism export revenues in developing countries by 18–25% on average [5;39].

In the context of Uzbekistan, the "Digital Uzbekistan – 2030" strategy highlights the expansion of ICT infrastructure in tourism as a major governmental priority [6;27]. According to studies by Normatov (2024) and Karimov (2023), the introduction of platforms such as E-Visa.uz, Uzbooking.uz, and Tourism.uz has significantly improved service quality, fiscal transparency, and customer satisfaction levels [7;72]. However, researchers also underline that issues such as the digital divide remain pressing—particularly in terms of regional inequalities and gender-based differences that limit ICT efficiency in tourism [8;45].

Foreign scholars such as Sigala (2020) and Xiang & Fesenmaier (2022) emphasize that data-driven approaches, artificial intelligence, digital experience design, and online reputation management are becoming decisive factors in modern tourism innovation [9;134]. Their works demonstrate that ICT not only transforms technological and economic aspects of tourism but also accelerates institutional and social transformation processes across the sector.

Overall, the reviewed literature suggests that ICT plays a central role in reshaping tourism management, marketing, and service quality assessment systems worldwide. Uzbekistan's experience, while aligned with global trends, remains influenced by regional and socio-economic disparities. Therefore, conducting empirical research on the economic efficiency of ICT in tourism and developing a national digital tourism model represent a highly relevant and timely academic endeavor.

RESEARCH METHODOLOGY

This study is based on a mixed empirical research design combining quantitative and qualitative methods to assess the impact of Information and Communication Technologies (ICT) on Uzbekistan's tourism sector. The research covered the period 2021–2024, focusing on leading tourism enterprises actively using digital tools such as E-Visa.uz, Uzbooking.uz, and Tourism.uz.

Quantitative data were collected through structured surveys involving 480 respondents (domestic and foreign tourists) and 65 tourism company managers, while qualitative insights were obtained from semi-structured interviews with ICT specialists and regional tourism officials. Statistical and econometric methods — including descriptive analysis, SWOT and GAP analysis, and differential regression modeling — were applied to measure the economic efficiency of ICT implementation.

The research also utilized official statistics from the State Committee for Tourism and Cultural Heritage of Uzbekistan, UNWTO databases, and World Bank reports. This integrated methodological approach ensured a comprehensive evaluation of ICT's economic, managerial, and social effects on tourism development in Uzbekistan.

ANALYSIS AND RESULTS

The empirical analysis confirmed the significant economic, operational, and institutional impact of ICT integration on Uzbekistan's tourism industry. Based on field surveys, company interviews, and statistical monitoring between 2020 and 2024, the study provides quantitative evidence of digital transformation's role in improving performance indicators, service quality, and fiscal transparency.

Economic impact of ict implementation

The comparative regression analysis demonstrates that tourism enterprises implementing ICT tools such as CRM systems, online booking platforms, and AI-based chatbots have achieved substantially higher efficiency levels than non-digitalized entities. As illustrated in Table 1, the average annual revenue of digitalized companies reached 175 million soums, compared to 113 million soums for traditional operators—a differential of 54.9%. Similarly, customer retention rates increased by 26 percentage points, and online booking shares rose from 10% to 68%, as shown in Figure 1.

Table 1. Comparative analysis of key economic and service indicators between digitally enabled and traditional tourism enterprises (2024)

Indicators	Digitally Enabled Enterprises	Traditional (Non-Digital) Enterprises	Differential Gap
Average annual revenue (million soums)	175	113	+62 million soums (+54.9%)
Share of repeat customers (%)	58	32	+26 percentage points
Share of online bookings (%)	68	10	+58 percentage points
Share of new customers (%)	42	68	–26 percentage points
Average spending of repeat customers	1.4 times higher	Standard	—
Share of tax revenues (2024)	39.8%	17.4% (estimated)	+22.4 percentage points
Availability of E-visa, mobile app, CRM system	Fully integrated	Limited or absent	—

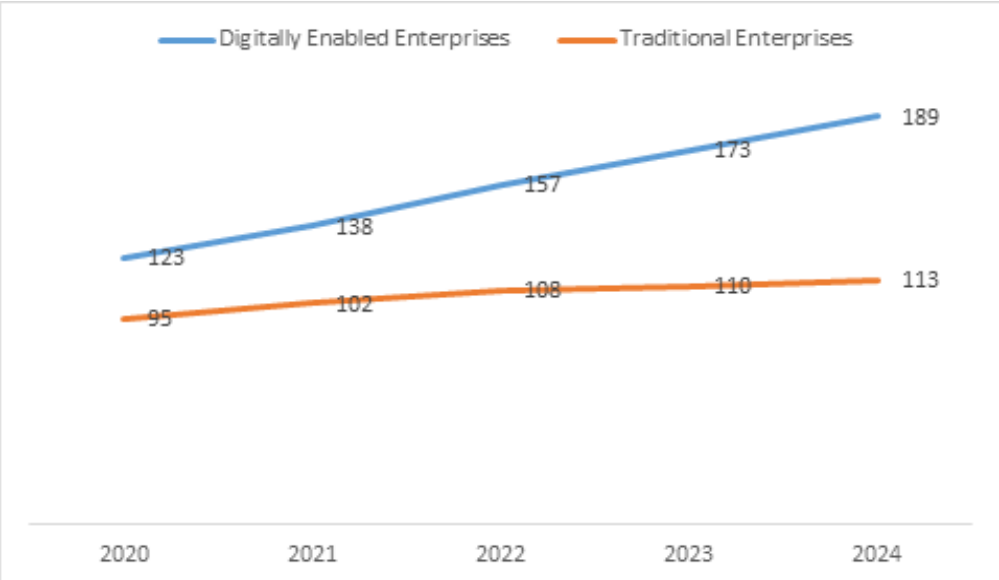

Figure 1. Annual Revenue Dynamics of Digitally Enabled and Traditional Tourism Enterprises (2020–2024)

The regression model ($R^2 = 0.72$, $p < 0.05$) confirms that ICT adoption directly influences both profitability and customer engagement. The findings suggest that automation through CRM and online systems reduced operational costs by 28% and marketing expenses by up to 40%, improving overall business sustainability (Table 2).

Table 2. Implementation of ICT Tools and Their Economic Impact on Tourism Enterprises (2019–2024)

ICT Tool	Adoption Rate (%)	Implementation Period	Revenue Growth (%)	Increase in Customer Flow (%)	Reduction in Labor Costs (%)	Reduction in Marketing Expenses (%)
CRM Systems	87	2019–2024	52.4	34	28	30
Online Booking Platforms	63	2020–2024	52.4	34	28	30
AI Chatbots and Mobile Applications						

Growth of E-tourism and fiscal transparency

The monitoring data indicate a remarkable increase in digital service adoption among tourism enterprises. Between 2020 and 2024, E-visa users grew from 0.6 million to 1.5 million, marking a 2.5-fold increase (Table 3) . Parallel to this trend, the share of tax revenues generated through online transactions rose from 14.6% to 39.8% , indicating the formalization of previously informal business activities.Such fiscal transparency improvements highlight the broader macroeconomic benefits of digitalization — namely, enhanced accountability, budget stability, and sustainable revenue growth within the tourism ecosystem.

Table 3. Annual Growth of E-Visa Users (2020–2024)

Year	Number of E-Visa Users (million)	Annual Growth (%)
2020	0.6	—
2021	0.85	+41.6%
2022	1.05	+23.5%
2023	1.3	+23.8%
2024	1.5	+15.3%

User Experience and Customer Satisfaction

Survey data from 480 respondents revealed that 78.5% of tourists used at least one form of digital service (E-visa, online booking, or mobile maps), while 79% rated these services as convenient and efficient . The overall satisfaction index for digital users averaged 4.2 out of 5, exceeding traditional service ratings by 0.6 points . The Table 4 results show that 44% of respondents reported poor internet quality, 31% noted difficulties with English-language interfaces, and 27% encountered limited payment system options. These issues underline the technological and linguistic barriers that still constrain digital inclusiveness.

Table 4. Most Common technical and functional problems encountered by tourists when using digital services

Type of Problem	Share of Respondents (%)
Low quality of Internet (Wi-Fi) and mobile network connection	44%
Deficiencies in English-language interface and UX/UI design	31%
Limited functionality of online payment systems (HUMO, national cards)	27%
Lack of sufficient information about products and services	15%
Technical errors in applications or service functions (crashes, bugs)	12%
Concerns about data security and privacy	8%

Regional and demographic disparities

Analysis of Figure 2 shows strong geographic and demographic variation in ICT utilization. Urban male users accounted for 72% of digital service engagement, whereas only 17% of rural women used digital tourism tools, revealing a 54% usage gap. Age-based disparities were also evident: 86% of tourists aged 18–35 used digital services compared to 35–38% among those over 45. These patterns confirm a persistent digital divide influenced by regional infrastructure, digital literacy, and gender-specific access to technology.

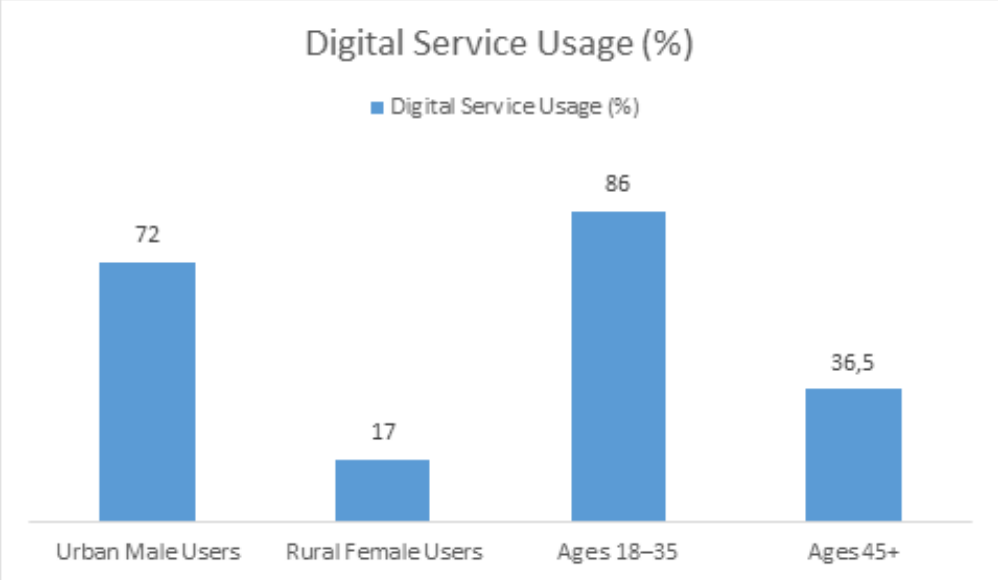

Figure 2. Geographic and Demographic Variations in Digital Service Usage:

Table 5. Comparative analysis of local and international digital platforms by technological and economic indicators

Platform	Number of Users	Commission Rate (%)	Payment System	AI Integration	Net Economic Benefit (%)
Uzbooking.uz	160,000	3–7	UzCard, HUMO	None	+24%
Booking.com	1.2 million+	15–20	Visa / MasterCard	Full integration	+36%
E-Visa.uz	1.5 million (2024)	0	—	Partial	+2.7× increase in tourist arrivals
TripAdvisor	30,000+ reviews	0	—	Full	—

Comparative evaluation of national and international platforms

The cross-platform analysis revealed structural and technological asymmetries between local and global tourism platforms.

– Local platforms such as Uzbooking.uz and E-Visa.uz demonstrated clear advantages in transaction costs (3–7% commissions), integration with local payment systems (UzCard, HUMO), and compliance with national regulations.

– International platforms such as Booking.com and TripAdvisor maintained dominance due to their algorithmic personalization, multi-language interfaces, and global reputation, but imposed higher commission rates (15–20%) and data-sovereignty risks.

Despite the strong economic performance of local platforms—Uzbooking.uz reportedly increased partner revenues by 18–24% technological limitations in user experience, AI integration, and global visibility still prevent them from achieving full competitiveness.

Regional Imbalances and Integration of SMEs

Table 6. Level of digital service utilization in uzbekistan's tourism sector (based on survey data)

Platform / Service	Share of Users (%)
E-Visa	78.5 %
Google Maps	62 %
Booking.com	58 %
TripAdvisor	37 %
VisitUzbekistan	22 %
Uzbooking.uz	16 %

Synthesis of Empirical Findings

Summarizing across all datasets and indicators:

– ICT-integrated enterprises increased revenues by 52–55% between 2020 and 2024 .

– The number of foreign tourists using digital services grew 2.3 times, with E-visa users reaching 1.5 million in 2024.

– The share of digital tax revenues rose from 14% to 39%, confirming formalization and fiscal transparency.

– Customer satisfaction with digital platforms averaged 4.2/5, driven by convenience, personalization, and transparency.

These results empirically validate that ICT adoption enhances tourism enterprises' productivity, transparency, and competitiveness while transforming the customer experience. Nevertheless, overcoming digital infrastructure gaps and promoting inclusive participation — especially for rural regions, women, and older users — remains an urgent policy priority.

CONCLUSION AND RECOMMENDATIONS

The conducted empirical analysis clearly demonstrates that the integration of Information and Communication Technologies (ICT) into Uzbekistan's tourism sector has become a decisive factor for its modernization and competitiveness. The results of the research — derived from surveys, interviews, and statistical models — confirm that digital transformation not only improves service efficiency but also stimulates economic growth, enhances customer satisfaction, and promotes transparency in the tourism value chain.ICT-based tools such as E-Visa.gov.uz, Uzbooking.uz, and Tourism.uz have simplified administrative processes, expanded market access, and encouraged the formation of new tourism ecosystems. Between 2020 and 2024, the number of digital service users increased more than twofold, while enterprises using ICT recorded a 54.9% higher revenue compared to traditional operators. This reflects the growing digital maturity of Uzbekistan's tourism market and the effective implementation of state policies supporting e-governance and smart tourism initiatives. However, the study also reveals persistent digital divides by region, gender, and age. Only 17% of rural women actively use digital tourism platforms, compared with 72% of urban male users. The limited digital literacy of small tourism businesses and the uneven development of Internet infrastructure remain key barriers to inclusiveness. Therefore, future strategies must focus on bridging these inequalities through targeted digital education programs, investment in regional infrastructure, and incentives for ICT adoption among small and medium-sized enterprises (SMEs).

In conclusion, ICT is no longer an auxiliary tool but a structural driver of sustainable tourism development in Uzbekistan. Strengthening the synergy between public policy, digital platforms, and private entrepreneurship will be essential to ensuring that digital transformation contributes to both economic prosperity and social inclusiveness in the national tourism industry.

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METHODOLOGY FOR FORECASTING AND ANALYZING MANAGEMENT ACCOUNTING INDICATORS AT AN ENTERPRISE

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Abstract: The article examines modern methodological approaches to the analysis and forecasting of management accounting indicators at an enterprise. The importance of economic analysis and forecasting in the processes of planning and managerial decision-making is substantiated. Key analytical and forecasting methods aimed at improving resource efficiency and reducing managerial risks are discussed. The research findings can be applied in the practical activities of enterprises across various industries to enhance the management accounting system and improve the rationale of managerial decisions.

Key words: management accounting, economic analysis, forecasting, analytical methods, managerial decisions, planning.

Annotatsiya: Maqolada korxonalarda boshqaruv hisobi ko‘rsatkichlarini tahlil qilish va prognozlashning zamonaviy metodik yondashuvlari yoritilgan. Iqtisodiy tahlil va prognozlashning rejalashtirish hamda boshqaruv qarorlarini qabul qilish jarayonidagi ahamiyati asoslab berilgan. Resurslardan foydalanish samaradorligini oshirish va boshqaruv xatarlarini kamaytirishga yo‘naltirilgan asosiy tahlil va prognozlash usullari ochib berilgan. Tadqiqot natijalari turli tarmoqlardagi korxonalar faoliyatida boshqaruv hisobi tizimini takomillashtirish va boshqaruv qarorlarining asoslanganligini oshirishda amaliy ahamiyatga ega.

Kalit so‘zlar: boshqaruv hisobi, iqtisodiy tahlil, prognozlash, tahlil usullari, boshqaruv qarorlari, rejalashtirish.

Аннотация: В статье рассматриваются современные методические подходы к анализу и прогнозированию показателей управленческого учета на предприятии. Обоснована значимость экономического анализа и прогнозирования в системе планирования и принятия управленческих решений. Раскрыты основные методы анализа и прогнозирования, направленные на повышение эффективности использования ресурсов и минимизацию управленческих рисков. Полученные результаты могут быть использованы в практической деятельности предприятий различных отраслей с целью совершенствования системы управленческого учета и повышения обоснованности управленческих решений.

Ключевые слова: управленческий учет, экономический анализ, прогнозирование, методы анализа, управленческие решения, планирование.

INTRODUCTION

In the context of intensified competition and increasing uncertainty in the external economic environment, the role of effective management accounting has become increasingly important as a key instrument for ensuring sustainable enterprise development. Modern organizations require not only the recording of actual performance indicators but also scientifically grounded forecasting of their dynamics in order to improve the quality of managerial decision-making. Forecasting management accounting indicators enables the timely identification of potential risks, a comprehensive assessment of development prospects, and the formulation of optimal strategies for the efficient use of enterprise resources.

The purpose of this article is to substantiate methodological approaches to the analysis and forecasting of management accounting indicators at the enterprise level. The study examines the fundamental principles and methods of economic analysis and forecasting applied within the management accounting system and clarifies

their role in planning and managerial decision-making processes. The practical significance of the research lies in the applicability of the proposed methodological approaches to enhancing the validity of managerial decisions and improving the overall operational efficiency of enterprises across various industries.

LITERATURE REVIEW

In academic research on management accounting and managerial decision-making, considerable attention is devoted to methods of economic analysis and forecasting. Studies by K. V. Baldin, S. N. Vorobyev, and B. G. Litvak view management accounting as a key informational foundation for developing and justifying managerial decisions, while forecasting enterprise performance indicators is identified as a crucial element of both strategic and operational planning. These authors emphasize the importance of applying an integrated approach that combines the analysis of actual data with the forecasting of future development trends.

The works of O. I. Larichev, A. I. Orlov, R. A. Fatkhutdinov, and L. G. Evlanov highlight the extensive use of economic and mathematical methods, expert evaluations, and modeling in the analysis and forecasting of business processes. Researchers note that the application of system analysis and multifactor models enhances the reliability of forecasts and improves the effectiveness of managerial decisions. At the same time, the adaptation of forecasting methodologies for management accounting indicators to the specific conditions of individual enterprises remains a relevant research direction and offers significant potential for further scientific development.

RESEARCH METHODOLOGY

The methodological foundation of this study is based on systemic and functional approaches to the analysis of management accounting indicators, which make it possible to examine these indicators in close connection with planning processes and managerial decision-making at the enterprise level. The research applies both general scientific and specialized methods of economic analysis, including comparative analysis, index methods, balance analysis, factor analysis, the chain substitution method, and value-based (functional cost) analysis. The application of these methods ensures the identification of the influence of individual factors on cost formation, financial results, and overall performance indicators of the enterprise.

For forecasting purposes, extrapolation techniques, expert evaluation methods, and economic and mathematical modeling were employed, enabling the identification of potential trends in key management accounting indicators over the forecast horizon. The information base of the study consists of enterprise management and financial accounting data, as well as planning and economic calculation materials. The obtained results were systematized and interpreted to develop practical recommendations aimed at enhancing the validity of managerial decisions and improving the overall efficiency of business operations.

ANALYS AND RESULTS

Analysis is defined as a scientific method of examining an economic situation or problem through the conceptual or empirical decomposition of an integrated whole into its constituent elements, followed by the identification and comparison of the object's key properties and characteristics. In the context of management accounting, analysis serves as a fundamental tool for obtaining reliable and structured information that supports objective evaluation of enterprise performance and informed managerial decision-making. The analytical process is grounded in several core principles, including the unity of analysis and synthesis, which ensures a comprehensive understanding of interrelated indicators, as well as the identification of leading factors through their systematic ranking.

Equally important are the principles of comparability, timeliness, and quantitative certainty, which guarantee the consistency, relevance, and measurability of analytical results. Ensuring comparability requires uniformity in scope, quality, time periods, data collection methods, and analytical conditions, thereby enhancing the reliability of conclusions. The principle of operational efficiency emphasizes the timely execution of analysis through rational organization, while quantitative certainty ensures that analytical outcomes are expressed in measurable and verifiable terms. The integrated application of these principles contributes to a logically coherent and methodologically sound analytical framework that enhances the effectiveness of management accounting and supports sustainable enterprise development.

The comparative method is widely applied in management accounting analysis and is aimed at identifying deviations from planned performance indicators, determining the causes of such deviations, and revealing internal reserves for improving efficiency. The effective use of this method requires strict comparability of the analyzed data in terms of evaluation criteria, time periods, seasonal characteristics, and geographic conditions, which ensures the validity and reliability of analytical conclusions.

Within this framework, comparative analysis involves the systematic comparison of actual reporting indicators with planned benchmarks, indicators of the previous period, and data from earlier periods, as well as comparisons with industry-average values. In addition, comparisons may be conducted on a daily basis to monitor short-term dynamics, while indicators of the technical level of production are assessed in relation to product quality parameters. The integrated application of these types of comparisons enables a comprehensive assessment of enterprise performance, supports the identification of development trends, and enhances the analytical justification of managerial decisions, thereby contributing positively to the overall effectiveness of management accounting systems.

The index method is applied when comparing indicators that describe two states of the same economic system. Indices are used to measure changes in complex phenomena, to determine the contribution of individual factors, and to conduct comparative analyses across different periods, regions, or established standards. This method enables the decomposition of both absolute and relative deviations of an aggregate indicator into its underlying factor components, thereby enhancing the depth and interpretability of analytical results.

The balance method is used to compare interrelated indicators of business activity in order to identify and measure their mutual influence and to determine reserves for improving production efficiency. Within this approach, the relationships among individual indicators are expressed through the equality of totals obtained from comparative assessments, which ensures internal consistency and supports a comprehensive evaluation of resource allocation and utilization. In addition, the chain substitution method serves to identify the impact of specific factors on an aggregate indicator or functional relationship. This method involves the sequential replacement of planned values of individual factors while keeping other variables constant, allowing the magnitude of each factor's influence to be determined through successive calculations.

The elimination method is applied to isolate the effect of a single factor on aggregate indicators of production and economic activity by excluding the influence of other factors. This approach enables a more precise assessment of causal relationships and contributes to a deeper understanding of the determinants of enterprise performance. By focusing on the net impact of individual factors, the method enhances the analytical clarity and reliability of managerial conclusions.

Graphical methods serve as effective tools for illustrating economic processes and analytical results. Depending on their purpose, they include comparison charts, chronological graphs, and control–planning charts, while their construction may involve line, bar, pie, three-dimensional, or coordinate formats. These visual instruments facilitate the interpretation of trends, dynamics, and interrelations among indicators. Functional cost analysis is applied to increase the useful effect per unit of cost over the entire life cycle of an object by assessing the rationality of the functional set. This method aims to achieve an optimal balance between utility and total costs, identify innovative solutions through a functional perspective, and reduce resource consumption by eliminating or minimizing non-essential functions. The implementation of functional cost analysis is based on functional, cost-based, systemic, integrated, and dynamic principles.

In addition, factor analysis employs multivariate statistical techniques, including correlation matrices, to examine complex relationships among variables. Economic and mathematical analytical methods are used to evaluate alternative managerial decisions and to identify optimal solutions under current or prospective economic conditions. These methods support the assessment of developed plans, optimization of business programs, determination of appropriate enterprise scale, definition of optimal product assortments, and evaluation of overall economic efficiency, thereby contributing positively to effective enterprise management.

Analytical techniques represent specific procedures used to process, structure, and interpret economic information in the course of enterprise performance evaluation. One of the key techniques is summarization and grouping, where summarization involves aggregating the overall effect of multiple factors on a generalized indicator of production and economic activity, while grouping consists of classifying the analyzed phenomena into characteristic categories based on selected criteria. This approach enhances the clarity and analytical value of the obtained results.

The use of absolute and relative indicators allows for a comprehensive assessment of economic phenomena. Absolute indicators reflect the scale or volume of economic activities, whereas relative indicators characterize the degree of plan fulfillment and the intensity of performance outcomes. Average values serve as generalized characteristics of mass, qualitatively homogeneous economic phenomena and include arithmetic, geometric, and weighted averages. In addition, continuous and sample observation techniques are applied, depending on the scope of analysis: continuous observation covers the entire population of relevant phenomena, while sample observation relies on representative subsets. The techniques of detailing and generalization further contribute to analytical accuracy by decomposing aggregate indicators into partial components and identifying the specific influence of individual factors, thereby supporting well-grounded and effective managerial decision-making.

Forecasting is understood as a scientifically substantiated judgment about the possible future states of an object, as well as about alternative paths and time horizons of its development. In this context, forecasting represents a systematic anticipation of future outcomes based on accumulated experience and current assumptions. It constitutes a complex and multifaceted process that requires addressing a wide range of analytical, informational, and methodological issues in order to ensure the reliability and relevance of forecasted results.

Forecasting of managerial decisions is closely linked to the planning process. Plans and forecasts represent complementary stages of planning, with the plan performing the leading role in management. Within the management system, a forecast serves as a pre-planning development of multi-variant models for the evolution of the managed object, whereas a plan specifies clearly defined implementation periods and concrete characteristics of the projected outcomes. The primary objective of forecasting managerial decisions is to obtain scientifically grounded projections of trends in quality indicators, cost components, and other performance measures used in long-term planning, research and development activities, and the overall advancement of the management system. Key forecasting tasks include assessing market demand based on marketing research, identifying major economic, social, and technological trends, selecting the most influential indicators, choosing appropriate forecasting methods and horizons, projecting quality indicators over time, optimizing forecasts according to maximum utility and minimum life-cycle costs, and substantiating the economic feasibility of developing new or improving existing products within available resources and strategic priorities.

The object of any forecast may include economic, social, technical, organizational, and other processes occurring both within an organization and in its external environment. From this perspective, forecasting can be defined as a scientific approach to identifying the current state of an organization and determining the most probable pathways of its future development. Forecasts are developed in the form of qualitative characteristics and, in simpler cases, as statements regarding the likelihood or unlikelihood of specific events. These characteristics should incorporate quantitative indicators expressed as point or interval estimates, as well as the probability of their achievement. A forecast therefore represents the outcome of the forecasting process and may be presented in verbal, mathematical, graphical, or other analytical forms describing the potential future state of an enterprise and its environment.

Forecasts may be classified according to several criteria. Based on their time horizon, forecasts range from short-term to long-term, reflecting different planning horizons. Very short-term forecasts, such as weekly or monthly projections, are typically used for operational purposes, while short-term forecasts support annual planning. Medium- and long-term forecasts, often referred to as strategic or prospective, provide a basis for long-range development planning. Forecasts can also be differentiated by their methodological orientation into exploratory, normative, and vision-based types. In terms of managerial influence, forecasts may be passive, assuming limited organizational intervention, or active, emphasizing the organization's capacity to shape its future through deliberate actions. Depending on the degree of uncertainty, forecasts may be invariant, involving a single highly probable scenario, or variant, allowing for multiple alternative development paths. Finally, according to the form of presentation, forecasts are classified as point forecasts, which specify a single expected value, or interval forecasts, which define a range of possible values for the forecasted indicator.

A forecasting method is defined as a systematic approach to studying a forecasting object with the purpose of developing a scientifically grounded forecast. According to scholarly assessments, more than 150 different forecasting methods have been identified in the literature; however, in practical applications, only approximately 15–20 methods are commonly used. The choice of a specific forecasting method is determined by several key factors, including the nature of the forecasting object, the required level of accuracy, the availability and reliability of initial data, and the professional competence of the forecaster.

Within the framework of technological forecasting, forecasts are developed for economic, commercial, social, and political activities. Technological forecasting is generally classified into exploratory and normative types. Exploratory forecasting is based on the identification of emerging opportunities and the analysis of development trends using available empirical information at the time of forecast preparation. In contrast, normative forecasting is oriented toward the organization's mission, strategic goals, and priority needs, focusing on achieving desired future states. This approach involves moving from defined objectives and needs toward the identification of appropriate means and technologies for their realization. Exploratory forecasting commonly employs methods such as extrapolation, modeling, historical analogy, and scenario development grounded in the analysis of reliable empirical data (Picture 1).

Picture 1. The Most Widely Used Forecasting Methods

Expert Judgment Method. The expert judgment method is based on the premise that a forecast can be derived from the informed opinions of a single specialist or a group of specialists whose judgments rely on extensive professional, practical, and scientific experience. This method assumes that experts are capable of integrating qualitative and quantitative information to assess future developments with a high degree of reliability. Expert judgments may be classified as either individual or collective, depending on whether the evaluation is provided by one expert or through a structured aggregation of opinions from multiple experts. The collective form, in particular, enhances objectivity by reducing the influence of individual bias and enabling the synthesis of diverse perspectives. Owing to its flexibility and adaptability, the expert judgment method is widely applied in situations characterized by limited statistical data and is often used in personnel assessment, strategic planning, and complex decision-making contexts where formalized quantitative models may be insufficient.

Extrapolation Method. The extrapolation method is based on the analysis of stable development trends observed in the past and present and their extension into the future. This approach assumes that previously identified patterns provide a reliable basis for anticipating future dynamics of enterprise development. Two main types of extrapolation are distinguished: formal and predictive extrapolation. Formal extrapolation relies on the assumption that existing trends will continue unchanged over time, while predictive extrapolation links current development patterns with hypotheses regarding future dynamics, taking into account the potential influence of changing internal and external factors.

In practical applications, extrapolation methods are most effective at the initial stage of the forecasting process, where their primary purpose is to identify general trends in the variation of key indicators. By providing an initial analytical framework, extrapolation supports subsequent forecasting stages and facilitates the selection of more sophisticated methods when higher accuracy or consideration of complex influences is required.

Modeling Methods. Modeling is defined as the construction of an abstract or mathematical model based on a preliminary analysis of the object and the processes under consideration, with the identification of its essential features and characteristics. In the context of forecasting, modeling provides a structured representation of complex economic relationships and enables the analysis of system behavior under various conditions. Forecasting based on models involves several interrelated stages, including model development, experimental or simulation analysis, comparison of preliminary forecast results with actual empirical data, and subsequent refinement and adjustment of the model.

The application of modeling methods enhances the analytical rigor and predictive accuracy of forecasts by allowing for the systematic testing of assumptions and scenarios. Through iterative validation and calibration, models can be adapted to reflect changing conditions and emerging patterns, thereby increasing their relevance

for managerial decision-making. As a result, modeling methods are widely used in situations that require a comprehensive assessment of interdependencies among variables and a high level of methodological precision.

Economic Forecasting Method. The economic forecasting method is based on the decomposition of an economic process or phenomenon occurring within an enterprise into its constituent components, followed by the identification of the relationships and mutual influences among these components as well as their impact on the overall dynamics of the process. Through systematic analysis, this method makes it possible to reveal the underlying essence of economic phenomena, identify patterns of future change, and comprehensively assess alternative pathways for achieving established objectives. By focusing on causal relationships, economic forecasting contributes positively to the development of well-grounded managerial strategies.

The process of economic analysis within this method is typically structured into several sequential stages. These stages include defining the problem and establishing evaluation criteria and objectives, preparing the information required for analysis, conducting analytical processing of the data after its examination, formulating recommendations for possible ways to achieve the stated goals, and presenting the results in an organized and interpretable form. The consistent application of these stages ensures methodological coherence, enhances analytical accuracy, and strengthens the practical relevance of forecasting outcomes for managerial decision-making.

Balance Method. The balance method is based on the construction of balance sheets that represent a system of indicators in which the first component characterizes resources according to their sources of formation, while the second component reflects their allocation across all areas of use. This method ensures internal consistency by maintaining equality between available resources and their distribution, thereby providing a coherent framework for analyzing and forecasting economic processes at the enterprise level.

Through the application of the balance method, the principles of proportionality and balance are effectively implemented in the forecasting process. Its core purpose is to link the enterprise's needs for raw materials, material inputs, financial resources, and labor with production capacities and available resource sources. Consequently, the system of balances used in forecasting typically includes financial, material, and labor balances. The use of this method contributes positively to the reliability of forecasts, supports rational resource planning, and enhances the effectiveness of managerial decision-making.

Normative Method. The normative method is one of the fundamental forecasting methods and has gained increasing importance in contemporary economic analysis and planning. The essence of this method lies in providing technical and economic justification for forecasts through the application of established norms and standards. These norms serve as benchmark indicators and are used to calculate resource requirements as well as to assess the efficiency and intensity of resource utilization.

By relying on standardized parameters, the normative method ensures consistency, comparability, and objectivity in forecasting results. It enables enterprises to align projected indicators with optimal or target levels of resource consumption and performance, thereby supporting rational planning and effective control. The application of this method contributes to improving the accuracy of forecasts and enhancing the methodological soundness of managerial decision-making, particularly in environments that require adherence to regulated or internally approved performance standards.

Program-Target Method (PTM). The program-target method has gained widespread application in recent years and is closely integrated with other forecasting approaches. This method involves developing forecasts by initially assessing final needs based on the enterprise's development goals, followed by the identification and selection of effective means, pathways, and resource provisions required to achieve these objectives. By starting from clearly defined targets, the program-target method ensures a strong alignment between strategic intentions and forecasting outcomes.

The essence of the program-target method lies in defining the key development goals of the enterprise and formulating a system of interrelated measures aimed at achieving these goals within predetermined time frames. This process is carried out under conditions of balanced resource provision and with careful consideration of efficient resource utilization. The application of the program-target method enhances the coherence of forecasting and planning processes, strengthens the linkage between goals and available resources, and contributes positively to the effectiveness of enterprise development strategies and managerial decision-making[1].

CONCLUSION AND RECOMMENDATIONS

The results of the conducted research indicate that the application of a comprehensive methodology for analyzing and forecasting management accounting indicators is an essential prerequisite for enhancing the

1 Boronenkova, S. A. Economic Analysis in Enterprise Management.Moscow: Finance and Statistics, 2003. 224 p.

effectiveness of enterprise management. The integration of systemic and functional approaches with methods of economic analysis and forecasting enables a more in-depth assessment of the current state of business activities, facilitates the identification of efficiency improvement reserves, and contributes to the reduction of managerial risks under conditions of external uncertainty.

From a practical perspective, it is recommended to introduce regular forecasting of key indicators related to costs, revenues, and financial results into the enterprise's management accounting system, using economic–mathematical models and expert evaluations. In addition, expanding the application of functional cost analysis and factor analysis in managerial decision-making processes is considered advisable. The implementation of these recommendations will improve the validity of planning calculations, enhance the quality of managerial decisions, and support the sustainable long-term development of the enterprise.

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WELLNESS TOURISM AS AN ESSENTIAL COMPONENT OF HEALTH TOURISM

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Abstract: Wellness tourism is one of the most successful segments of the tourism industry, and in the context of the 21st century, it can be said that achieving a healthy body and mind represents a triumph of modern medicine. This type of tourism not only encompasses treatment and rehabilitation processes but also aims to improve physical and mental well-being, prevent diseases, and strengthen immunity. It relies on a comprehensive use of natural resources (mineral waters, therapeutic muds, climate), modern medical technologies, and wellness methods (physiotherapy, massage, balneotherapy, phytotherapy). When integrated with other segments of medical tourism, such as post-surgical rehabilitation or support for oncology patients, wellness tourism provides patients with the opportunity for complete recovery and a return to a high quality of life.

Key words: wellness tourism, medical tourism, e-health, stress, spa, recreation, health policy, global spa industry, sanatorium.

Annotatsiya: Salomatlantirish turizmi turizm sanoatining eng muvaffaqiyatli segmentlaridan biri bo‘lib, XXI asr sharoitida sog‘lom tana va ruhiy muvozanatga erishish zamonaviy tibbiyot yutuqlarining muhim natijasi sifatida qaralmoqda. Ushbu turizm turi nafaqat davolash va reabilitatsiya jarayonlarini, balki jismoniy va ruhiy holatni yaxshilash, kasalliklarning oldini olish hamda immunitetni mustahkamlashni ham o‘z ichiga oladi. Salomatlantirish turizmi tabiiy resurslardan (mineral suvlar, shifobaxsh loylar, iqlim), zamonaviy tibbiy texnologiyalardan hamda salomatlantiruvchi usullardan (fizioterapiya, massaj, balneoterapiya, fitoterapiya) kompleks tarzda foydalanishga asoslanadi. Jarrohlikdan keyingi reabilitatsiya yoki onkologik bemorlarni qo‘llab-quvvatlash kabi tibbiy turizmning boshqa yo‘nalishlari bilan integratsiyalashgan holda, salomatlantirish turizmi bemorlarga to‘liq sog‘ayish va hayot sifatini yuqori darajada tiklash imkonini beradi.

Kalit so‘zlar: salomatlantirish turizmi, tibbiy turizm, e-sog‘liqni saqlash, stress, spa, rekreatsiya, sog‘liqni saqlash siyosati, global spa industriyasi, sanatoriy.

Аннотация: Оздоровительный туризм является одним из наиболее успешных сегментов туристской индустрии, и в условиях XXI века достижение здорового тела и психического равновесия рассматривается как важный результат развития современной медицины. Данный вид туризма охватывает не только процессы лечения и реабилитации, но и направлен на улучшение физического и психического состояния, профилактику заболеваний и укрепление иммунитета. Оздоровительный туризм основывается на комплексном использовании природных ресурсов (минеральные воды, лечебные грязи, климат), современных медицинских технологий, а также оздоровительных методов (физиотерапия, массаж, бальнеотерапия, фитотерапия). В сочетании с другими направлениями медицинского туризма, такими как послеоперационная реабилитация или сопровождение онкологических пациентов, оздоровительный туризм предоставляет пациентам возможность полного восстановления и возвращения к высокому качеству жизни.

Ключевые слова: оздоровительный туризм, медицинский туризм, электронное здравоохранение, стресс, спа, рекреация, политика в сфере здравоохранения, глобальная спа-индустрия, санаторий.

INTRODUCTION

According to the Global Wellness Institute, “wellness tourism is travel associated with the maintenance and improvement of personal health [1].” Here, the Institute defines “personal health” as a life free from stress, a prosperous lifestyle, good mood, and mental vitality. Wellness tourism initially emerged in 2008 as part of the “global spa industry” and was distinguished by seven main segments: resorts, thermal/mineral springs, wellness tourism, workplace wellness, healthy lifestyle, physical activity, and mental well-being. Over time, as a result of challenges arising from global integration processes, additional segments have been incorporated into wellness tourism, including personal care and beauty, healthy nutrition, weight loss, preventive healthcare, personalized medicine, and traditional medicine.

LITERATURE REVIEW

In Brenda Nasiche's research, wellness tourism is defined as a travel segment aimed at maintaining or improving personal well-being. She notes that it can encompass a wide range of activities, including spa treatments, fitness programs, holistic health experiences, and mental wellness initiatives [2]. This definition of wellness tourism serves as an important theoretical foundation for understanding the modern paradigm of the field. According to the researcher, unlike traditional medical services, wellness tourism does not focus on treating illness but rather on activities designed to maintain, enhance, and strengthen personal well-being. It is closely associated with resorts, fitness programs, general health practices, and mental wellness services, and the growing demand for such services in the post-pandemic era can be explained by increased attention to a healthy lifestyle.

According to Sanjay Karn, "wellness tourism is the practice of ensuring an individual's mental, physical, emotional, and social well-being, encompassing all dimensions of mind, body, and spirit, while being carried out abroad," which forms the theoretical foundation of this field [3]. Wellness practices applied after major surgical procedures and medical examinations play a crucial role in patients' rapid and effective recovery. This approach aligns particularly well with contemporary trends in modern healthcare systems. Viewing medical tourism and wellness tourism not as opposing, but as sequential and complementary stages provide an important theoretical basis for the strategic development of these sectors. Based on this approach, countries can achieve both health and economic efficiency by harmonizing national health policies with international tourism opportunities.

RESEARCH METHODOLOGY

This study is based on a qualitative and analytical research approach. The research uses secondary data collected from academic journals, international reports, policy documents, and publications of international tourism and health organizations. A systematic literature review was conducted to identify key concepts, trends, and models related to wellness tourism and health tourism.

Comparative analysis was applied to examine the role of wellness tourism within the broader health tourism framework and to identify best practices from different countries. Descriptive and logical analysis methods were used to interpret the data and summarize the findings. The study also employs inductive reasoning to develop conclusions and practical recommendations.

ANALYSIS AND RESULTS

In the international tourism market, consumers often perceive medical tourism and wellness tourism as the same concept. This confusion arises from incomplete understanding of marketing, as well as inappropriate use of terminology by destinations, government organizations, and advertising agencies. Wellness tourism services are utilized to improve, restore, and monitor patients' health and recovery after surgical procedures, and this usage is sometimes applied to define the tourism type. In reality, these two sectors differ because they meet distinct consumer needs. In our view, wellness tourism is a form of tourism aimed at promoting health, reducing stress, and supporting a healthy lifestyle.

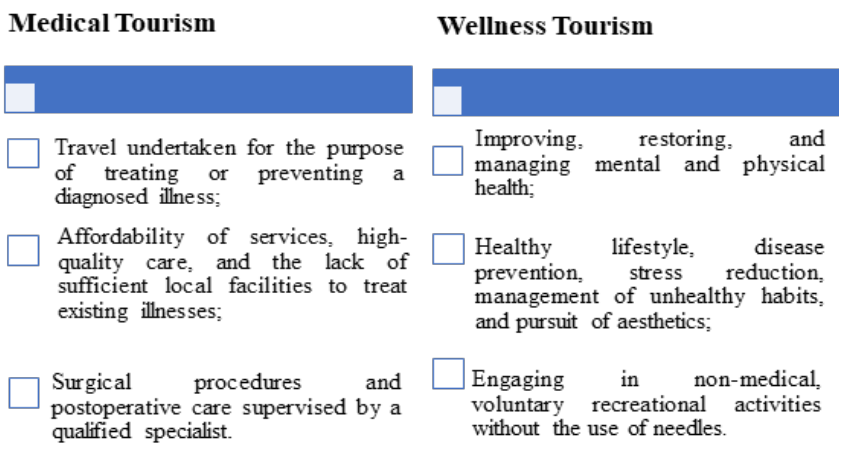

Figure 1. Distinctive Features of Medical Tourism and Wellness Tourism.

Source: The Global Wellness Institute, Global Wellness Tourism Economy, November, 2018.

Based on the views of I.S. Tuxliyev and B.Sh. Safarov, it can be noted that "wellness tourism for restorative recreation is highly personalized and individual in nature [4]". Depending on the method of affecting the human body, therapeutic recreation can be classified into climatic therapy, thalassotherapy (sea-based treatment), mud therapy, and others. European countries play a leading role in the development of wellness tourism. Among them, the Czech Republic stands out, receiving medical and wellness tourists from more than 70 countries. Czech wellness centers are particularly in high demand among the population of CIS countries, having earned their trust and annually serving almost over 50,000 patients. The Karlovy Vary spa, in particular, is renowned for its expertise in balneotherapy and is highly attractive to foreign tourists. Germany, with over 300 spa regions; Austria and Switzerland, with mountain and balneotherapy treatment centers; France, with its world-famous thalassotherapy centers; and Italy, with its mineral water treatment facilities, serve as exemplary models of Europe's achievements and prospects in the wellness tourism sector.

The United States is considered a leading country in health tourism. U.S. resort areas are primarily designed for domestic visitors, while people often prefer to seek treatment in resorts located in the Bahamas, Cuba, and Central America.

In 2013, the Global Wellness Institute (GWI) published the first edition of its Global Wellness Tourism Economy report. This significant study analyzed the parameters and characteristics of the developing wellness tourism sector, estimating its global size and highlighting its broad economic impact. The report noted that in 2012, GWI valued wellness tourism at $439 billion for the first time. From that year onward, wellness tourism emerged as a major force in the global tourism market. The growth of this sector is reflected in the increasing number of tourists traveling abroad to access medical and wellness services, as well as the continuous expansion of services offered within this segment.

Figure 2. Global wellness tourism market size and growth forecasts (2019-2028-y.)

Source: Global Wellness Institute, Global Wellness Economy Monitor 2024.

According to global economic data, wellness-related activities accounted for $6.3 trillion in 2023, representing 6.03% of the world's gross domestic product (GDP) [5]. Specifically, wellness tourism exports reached $830 billion in 2023, recovering after the decline observed in 2020 [6]. Statistical analysis indicates that the annual growth rate of wellness programs between 2019 and 2023 was 5.9%, and this rate is projected to increase to 7.3% by 2028 (Figure 7).

Until 2020, wellness tourism was one of the fastest-growing sectors within the global healthcare economy. However, due to worldwide travel restrictions and border closures, wellness tourism expenditures declined to $343.0 billion in 2020. Notably, in 2021-2022, the sector recovered more rapidly compared to overall tourism, highlighting its resilience and growing significance in the international tourism market.

Alongside the easing of pandemic-related travel restrictions and the recovery of the overall tourism market, wellness tourism experienced rapid growth over a three-year period.

Table 1. Health tourism spending by region over the period of 2019-2023 years [5].

	Wellness tourism export					Annual growth	
	USD, billion					2022-2023	2019-2023
	2019	2020	2021	2022	2023		
South America	$261.9	$151.4	$209.3	$279.4	$313.9	12.3%	4.6%
Europe	$240.6	$119.6	$166.9	$232.8	$286.5	23.1%	4.5%
Asia-Pacific Ocean	$142.4	$51.1	$56.0	$76.7	$165.8	116.2%	3.9%
Latin America	$33.4	$13.2	$20.1	$29.6	$37.5	26.7%	2.9%
Middile East and North Africa	$12.3	$5.3	$7.4	$13.4	$19.1	42.4%	11.6%
Sub-Saharan Africa	$6.0	$2.3	$2.8	$5.3	$7.4	41.3%	5.6%
World	$696.6	$343.0	$462.5	$637.2	$830.2	30.3%	4.5%

Over the past five years, North American countries have led the export of wellness tourism services, followed by Europe and Asia-Pacific countries. Prior to the pandemic, North America's revenue share amounted to USD 261 billion, and it can be noted that these figures remained largely unchanged before COVID-19 could fully disrupt global travel. Data indicate that Eastern countries, which experienced revenue losses due to the pandemic, have recovered at a slower pace compared to America and Europe (Table 8).

The development of restorative wellness tourism has been influenced not only by Europe and North America but also by Eastern countries, which contribute their unique traditional medicine practices and Eastern wellness approaches. Considering the latest data and the potential of Eastern nations, countries such as India, Singapore, Thailand, China, and Malaysia have shown significant growth in recent years. To meet the increasing demand, SPA hotels and wellness centers are increasingly incorporating Eastern medicine practices to promote healthy lifestyles and holistic recovery.

Table 2. Wellness tourism visits by region [5].

	Wellness tourism visits					Cost per each visit
	Million					2023
	2019	2020	2021	2022	2023	
South America	216.6	$136.70	176.3	205.4	224	$1,401
Europe	324	174	222.1	292.6	328.5	$872
Asia-Pacific Ocean	323.6	136.6	150.9	196.6	403.4	$411
Latin America	52.4	26.2	34.8	47.2	55	$682
Middile East and North Africa	11.7	4.8	6.7	11.2	15.9	$1,198
Sub-Saharan Africa	6.6	2.7	2.9	5.7	7.8	$956
World	934.8	481.1	593.7	758.7	1,034.50	$803

According to data from Euromonitor, in the years preceding the pandemic, Asia-Pacific countries ranked among the leaders in terms of wellness tourism visits. Although the number of visitors to Asian countries seeking wellness services increased during 2021-2022, they still lagged behind European and American destinations. In 2023, however, the number of visitors surged, with over 403 million tourists traveling to Asia-Pacific countries. Despite this growth in arrivals, Western countries maintain a leading position in terms of revenue. The primary reason for this is the higher prices: in Eastern countries, the average cost per wellness tourism visits ranges from $400–500, whereas in the United States, it reaches $1,400–1,500 (Table 9).

Wellness tourism, as a form of treatment and recovery offered in sanatoriums and resorts, is directly connected with ecological tourism. By fully satisfying the population's need for rest while preserving and restoring health, it creates a tourism product based on therapeutic or wellness technologies that improves quality of life. This involves the use of various components of natural complexes – exotic nature, favorable climate, healthy lifestyle, environment, and more – alongside interventions such as balneotherapy, peloid therapy, landscape therapy, thalassotherapy, and climatotherapy to promote wellness and treatment. For effective outcomes in health tourism, it is recommended that visitors utilize medical resorts or sanatorium services for at least three weeks, after which the therapeutic effects of the treatments can be observed.

In addition to the aforementioned therapeutic methods, services aimed at restoring and strengthening psychological and mental health can also be included. This direction contributes to enhancing an individual's mental stability, emotional balance, and inner energy state. In the 21st century, stress, psychological strain, and depression are regarded as critical factors exerting a significant impact on human health. Therefore, the global demand for psychological and mental wellness methods is steadily increasing.

Wellness practices are also integrated into rural tourism, which involves the utilization of local health resources such as dietary therapy, hippotherapy, apitherapy, and kumis-based treatments. Traditional medicine-based wellness tourism, combined with technological integration, meditation, and family- and child-oriented programs, defines contemporary trends in Eastern countries. To further stimulate the development of this sector, Malaysia announced new health tourism initiatives in 2024, which have served as a catalyst for the expansion of wellness tourism.

There is a comparative analysis of wellness tourism practices demonstrates clear distinctions between Eastern and Western approaches, both of which have contributed uniquely to the global development of this sector. The Western model of wellness tourism is largely shaped by medicalization, standardization, and technological integration. It places emphasis on spa and thermal resorts, advanced physiotherapy, balneotherapy, and climate therapy. The demand in Western countries is strongly tied to preventive healthcare, lifestyle modification, stress reduction, and luxury experiences. The industry is highly commercialized and strongly linked to broader healthcare and tourism systems, ensuring that wellness is positioned as part of a structured, regulated service economy. Moreover, Western destinations generally command higher revenue per visitor, due to advanced infrastructure and premium pricing.

By contrast, the Eastern model of wellness tourism is grounded in traditional medicine, holistic approaches, and spiritual healing practices. Methods such as yoga, meditation, acupuncture, herbal therapy, apitherapy, and dietary-based treatments (e.g., kumis therapy, tea culture) form the backbone of the sector. These practices are deeply connected to cultural heritage, emphasizing harmony between body, mind, and spirit rather than focusing solely on disease prevention. The affordability of Eastern destinations, combined with the authenticity of their healing traditions, has made them increasingly attractive in the post-pandemic era, particularly as global travelers seek meaningful, transformative, and immersive experiences.

Despite these differences, both approaches are complementary rather than mutually exclusive. While Western countries dominate in terms of economic returns, Eastern destinations are experiencing rapid growth in visitor numbers. Increasingly, hybrid models are emerging – where Eastern traditional practices are integrated into Western-style spa and wellness facilities demonstrating the globalization of wellness tourism. Thus, the comparative study indicates that the future trajectory of wellness tourism will depend on the successful synthesis of Western technological advances with Eastern holistic philosophies, thereby addressing the growing demand for comprehensive physical, psychological, and spiritual well-being.

Wellness and recreational zones are suitable not only for patients but also for completely healthy individuals. Such destinations offer wellness programs such as anti-stress training, fitness sessions, cosmetology, and similar services. Hotels located near the seaside and equipped with thalassotherapy centers are consistently in high demand.

Table 4. Wellness tourism destinations in Eastern countries [1].

Country	Methods	Examples
China	Traditional Chinese Medicine (TCM), Tai Chi, Acupuncture	Hainan Island, Sichuan Hot Springs
India	Ayurveda, Yoga, Meditation	Ananda (Himalayas), Six Senses Vana
Tailand	Spa therapies, Detox programs, Meditation retreats	Chiva-Som International Health Resort
Malaysia	Health resorts, Sanatoriums, Thermal and mineral spring treatments	Wellness centers in Kuala Lumpur
Japan	Onsen (hot springs), Traditional medicine	Beppu Hot Springs, Misugi Onsen
South Korea	Jjimjilbang (sauna culture), Cosmetic wellness and beauty treatments	Wellness centers in Seoul

In the 21st century, medical tourism has become one of the fastest-growing sectors of the global healthcare and service economy. The scientific and theoretical foundations of medical tourism are closely related to modern economic approaches, healthcare systems, consumer behavior, and the export of services. This concept

encompasses not only treatment, but also prevention, rehabilitation, and psychophysiological recovery. Today, medical tourism is regarded as a complex sector that reflects the demand for a high quality of life alongside disease treatment. Current trends show that medical tourism serves not only individual needs but also national economic interests. Countries such as South Korea, India, Turkey, Singapore, and Thailand are developing medical tourism as a strategic export service, thereby achieving high income levels and building international healthcare brands. Digital technologies, robotic surgery, artificial intelligence, telemedicine, and internationally accredited institutions are bringing this field to a new level of quality. At the same time, economic and geopolitical factors, post-pandemic recovery, and eco-medicine approaches contribute to ensuring sustainability in medical tourism.

Wellness tourism stands out as one of the most important and comprehensive directions within medical tourism. It is aimed at improving both the physical and mental state of individuals by incorporating traditional treatments, SPA therapies, yoga, dietetics, and psychological rehabilitation. This type of tourism has developed rapidly, especially in the post-pandemic period, driven by the growing demand for health and increasing attention to quality of life. Wellness tourism, as a complex set of services that meet the needs of modern individuals, has become a strategic component of the medical tourism system.

CONCLUSION AND SUGGESTION

The findings of this study confirm that wellness tourism has become an essential and integral component of health tourism, driven by growing global demand for preventive healthcare, stress management, lifestyle improvement, and holistic well-being. Unlike traditional medical tourism, which is primarily treatment-oriented, wellness tourism focuses on maintaining physical, mental, and emotional health through non-invasive, long-term, and experience-based services. This shift reflects a broader transformation in the global health tourism market toward sustainability, personalization, and quality of life enhancement.

The analysis demonstrates that wellness tourism contributes significantly to the diversification of tourism products, the reduction of seasonality, and the extension of tourist length of stay. Moreover, wellness tourism generates stable economic benefits by stimulating related sectors such as hospitality, transport, food services, spa and fitness industries, and local wellness-based entrepreneurship. As a result, wellness tourism strengthens regional development and supports inclusive economic growth, particularly in destinations with natural, cultural, and therapeutic resources.

The study also highlights that successful development of wellness tourism requires an integrated approach combining healthcare services, tourism infrastructure, environmental sustainability, and digital innovation. Destinations that align wellness tourism with national health strategies and sustainable tourism policies demonstrate higher competitiveness and resilience, especially in the post-pandemic context, where demand for immunity enhancement, rehabilitation, and mental health recovery has significantly increased. Based on the conclusions of this research, the following recommendations are proposed:

- governments and tourism authorities should recognize wellness tourism as a strategic segment of health tourism and incorporate it into national tourism and public health development programs. This includes establishing clear regulatory frameworks, quality standards, and certification systems to ensure service reliability and international competitiveness.
- investment in wellness-oriented infrastructure such as spa resorts, thermal facilities, rehabilitation centers, and nature-based wellness destinations should be encouraged through public-private partnerships. Special attention should be given to integrating medical supervision with wellness services to enhance trust and safety for international tourists.
- digital technologies should be actively utilized to promote wellness tourism through online platforms, tele-wellness services, and personalized wellness programs. Digital marketing, data-driven customer profiling, and virtual consultations can significantly improve destination visibility and service accessibility.
- human capital development remains a critical factor. Continuous training of wellness professionals, including therapists, instructors, and healthcare specialists, along with foreign language and intercultural communication skills, will enhance service quality and customer satisfaction.

sustainability principles should be embedded in wellness tourism development by promoting environmentally responsible practices, preserving natural resources, and engaging local communities. This approach ensures long-term competitiveness while aligning wellness tourism with global sustainable development goals.

In conclusion, wellness tourism represents a dynamic and resilient component of health tourism with strong potential to contribute to public health improvement, economic diversification, and sustainable tourism development worldwide.

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THE EXPERIENCE OF GERMANY IN DEVELOPING SMALL AND MEDIUM ENTERPRISES

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Abstract: This article provides a systematic analysis of the institutional, financial, and organizational mechanisms supporting small and medium-sized enterprises (SMEs) in Germany. The primary objective of the study is to identify effective government policy instruments aimed at fostering SME development by examining Germany's experience and to assess their economic outcomes.

The analysis demonstrates that SME support in Germany is implemented through a comprehensive and long-term policy framework characterized by strong public–private partnerships, a stable and transparent institutional environment, and diversified financing mechanisms. Key instruments include development banking through KfW, credit guarantee schemes, innovation and investment support programs, and market-based scale-up finance tools. These mechanisms play a crucial role in enhancing the competitiveness of SMEs, promoting innovation, expanding employment opportunities, and ensuring sustainable economic growth.

Furthermore, the article explores the potential for adapting Germany's SME development model to the context of developing economies, with particular emphasis on Uzbekistan. Based on the analysis, practical policy recommendations are proposed to improve access to finance, strengthen institutional capacity, and support innovation-driven growth among SMEs. The findings suggest that selective and context-sensitive adaptation of Germany's experience can significantly contribute to the sustainable development of the SME sector in emerging economies.

Key words: small business, government support, experience of developed countries, institutional mechanisms, financing, economic stability.

Annotatsiya: Ushbu maqola Germaniyada kichik va o'rta biznesni (KO'B) qo'llab-quvvatlovchi institutsional, moliyaviy va tashkiliy mexanizmlarning tizimli tahlilini taqdim etadi. Tadqiqotning asosiy maqsadi Germaniya tajribasini o'rganish va ularning iqtisodiy natijalarini baholash orqali KO'B rivojlanishini rag'batlantirishga qaratilgan samarali davlat siyosati vositalarini aniqlashdir.

Tahlil shuni ko'rsatadiki, Germaniyada KO'Bni qo'llab-quvvatlash kuchli davlat-xususiy sheriklik, barqaror va shaffof institutsional muhit va diversifikatsiyalangan moliyalashtirish mexanizmlari bilan tavsiflangan keng qamrovli va uzoq muddatli siyosat doirasi orqali amalga oshiriladi. Asosiy vositalar qatoriga KfW orqali rivojlanish bankchiligi, kredit kafolati sxemalari, innovatsiya va investitsiyalarni qo'llab-quvvatlash dasturlari va bozorga asoslangan miqyosni kengaytirish moliyalashtirish vositalari kiradi. Ushbu mexanizmlar KO'Bning raqobatbardoshligini oshirish, innovatsiyalarni rag'batlantirish, bandlik imkoniyatlarini kengaytirish va barqaror iqtisodiy o'sishni ta'minlashda muhim rol o'ynaydi.

Bundan tashqari, maqolada Germaniyaning KO'Bni rivojlantirish modelini rivojlanayotgan iqtisodiyotlar kontekstiga, xususan, O'zbekistonga moslashtirish imkoniyatlari o'rganiladi. Tahlil asosida moliyalashtirish imkoniyatlarini yaxshilash, institutsional salohiyatni mustahkamlash va KO'B o'rtasida innovatsiyalarga asoslangan o'sishni qo'llab-quvvatlash bo'yicha amaliy siyosat tavsiyalari taklif etiladi. Tadqiqot natijalari shuni ko'rsatadiki, Germaniya tajribasini tanlab va kontekstga sezgir moslashtirish rivojlanayotgan iqtisodiyotlarda KO'B sektorining barqaror rivojlanishiga sezilarli hissa qo'shishi mumkin.

Kalit so'zlar: kichik biznes, davlat tomonidan qo'llab-quvvatlash, rivojlangan mamlakatlar tajribasi, institutsional mexanizmlar, moliyalashtirish, iqtisodiy barqarorlik.

Аннотация: В данной статье представлен систематический анализ институциональных, финансовых и организационных механизмов поддержки малых и средних предприятий (МСП) в Германии. Основная цель исследования — выявление эффективных инструментов государственной политики, направленных на содействие развитию МСП, на основе опыта Германии и оценка их экономических результатов. Анализ показывает, что поддержка МСП в Германии осуществляется посредством комплексной и долгосрочной политической структуры, характеризующейся прочными государственно-частными партнерствами, стабильной и прозрачной институциональной средой и диверсифицированными механизмами финансирования. Ключевые инструменты включают в себя банковское дело развития через KfW, схемы кредитных гарантий, программы поддержки инноваций и инвестиций, а также рыночные инструменты финансирования масштабирования. Эти механизмы играют решающую роль в повышении конкурентоспособности МСП, содействии инновациям, расширении возможностей трудоустройства и обеспечении устойчивого экономического роста. Кроме того, в статье рассматривается потенциал адаптации немецкой модели развития МСП к контексту развивающихся экономик, с особым акцентом на Узбекистан. На основе анализа предлагаются практические рекомендации по улучшению доступа к финансированию, укреплению институционального потенциала и поддержке инновационного роста среди МСП. Результаты исследования показывают, что избирательная и учитывающая контекст адаптация опыта Германии может внести существенный вклад в устойчивое развитие сектора МСП в странах с развивающейся экономикой.

Ключевые слова: малый бизнес, государственная поддержка, опыт развитых стран, институциональные механизмы, финансирование, экономическая стабильность.

INTRODUCTION

In the context of globalization, technological innovation, and intensifying international competition, small and medium-sized enterprises (SMEs) are recognized as one of the key drivers of economic development. Experience from developed countries shows that SMEs play a crucial role in increasing gross domestic product, ensuring stable employment, accelerating innovative activities, and deepening structural diversification of the economy. Therefore, systematic and targeted support for SMEs is considered one of the priority directions of state economic policy.

In recent years, the development of small and medium-sized businesses has been placed at the center of state policy in the Republic of Uzbekistan. In particular, the Decree of the President of the Republic of Uzbekistan No. PF–50 dated March 19, 2025, “On Measures to Increase the Role of Small and Medium-Sized Businesses in the Economy” has launched a new stage in this area. The decree sets out clear objectives, including creating favorable conditions for the rapid development of SMEs, fundamentally improving the business environment in regions, encouraging new business initiatives, and supporting access to external markets.

According to the decree, by 2025, the strategic targets include increasing the share of SMEs in gross domestic product to 55%, in industry and exports to 34%, and in employment to 75%. Furthermore, specific targets have been set, such as transforming at least 600 SMEs into “champion” enterprises through scaling up, increasing the number of enterprises employing over 100 people to 4,000, and doubling the share of SMEs in service provision and social sectors. This approach demonstrates that the aim is to develop SMEs not only quantitatively but also qualitatively.

Additionally, the decree outlines objectives such as implementing at least 200 startup projects with SME participation, establishing brand-product manufacturing in 100 enterprises, and cultivating high-yield crops on 30,000 hectares of agricultural land while forming modern agro-industrial structures. These measures aim to strengthen the role of SMEs in innovation, industry, and the agricultural sector.

These priority tasks are closely linked to the goals of the “Uzbekistan – 2030” strategy, which aims to build a sustainable, inclusive, and competitive economy. The strategy emphasizes long-term economic growth through the development of the private sector, expanding financial and institutional opportunities for entrepreneurial entities, and supporting innovative, export-oriented SMEs.

From this perspective, a detailed analysis of the experience of developed countries in supporting small businesses and adapting their effective mechanisms to the Uzbek context has significant scientific and practical importance. The experience of the United States, European Union countries, and Japan demonstrates that institutional, financial, and innovative mechanisms for supporting SMEs play a crucial role in ensuring economic stability and competitiveness.

The main objective of this study is to identify the key mechanisms for supporting SMEs in developed countries, assess their economic effectiveness, and scientifically analyze the possibilities of applying this experience in the Republic of Uzbekistan, particularly within the framework of Decree No. PF–50 and the “Uzbekistan – 2030” strategy.

LITERATURE REVIEW

The development of small and medium-sized enterprises (SMEs) and private entrepreneurship in Uzbekistan has been one of the priority areas of economic policy since the country gained independence. Recent deep economic reforms have further increased attention to this sector, and the relevance of the topic has grown in scientific literature. This section analyzes the current state, challenges, and prospects of SME development based on the existing literature.

Firstly, decrees and resolutions of the President of the Republic of Uzbekistan serve as the main political and legal sources for the development of small businesses and private entrepreneurship. For example, the "Action Strategy" implemented since 2017 and later the "New Uzbekistan" development strategy for 2022–2026 specifically highlight support for small entrepreneurship, expansion of free-market relations, and creation of opportunities for unrestricted access to credit resources. Additionally, Presidential Decree No. PQ–366 dated August 8, 2022, and Decree No. PF–50 dated March 19, 2025, "On Measures to Increase the Role of Small and Medium-Sized Businesses in the Economy," set out specific measures to expand infrastructure networks specialized in supporting entrepreneurship.

Statistical data also confirm the stable growth of SMEs. According to the State Statistics Committee of the Republic of Uzbekistan, by the end of 2023, the number of active small business entities in the country exceeded 600,000, and their share in GDP reached 56.5%. This represents a significant increase compared to 2017 (46.3%) and reinforces the role of SMEs as a key driver of the economy.

The works of D. Ruzmetov and M. Saidov examine the socio-economic effectiveness of financial support provided through preferential lending mechanisms. Their research offers an important empirical basis for analyzing methods of strengthening the financial stability of SMEs under the conditions of Uzbekistan. [12]

Similarly, the article published by N.Irgasheva analyzes the experience of developed countries in supporting SMEs through bank lending mechanisms and explains how these instruments function in practice. The study highlights the relevance of adapting international best practices to enhance the effectiveness of SME financing through commercial banks in Uzbekistan. [13]

From an international perspective, according to the World Bank's 2024 Doing Business report, Uzbekistan improved its ranking to 69th in terms of the ease of doing business. This improvement is attributed to regulatory simplifications, a streamlined tax system, and optimized licensing procedures. However, UNDP (2024) and IFC (2024) reports indicate that collateral requirements and financial barriers for entrepreneurs remain pressing challenges.

Local sources also emphasize social aspects. In particular, youth and women entrepreneurship development has received special attention. Within the frameworks of the "Youth Register" and "Women Register," nearly 300,000 citizens in 2024 were provided with subsidies, preferential loans, and essential equipment for entrepreneurship. Nevertheless, the effectiveness of existing programs has not yet been fully monitored, and analytical mechanisms remain insufficient.

Overall, scientific literature and statistical analyses indicate that there is political will in Uzbekistan to develop SMEs and private entrepreneurship. However, to ensure real growth, it is necessary to implement evidence-based strategies, infrastructure shaped by international experience, and effective monitoring systems. Existing literature demonstrates a significant need for consistent study and improvement in this area.

RESEARCH METHODOLOGY

This study is aimed at identifying the institutional and economic mechanisms for supporting small and medium-sized enterprises (SMEs) developed in advanced countries and evaluating the possibilities of applying them in the context of the Republic of Uzbekistan. The research design employed a comprehensive methodology based on the integration of comparative-analytical and institutional approaches.

The study was conducted using a sequential explanatory design. Initially, the current political and economic mechanisms for supporting SMEs in developed countries were identified, followed by an assessment of the economic outcomes of these mechanisms using quantitative indicators. In the final stage, the results were interpreted in the context of the target indicators set forth in Decree No. PF–50 of the President of the Republic of Uzbekistan dated March 19, 2025, and the "Uzbekistan–2030" strategy.

The study relied on secondary data, with the database formed from the following sources:

- Official statistical data and reports published by the OECD, World Bank, IMF, and UNCTAD;
- Legal and regulatory documents and strategic programs of developed countries concerning SME support;
- Decree No. PF–50 of the President of the Republic of Uzbekistan and the "Uzbekistan–2030" strategy;
- International indices (Doing Business, Global Entrepreneurship Index, SME Policy Index) and empirical studies published in scientific journals.

The following scientific methods were systematically applied:

- Comparative institutional analysis – to identify and compare the normative, financial, and organizational mechanisms for supporting SMEs in developed countries;
- Benchmarking – to determine normative and regulatory directions by comparing the best practices of developed countries with the target indicators outlined in Decree No. PF–50;
- Inductive and deductive logical analysis – to derive general conclusions from the experience of individual countries and substantiate their adaptation to the Uzbek context.

The study primarily relies on open statistical and normative-legal sources, which may result in methodological differences in data across certain countries. Moreover, the full application of support mechanisms used in developed countries to the Uzbek context requires consideration of the specific characteristics of the institutional environment and economic structure.

ANALYSIS AND RESULTS

Over the past decade, small and medium-sized enterprises (SMEs) have been recognized as one of the key drivers of economic growth, employment, and innovative development. Experience from developed countries shows that the institutional support of the SME sector is crucial for building a stable and competitive economy. From this perspective, the experience of the Federal Republic of Germany is of particular scientific and practical interest. In Germany, SMEs are represented by the concept of “Mittelstand,” which is not only a collection of business entities but also a unique economic and cultural model.

Mittelstand enterprises form the backbone of the German economy, playing a significant role in industry, services, exports, and innovation. They are distinguished by long-term strategic planning, family business traditions, the preparation of highly skilled personnel, and a focus on technological advancement. Therefore, Germany’s experience is an example of a systematic, comprehensive, and balanced approach to SME development.

In Germany, SMEs account for nearly 99% of all enterprises by number. They generate almost half of the country’s gross value added and provide employment for the majority of the workforce. Mittelstand enterprises not only meet domestic market needs but also serve as key actors ensuring Germany’s high export potential.

Table 1. Almost half of the German economy’s value added is produced by SMEs

2024	Enterprises		Persons employed		Value added	
	Number	Share	Number	Share	EUR billion	Share
SMEs	2 520 981	99.6%	17 856 188	58.2%	924	47,4%
Large enterprises	11 303	0.4%	12 744 228	41.8%	1024	52.6%

One important characteristic of SMEs is their role in regional economic development. In Germany, industry and services are developed not only in large cities but also in small towns and rural areas, which helps reduce interregional economic disparities and strengthen social stability.

The policy for SME development in Germany is implemented through a multi-level institutional system. While the federal government defines overall strategic directions, the Länder and local authorities implement these policies based on regional characteristics. This approach ensures a combination of centralized strategy and decentralized execution.

The Federal Ministry for Economic Affairs and Climate Action plays a crucial role in SME support by shaping policy, improving the legal framework, and coordinating financial support programs. At the same time, the KfW Development Bank serves as the main institutional pillar for SME financing.

A key feature of Germany’s experience is the diversification of SME financing mechanisms. Alongside traditional bank loans, government guarantees, subsidies, grants, mezzanine finance, and venture capital instruments are widely used. Preferential loans provided through KfW are long-term, low-interest, and offered under favorable conditions, stimulating SME investment activity. These loans primarily target innovation, digitalization, energy efficiency, and production modernization. Importantly, the state channels financial resources not directly but through commercial banks, ensuring the stable functioning of the financial market.

Innovation occupies a central place in Germany’s SME policy. State programs aim to expand SME participation in research and development (R&D) and experimental design activities. The Central Innovation Program (ZIM) provides financial support for SMEs to develop new products, technologies, and services.

Additionally, special venture funds support high-tech startups, offering not only financial resources but also consulting, mentorship, and networking services. This ensures that innovative ideas enter the market quickly and effectively.

In recent years, Germany's SME development policy has become closely linked to digitalization and green economy principles. The adoption of digital technologies enhances production efficiency, reduces costs, and expands access to global markets.

In the context of green transformation, special attention is given to energy-efficient technologies, renewable energy sources, and environmentally friendly production methods. The state has introduced preferential financing mechanisms for ecological projects, supporting the sustainable development of SMEs.

German SMEs are highly active in international trade. Mittelstand companies often specialize in narrow niches but produce high-quality products and are global leaders in their fields. State policies to promote exports focus mainly on consulting, information, and insurance mechanisms. Notably, direct state intervention in SME export activities is relatively limited, reflecting the high competitiveness and independent growth potential of SMEs.

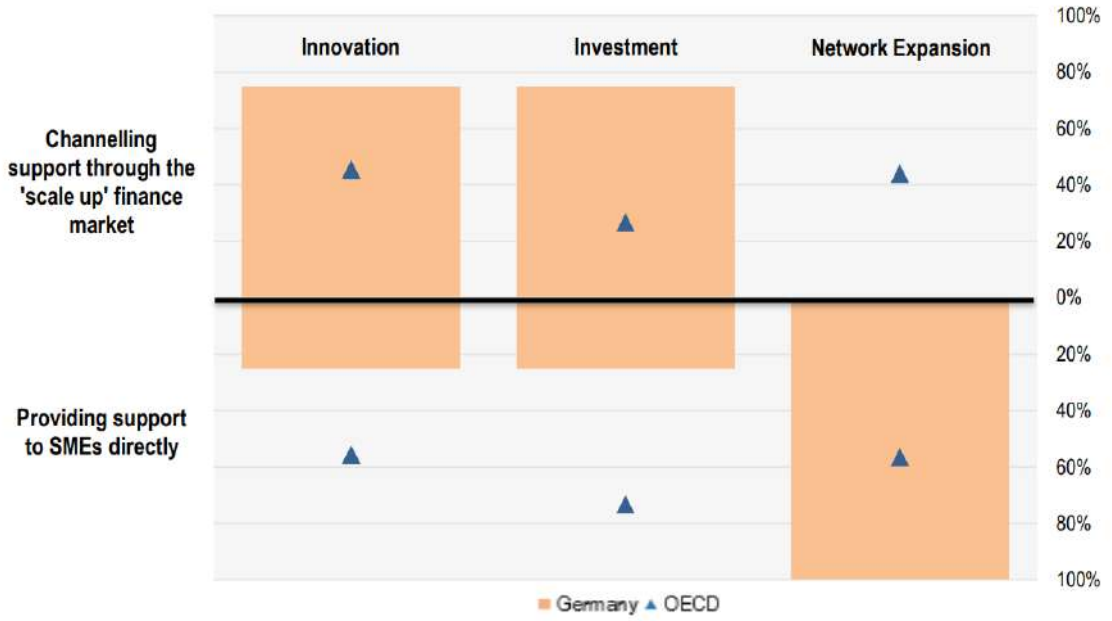

Figure 1. Germany relies heavily on the 'scale up' finance market to support SME growth through innovation and investment

Figure 1 illustrates the distribution of SME scale-up finance policies in Germany across three key scaling-up drivers – innovation, investment, and network expansion—and distinguishes between two main support channels: support channelled through the scale-up finance market and direct support provided to SMEs. The figure highlights a distinctive structural feature of the German SME support model, namely its strong reliance on market-based financial intermediation, particularly for innovation- and investment-led growth.

The results show that, in the areas of innovation and investment, Germany predominantly channels public support through the scale-up finance market rather than providing direct financial assistance to SMEs. This indicates a policy preference for leveraging financial intermediaries, such as commercial banks, public development banks, venture capital funds, and guarantee schemes, to mobilise private capital and allocate resources efficiently. Compared to the OECD average, Germany's reliance on market-based mechanisms in these two domains is noticeably stronger, reflecting the country's well-developed financial system and its long-standing tradition of close cooperation between the public sector and financial institutions.

In the case of innovation-driven scale-up, this approach is consistent with Germany's emphasis on financing research and development (R&D), disruptive innovation, and digital transformation through instruments such as venture capital co-investment, innovation loans, mezzanine finance, and guarantee facilities. Rather than directly subsidising firms, policy makers seek to reduce market failures by improving access to risk finance and strengthening the functioning of innovation finance markets. This strategy is particularly relevant for high-growth and technology-oriented SMEs, which typically face higher financing constraints due to information asymmetries and elevated risk profiles.

A similar pattern is observed for investment-related scale-up, where Germany again relies mainly on financial market channels. Investment financing policies are designed to support both tangible and intangible assets, including machinery, digital infrastructure, and intellectual property. The strong role of the scale-up

finance market in this area suggests that public policy in Germany aims to crowd in private investment rather than substitute for it. By contrast, direct support to SMEs plays a relatively minor role, which may limit access for firms that are less integrated into formal financial markets.

In contrast, the distribution of support for network expansion exhibits a markedly different pattern. Here, Germany relies more heavily on direct support to SMEs, while the use of scale-up finance market instruments is comparatively limited. This reflects the nature of network expansion policies, which often involve non-financial or semi-financial measures such as export promotion services, internationalisation support, partnership facilitation, and advisory programmes. Given the strong export performance and global integration of the German Mittelstand, the relatively lower intensity of market-based financial intervention in this area may also indicate that many SMEs are already capable of financing network expansion through retained earnings or existing commercial relationships.

Overall, Figure 1 underscores that Germany's SME scale-up finance policy is highly differentiated by growth driver. The policy mix prioritises market-based financial instruments for innovation and investment, while relying more on direct support mechanisms for network expansion. This structure highlights both the strengths and potential limitations of the German model: while it effectively mobilises private finance and supports high-potential firms, it may also risk excluding SMEs with growth potential that lack sufficient access to sophisticated financial markets. From a comparative perspective, the German experience provides valuable insights into how advanced financial systems can be leveraged to support SME growth in a sustainable and innovation-oriented manner.

The main advantage of the German model is its systematic and balanced approach. Financial support, innovation, workforce training, and the institutional environment are well coordinated. However, some limitations exist, such as a high degree of regulation and complex bureaucratic procedures, which may pose challenges for certain SMEs.

CONCLUSION AND SUGGESTIONS

In conclusion, Germany has developed an advanced and effective model for SME development. Built on the Mittelstand concept, this model ensures economic stability, innovative growth, and social balance. This experience warrants thorough scientific study and adaptation to national conditions for practical implementation.

This article has examined the German experience in supporting small and medium-sized enterprise (SME) growth, with a particular focus on the role of scale-up finance policies and the balance between market-based financial instruments and direct public support. The analysis demonstrates that Germany has developed a highly structured and differentiated SME support model, in which innovation- and investment-driven growth is predominantly financed through the scale-up finance market, while direct support mechanisms play a more prominent role in facilitating network expansion.

The German approach highlights the strategic importance of leveraging financial markets as intermediaries rather than relying excessively on direct subsidies. By channelling public resources through banks, venture capital funds, guarantee schemes, and development finance institutions, Germany succeeds in crowding in private capital, mitigating market failures, and allocating financial resources more efficiently. This model is particularly effective in fostering innovation, supporting high-growth firms, and sustaining long-term competitiveness within a knowledge-based economy.

At the same time, the analysis reveals that such a market-oriented approach requires a mature financial system, strong institutions, and high levels of financial literacy among SMEs. Without these prerequisites, scale-up finance mechanisms may primarily benefit a narrow group of firms, potentially leaving behind SMEs with latent growth potential. Therefore, the German experience underscores the need for a balanced policy mix that aligns financial market development with targeted public intervention.

For Uzbekistan, where the SME sector plays a crucial role in employment generation, regional development, and economic diversification, the German case provides valuable lessons. However, direct replication is neither feasible nor desirable. Instead, selective adaptation of key principles—adjusted to national institutional, financial, and developmental conditions—offers a more effective pathway for strengthening SME growth and resilience.

Based on the German experience and the analysis of scale-up finance policies, the following policy recommendations are proposed for Uzbekistan:

First, Uzbekistan should gradually shift from a predominantly direct-support-oriented SME policy toward a hybrid model that increasingly leverages market-based financial mechanisms. While grants and concessional loans remain important at early stages of SME development, greater emphasis should be placed on credit guarantees, co-financing schemes, and risk-sharing instruments that encourage commercial banks and private investors to participate in SME scale-up financing.

Second, strengthening the role of national development finance institutions is essential. Institutions similar to Germany's KfW could be further empowered to act as financial intermediaries rather than direct lenders, operating through commercial banks and capital market instruments. This would improve resource allocation efficiency, reduce fiscal pressure, and enhance the sustainability of SME financing programmes.

Third, innovation-driven SME growth should be prioritised through the development of dedicated scale-up finance instruments. These may include innovation loans, mezzanine finance, venture capital co-investment funds, and public–private partnership schemes targeting R&D, digitalisation, and technology adoption. Particular attention should be given to reducing information asymmetries and collateral constraints faced by innovative SMEs.

Fourth, while market-based instruments should be expanded for innovation and investment, direct support mechanisms should remain central for network expansion and internationalisation. Export promotion programmes, advisory services, matchmaking platforms, and support for participation in global value chains are especially relevant for Uzbek SMEs, which often lack experience and networks in foreign markets.

Fifth, improving financial literacy and managerial capacity among SMEs is a critical complementary reform. Without adequate understanding of financial products and growth-oriented strategies, SMEs may be unable to fully benefit from advanced financing instruments. Targeted training programmes, advisory services, and digital platforms can play a key role in this regard.

Finally, SME scale-up finance policy in Uzbekistan should be explicitly aligned with broader national objectives, including industrial diversification, digital transformation, green growth, and regional development. Integrating SME policy across innovation, investment, and sustainability agendas will help ensure coherence and maximise long-term economic impact.

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ANALYSIS OF THE APPLICATION OF THE INTERNATIONAL STANDARD ON AUDITING "ANALYTICAL PROCEDURES" IN NATIONAL AUDIT ACTIVITIES

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Abstract: This article describes the features and stages of applying analytical procedures when conducting an audit of inventory. In particular, recommendations are developed on the use of the vertical analysis method and the stages of applying analytical procedures when conducting an audit of inventory.

Key words: inventory, analytical procedures, vertical analysis, substantive testing, audit, materiality, international auditing standards (IAS).

Annotatsiya: Mazkur maqolada tovar moddiy zaxiralar auditini o'tkazishda tahliliy amallarni qo'llash xususiyatlari va bosqichlari ochib berilgan. Xususan, tovar moddiy zaxiralar auditni o'tkazishda vertikal tahlil usulini qo'llash va tahliliy amallarni qo'llash bosqichlari bo'yicha tavsiyalar ishlab chiqilgan.

Kalit so'zlar: tovar moddiy zaxiralar, tahliliy amallar, vertikal tahlil, mohiyatan tekshiruv, audit, muhimlik, xalqaro audit standartlari (XAS).

Аннотация: В данной статье описываются особенности и этапы применения аналитических процедур при проведении инвентаризации. В частности, разработаны рекомендации по использованию метода вертикального анализа и этапов применения аналитических процедур при проведении инвентаризации.

Ключевые слова: Инвентаризация, аналитические процедуры, вертикальный анализ, проверка по существу, аудит, существенность, международные стандарты аудита (МСА).

INTRODUCTION

The audit service sector in Uzbekistan has undergone fundamental reforms in the last 10 years. Systematic changes and consistent transformation processes are being implemented to develop audit services and related services. As a result of the reforms, the audit and assurance services sector has improved somewhat in terms of quality and the level of integration into international practice.

Review of literature on the subject

If we look at the audit companies, it is clear that the holders of internationally recognized certificates are mainly included in the Big 4 audit companies and occupy high positions in the ranking, it is clear that it will not be difficult for them to implement international auditing standards in their audit practice. About 151 out of 1154 certified auditors in the audit market of Uzbekistan are holders of internationally recognized certificates, that is 13.09%. Of the total 153 audit organizations, 72% are located in Tashkent. In other regions of the republic, taking into account these factors, the qualitative implementation of IAS in audit activities creates certain difficulties.

Abdiyeva N.Sh, in her doctoral dissertation on the topic of "Improving the internal audit methodology in joint-stock companies", emphasizes that although the application of international auditing standards and advanced foreign experience in the auditing practice of Uzbekistan is legally consolidated, 10 issues specified in international standards in auditing practice remain unresolved. N.Sh. Khajimuratov emphasizes in his research that the preparation of financial statements based on the requirements of international standards contributes to the accuracy and reliability of information, but methodological problems arise in the preparation of financial statements based on the requirements of international financial reporting standards (IFRS) in business entities.

RESEARCH METHODOLOGY

The reforms being carried out in Uzbekistan in the field of auditing are certainly leading to the development of this market. The number of audit companies and the potential of the auditors working for them are increasing accordingly. The presence of audit companies that are members of international auditing organizations in the local market is also having a positive effect on the qualitative strengthening of national audit companies. However, there is a need to assess what qualitative changes have occurred in the application of IAS by audit companies in their practice. Assessments can be carried out using empirical methods, based on the goals and objectives of the study. Among empirical methods, questionnaires are a common research method that allows qualitatively measuring the dynamics in the field.

In order to analyze the state of practical application of the Auditing Standard No. 520 “Analytical Practices” in business entities and other organizations, to identify existing problems and to draw scientific conclusions, a questionnaire consisting of 4 questions was communicated to me companies operating in Uzbekistan. The questionnaire was prepared based on interviews with 1 auditor from the Big 4, “KPMG audit” and 2 auditors from the national audit companies “Global audit” and “Audit maxima” as experts. The Chamber of Auditors of the Republic of Uzbekistan provided special assistance in obtaining the questionnaire.

A total of 150 auditors from various audit firms participated in the questionnaire. The questionnaire was administered anonymously, partly via a web application (58%, 87 auditors) and partly in paper form (42%, 63 auditors) and was summarized.

The auditors were asked the following questions:

1. question: What percentage of your overall audit time do you spend on analytical procedures?

2 - question: How important are analytical procedures to you in achieving audit objectives? (1-most important, 2-more important, 3-moderate, 4-less important, 5-least important).

3 - question: Do you use special computer programs or software to perform analytical procedures? (Yes [ ] Please write the name, No [ ] Please write the reason)

4 - question: Below are some of the challenges you may encounter when applying analytical procedures. Please rate the challenges you encounter in order of importance.

Analysis and results

We analyze the responses received from audit companies one by one:

Analysis of the answer to question 1 (Figure 1):

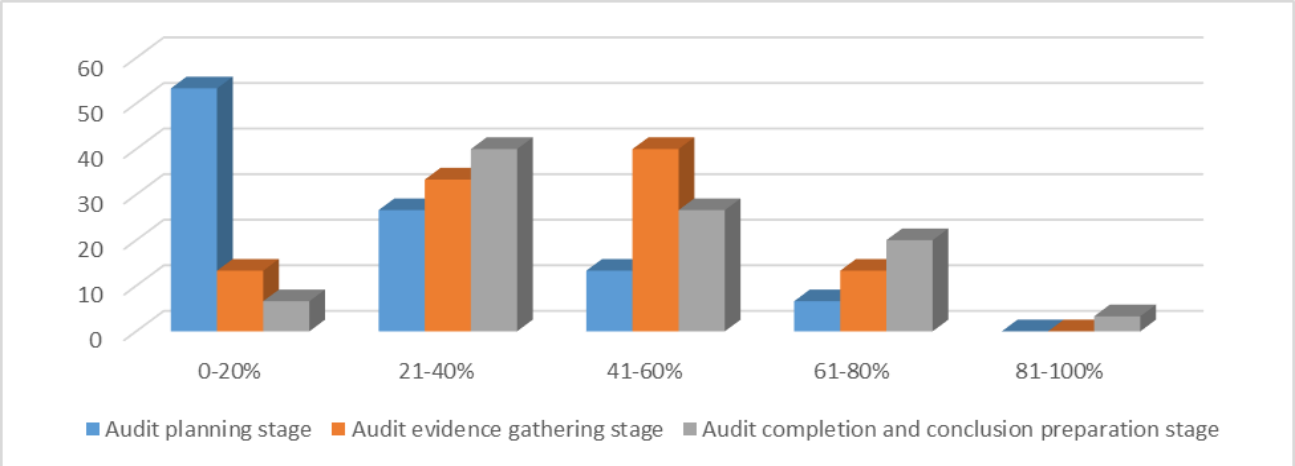

Figure 1. What percentage of your overall audit time do you spend on analytical procedures?

53.3% of the auditors who participated in the questionnaire stated that they spend up to 20% of their time on planning the audit, and 26.6% stated that they spend up to 40%. At the stage of obtaining audit evidence, that is, conducting the main audit, 40% of auditors stated that they spend up to 60% of their time, and at the stage of completing the audit and preparing the conclusion, 40% of auditors stated that they spend up to 40%. From this table, it can be seen that analytical procedures take up the most time in planning the audit, up to 60% of the time in collecting evidence, and up to 40% of the time in the final part of the audit. If we look at a similar study, 36 auditors who participated in the questionnaire stated that they spend 25% of the time allocated for analytical procedures (planning, substantive testing and general review). A study conducted two to seven years before the data collection for this study found that this figure was 21%. A study by E. Ameen and J. Strawser on the trend of time spent on analytical procedures found that in the 1990s, the time spent was 15%.

Analysis of responses to question 2: In the responses to this survey, almost all responses selected the most important (level 2) category in terms of the importance of analytical procedures for auditors. Only 20% of respondents considered the option “Assessing the accuracy of balances in accounts” as the most important, and 26.6% indicated that they considered it more important. The options “Identifying weaknesses in the financial structure and business activities”, “Focusing on risky areas for inspections at earlier stages” and “Evaluating the consistency of the relationship between the financial and non-financial information of the enterprise” were indicated by 60% of respondent-auditors. In a study conducted among Egyptian auditors, the category “least important ” (level 5) was selected.

Analysis of the answer to question 2 (Figure 2):

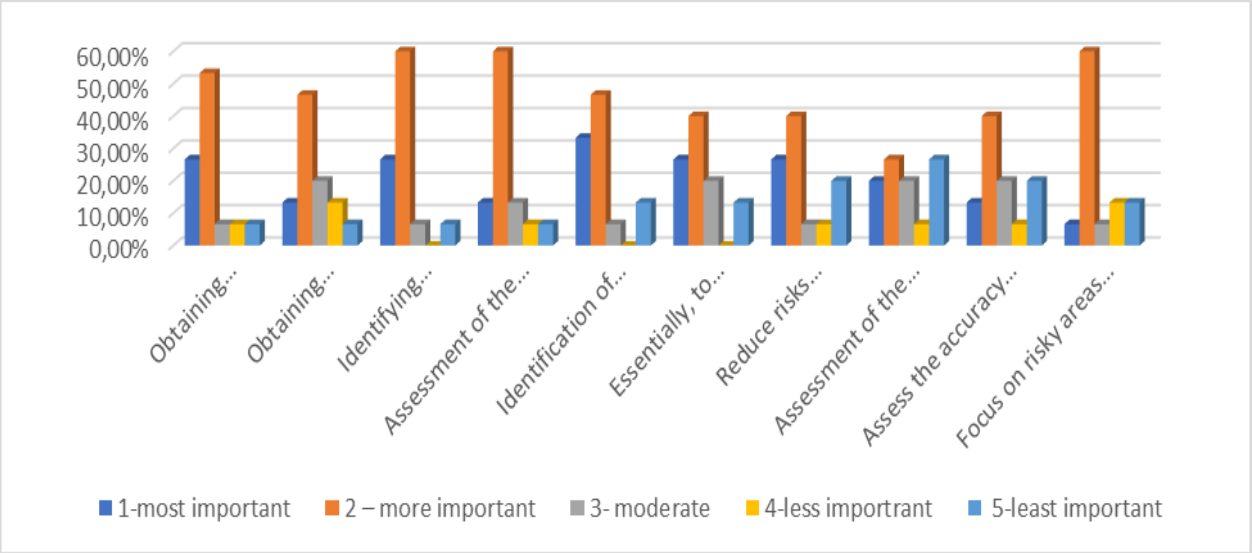

Figure 2. Question: How important are analytical procedures to you in achieving audit objectives?

Analysis of the answer to question 3 (Figure 3):

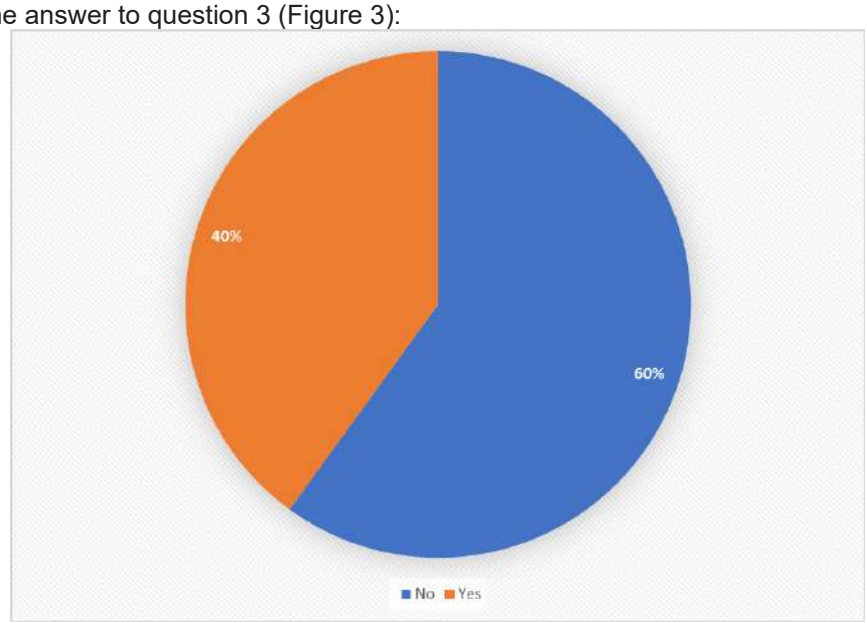

Figure 3. Do you use special computer programs or software when performing analytical procedures?

When asked this question, 60% (90 auditors) of respondents indicated that they use software to perform analytical procedures. However, 44% (40 auditors) of them indicated that they use Microsoft Excel and the rest indicated that they use other programs. 40% (60 auditors) of the respondents indicated that they do not use software at all to perform analytical procedures. This qualitative data indicates that there are issues in using software to perform analytical procedures. In the responses to the questionnaire, some respondents indicated that the reason for not using the programs was their high cost and complexity.

Analysis of the answers to question 4 (Figure 4):

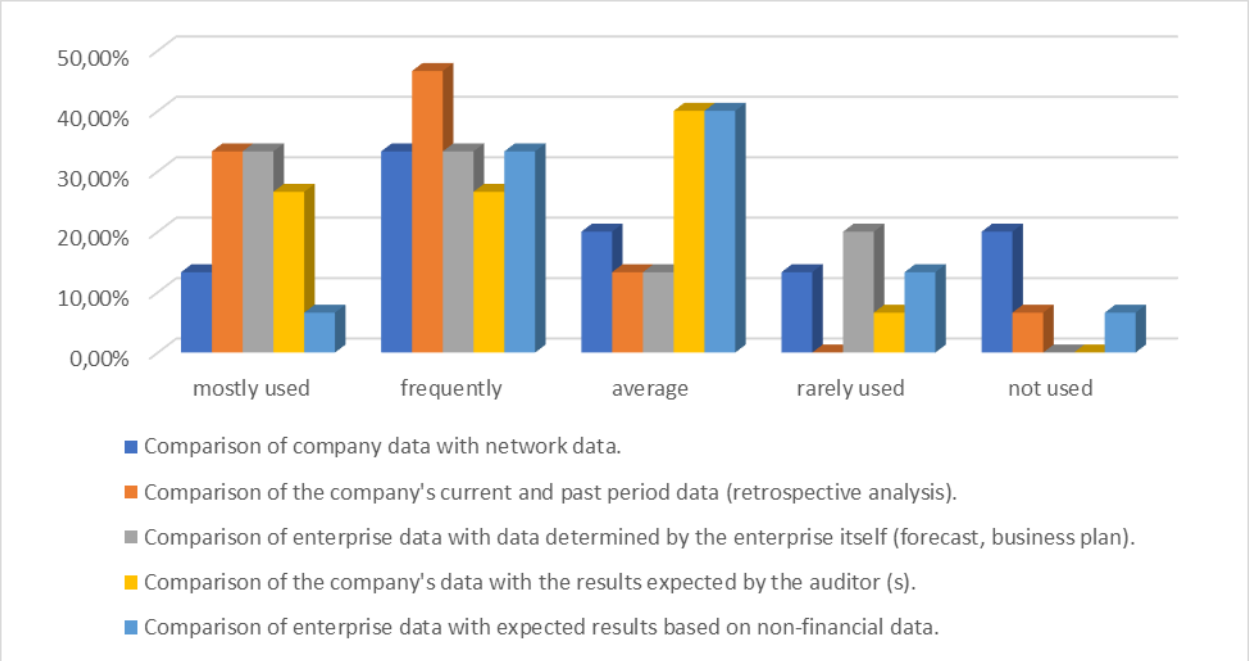

Figure 4. Rate the difficulties you encountered in applying analytical procedures in numerical order according to their importance (1 being the most important, 4 being the least important).

In this question, 46.6% of the auditors who participated in the survey expressed their opinion on the problem of “Complexity of obtaining data”. It turned out that 40% of auditors face the problem of “Lack of experienced (qualified) personnel (auditors)”, and 46.6% of auditors noted the problem of “Lack of time”. The problem of “Lack of documentation bases” was indicated as the most common problem and a significant problem by 66.6% of the total number of respondent auditors. From this data, it can be said that in the application of analytical methods, 4 out of 6 problems were highlighted as significant problems, and the remaining two were indicated as problems less than significant.

CONCLUSIONS AND SUGGESTIONS

The application of the International Standard on Auditing (ISA) 520 “Analytical Procedures” in national audit activities is of great importance in improving the quality of audit examinations. This standard allows auditors to identify significant inconsistencies in financial statements, assess audit risks, and strengthen the reliability of audit evidence. Analytical procedures serve as an effective tool for planning an audit, conducting the audit process, and assessing the overall soundness of financial statements at the final stage. The introduction of this standard in national audit practice ensures compliance with international experience and increases the validity and transparency of audit conclusions. At the same time, the professional qualifications of auditors, the level of use of information technologies, and the quality of financial information remain important factors in the use of analytical procedures in practice.

In some cases, insufficiently thorough application of methodological approaches or limited use of statistical analysis tools can reduce audit effectiveness. In general, the application of the International Auditing Standard “Analytical Practices” in national audit activities will contribute to the conduct of audit engagements at the level of international requirements. In the future, it is possible to further strengthen the competitiveness of the national audit system by improving the skills of auditors, widely introducing digital analysis tools, and fully implementing the requirements of the standard in practice.

The application of the International Auditing Standard on Analytical Procedures (ISA 520) in the national audit system is helping to transform auditing into a results-oriented and risk-based mechanism. This standard enhances the auditor’s professional judgment and ensures the logical and economic basis of the audit process by identifying cause-and-effect relationships between financial indicators. The use of analytical procedures in national audit practice allows for optimization of the scope of the audit, rational use of resources, and focusing the audit on the most important risk areas. As a result, the effectiveness of selective examination methods in collecting audit evidence is increased and redundant procedures are reduced.

At the same time, the full implementation of this standard in the national context requires auditors to master in-depth economic analysis skills, forecasting and comparative assessment methods of financial indicators. In practice, it is observed that in some audit entities, analytical procedures are used only as a formal requirement, and their results are not sufficiently documented.

From the survey conducted it is clear that the answers given by auditors operating in the national audit market are somewhat vague or they indicate limited knowledge of analytical procedures. It can be explained due to the lack of knowledge of local majority of auditors on the use of analytical procedures and their purposes. The empirical data collected via questionary may have misleading characteristics. So in the future it is recommended to have it conducted in an interview format so that the result will be more reliable.

Another reason is related to the limited use of special software in practice in most audit companies and the fact that auditors have problems with insufficiency of skills for using of information technologies.

To summarize, the audit market in the Republic of Uzbekistan, while undergoing fundamental transformation processes and developing in its own way, faces a number of organizational, methodological, institutional and quality control-related difficulties. Systematic resolution of these issues will lead to further development of the national audit market.

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ORGANIZATIONAL AND ECONOMIC FOUNDATIONS OF GREEN ENTERPRISE DEVELOPMENT IN ENSURING REGIONAL ENVIRONMENTAL SAFETY

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Abstract: This article analyzes the organizational and economic foundations of the development of green enterprises in ensuring environmental security in the region from a scientific, theoretical and practical perspective. The main goal of the study is to identify mechanisms for reducing the negative impact on the environment, effectively using resources, and strengthening regional economic stability through the development of green enterprises. The article reveals the institutional conditions, economic incentives, and financial mechanisms for supporting green enterprises based on a systematic approach. It also substantiates the introduction of green technologies, the development of ecological innovations, and the expansion of green entrepreneurship as important factors in ensuring environmental security. The results of the study are of practical importance in improving regional environmental policy and developing sustainable development strategies.

Key words: green enterprises, environmental safety, regional economy, sustainable development, organizational and economic mechanism, green technologies, environmental innovations, economic incentives, institutional environment, green entrepreneurship.

Annotatsiya: Maqolada hududlarda ekologik xavfsizlikni ta’minlashda “yashil” korxonalarni rivojlantirishning tashkiliy-iqtisodiy asoslari ilmiy-nazariy va amaliy nuqtayi nazardan tahlil qilinadi. Tadqiqotning asosiy maqsadi atrof-muhitga salbiy ta’sirni kamaytirish, resurslardan samarali foydalanish hamda “yashil” korxonalarni rivojlantirish orqali hududiy iqtisodiy barqarorlikni mustahkamlash mexanizmlarini aniqlashdan iborat. Maqolada tizimli yondashuv asosida “yashil” korxonalarni qo‘llab-quvvatlashning institutsional sharoitlari, iqtisodiy rag‘batlantirish choralari va moliyaviy mexanizmlari ochib berilgan. Shuningdek, ekologik xavfsizlikni ta’minlashda “yashil” texnologiyalarni joriy etish, ekologik innovatsiyalarni rivojlantirish va “yashil” tadbirkorlikni kengaytirish muhim omillar sifatida asoslab berilgan. Tadqiqot natijalari hududiy ekologik siyosatni takomillashtirish hamda barqaror rivojlanish strategiyalarini ishlab chiqishda amaliy ahamiyatga ega.

Kalit so‘zlar: yashil korxonalar, ekologik xavfsizlik, hududiy iqtisodiyot, barqaror rivojlanish, tashkiliy-iqtisodiy mexanizm, yashil texnologiyalar, ekologik innovatsiyalar, iqtisodiy rag‘batlantirish, institutsional muhit, yashil tadbirkorlik.

Аннотация: В статье с научно-теоретической и практической точек зрения анализируются организационно-экономические основы развития «зелёных» предприятий в обеспечении экологической безопасности региона. Основной целью исследования является выявление механизмов снижения негативного воздействия на окружающую среду, эффективного использования ресурсов и укрепления экономической устойчивости регионов посредством развития «зелёных» предприятий. В работе на основе системного подхода раскрываются институциональные условия, экономические стимулы и финансовые механизмы поддержки «зелёных» предприятий. Обоснована значимость внедрения «зелёных» технологий, развития экологических инноваций и расширения «зелёного» предпринимательства как ключевых факторов обеспечения экологической безопасности. Результаты исследования имеют практическое значение для совершенствования региональной экологической политики и разработки стратегий устойчивого развития.

Ключевые слова: зелёные предприятия, экологическая безопасность, региональная экономика, устойчивое развитие, организационно-экономический механизм, зелёные технологии, экологические инновации, экономические стимулы, институциональная среда, зелёное предпринимательство.

INTRODUCTION

In recent years, the issue of environmental safety in the global economy has been viewed as a strategic direction inextricably linked to production efficiency, regional competitiveness and social stability. In the context of climate change, increasing industrial emissions and intensive use of natural resources, ensuring environmental safety in the regions requires not only traditional environmental control measures, but also a "green" transformation of economic activity. From this point of view, the development of green enterprises is emerging as one of the most important organizational and economic foundations for ensuring environmental safety in the region. Green enterprises, through the introduction of environmentally friendly technologies, waste reduction and efficient use of resources, not only reduce environmental risks, but also ensure the long-term sustainability of the regional economy [1].

In the studies of international organizations, the development of green enterprises is considered as the main mechanism for ensuring the balance between environmental safety and economic growth. According to reports of the International Labor Organization (ILO), in regions where green enterprises have expanded, economic losses associated with environmental risks are reduced, and employment and labor productivity are stabilized [2]. The United Nations Industrial Development Organization (UNIDO) recognizes the support of green industrial enterprises as an effective way to modernize regional industrial policy, while ensuring environmental safety [3]. These approaches indicate the need to consider the development of green enterprises not as a separate direction of environmental policy, but as a component of regional economic policy.

These global trends are also of urgent importance for Uzbekistan. The expansion of industrial production and entrepreneurial activity in the country is increasing the environmental burden in the regions and creating the need to ensure environmental safety through economic mechanisms. Therefore, in recent years, new decisions and programs have been adopted aimed at developing the green economy and green entrepreneurship. In particular, institutional measures are being strengthened to encourage environmentally friendly production, introduce energy-saving technologies, and provide financial support for green enterprises [4]. This process is further increasing the role of green enterprises in ensuring environmental safety in the regions.

At the same time, the analysis of existing scientific research shows that the impact of green enterprise development on environmental safety is often studied within the framework of separate environmental or technological aspects, and their organizational and economic foundations at the regional level are not sufficiently comprehensively covered. In particular, the issue of the interaction of the institutional environment, economic incentives and territorial management mechanisms in the development of green enterprises requires a deep scientific analysis [5]. Therefore, the main relevance of this article is to identify and improve the organizational and economic foundations of green enterprise development in ensuring environmental safety in the region.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of the relationship between the development of green enterprises and environmental safety has been emerging as an independent scientific direction in the fields of sustainable development, ecological economics, and regional management in recent years. An analysis of the scientific literature shows that, while initially green enterprises were interpreted mainly as entities implementing environmentally friendly production technologies, at the current stage they are considered as an organizational and economic mechanism for ensuring environmental safety. In the Triple Bottom Line concept put forward by J. Elkington, green enterprises are evaluated as institutions that combine economic benefit, environmental sustainability, and social responsibility [6]. This approach creates a theoretical basis for linking the development of green enterprises with regional environmental safety.

In international scientific research, the relationship between green enterprises and environmental safety is often analyzed in the context of innovative development. R. Kemp and D. Pearson emphasize that enterprises implementing green innovations become important economic entities that reduce environmental risks and increase regional competitiveness [7]. In their opinion, the widespread introduction of green technologies allows ensuring environmental safety through market mechanisms. This approach shows the development of green enterprises as a more effective mechanism than direct environmental control by the state.

The institutional foundations of green enterprise development are deeply rooted in the framework of institutional economics by D. North and his followers. North shows that the effectiveness of green enterprises largely depends on the consistency of property rights, the incentive system and state policy [8]. This approach scientifically justifies the need to create a favorable institutional environment for the development of green enterprises in order to ensure environmental security in the region.

The issue of the economic efficiency of green enterprises in ensuring environmental security was analyzed from the perspective of corporate sustainability in the studies of S. Schaltegger and M. Wagner. The authors

provide scientific evidence that green enterprises may increase costs in the short term, but in the medium and long term they provide economic stability due to reduced environmental risks and resource efficiency [9]. These results allow us to evaluate green enterprises as an economically sound mechanism for ensuring environmental security.

The relationship between green enterprises and environmental security within the regional economy was studied in the study of P. Krugman and M. Storper on the example of regional clusters. Their work noted that in regions where green enterprises are concentrated, environmental risks are relatively low, and innovative activity and employment are more stable [10]. This fact indicates that the development of green enterprises is a factor strengthening regional environmental security.

In studies on the experience of the European Union, green enterprises are interpreted as an important institutional link in ensuring environmental security. In the work of A. Jordan and D. Lenschow, it is emphasized that policies aimed at supporting green enterprises provide a combination of state and market mechanisms in ensuring environmental security [11]. This approach indicates the need to integrate political and economic instruments for the development of green enterprises at the regional level.

The issue of green enterprises and environmental security in developing countries is based on the concept of “green industrialization” by JA Mathews. The author emphasizes that green enterprises form a new model of economic growth while ensuring environmental security in the process of industrialization [12]. This approach allows ensuring environmental security in the region without separating it from economic development.

In studies at the local and regional levels, the organizational and economic aspects of green enterprise development are analyzed more in connection with state policies and regional programs. L. Fransen and A. Burgoon show that the effectiveness of green enterprise support mechanisms is closely related to the institutional capacity of the state and the quality of regional governance [13]. This situation reinforces the need to consider green enterprise development as a management mechanism for ensuring environmental safety.

In general, the literature review shows that the development of green enterprises plays an important economic and institutional role in ensuring environmental security. However, existing studies do not sufficiently systematically and comprehensively cover the organizational and economic foundations of the development of green enterprises at the regional level. It is this scientific gap that determines the scientific novelty and practical significance of this article.

RESEARCH METHODOLOGY

The article uses a comprehensive and systematic scientific approach to identify the organizational and economic foundations of the development of green enterprises in ensuring environmental safety in the region. The theoretical and methodological basis of the study was an analysis based on the fundamental principles of the theory of sustainable development, ecological economics, institutional economics, and regional economics. In the process of the study, methods of logical analysis and synthesis, induction and deduction, a systematic approach, structural-functional and institutional analysis were used to study green enterprises as an organizational and economic mechanism that ensures environmental safety in the region.

In the empirical part of the study, economic-statistical, comparative and integrated assessment methods were used to assess the impact of the development of green enterprises on regional environmental safety. In this case, official statistical data, regional environmental indicators, information on the introduction of green technologies, and regulatory and legal documents were used as the main sources of information. When assessing the activities of green enterprises, indicators such as production efficiency, waste recycling rate, energy efficiency and environmental investments were systematized, and integrated indices were formed on their basis.

ANALYSIS AND RESULTS

This section analyzes the organizational and economic foundations of the development of green enterprises in ensuring environmental safety in the region using the example of Namangan region, based on an empirical and systematic approach. In the process of analysis, the level of implementation of target indicators for waste management, waste recycling indicators in 2023, and indicators of environmental, economic and social efficiency that can be achieved as a result of the development of green enterprises are considered in an interconnected manner.

The results of the three tables presented serve to comprehensively assess the impact of green enterprises on the regional economy. In particular, the expansion of waste collection and processing infrastructure and the high utilization of processing capacities indicate that the material and technical base for ensuring environmental safety is being strengthened. At the same time, indicators such as reducing carbon dioxide emissions, increasing

production efficiency, and creating green jobs as a result of the development of green enterprises confirm that they have a positive impact on the environmentally and socially sustainable development of the regional economy (Table 1).

Table 1. Target indicators to be achieved by the Namangan regional administration in the field of waste-related work in 2020-2021[1]

№	Name of target indicators	Unit of measurement	Current status	Annual indicators		
				January 1, 2021	July 1, 2021	January 1, 2022
1. General indicators						
1.	Neighborhood citizens meetings household waste collect and take out to leave services with cover to take level	piece	409	697	775	775
		percent	53	90	100	100
2.	Hard household waste again work level	percent	17.4	28.3	31.5	36
3.	The share of the private sector in the organization of household waste collection and disposal services	percent	4	50	70	100
2. Waste collect, sort, recycle work and burial infrastructure						
4.	Hard household waste collect branches number, of which:	piece	317	417	497	567
	those that need to be repaired	*piece*	29	38	46	51
5.	Hard household waste sorting and again work objects number	piece	21	21	22	22
6.	Budget organizations waste containers with provision	required, pcs	1 321	1 351	1 381	1 321
		available, pcs	145	432	914	1,294
		percent	11	32	66.1	90.4
7.	Waste polygons number, that's it including:	piece	19	11	11	11
	a) household waste polygon, of which:	piece	16	8	8	8
	landfills that need reconstruction	*piece*	2	2		
	landfills to be closed	piece	8	8	8	4
	landfills to be reclaimed	piece	8	8	8	8
	b) construction waste landfill	piece	1	1	1	2
3. Household waste collect and take out to leave in the field material and technical base						
8.	Waste transportation for special technique supply	piece	137	237	237	295
9.	Polygons for special technique and mechanisms supply	piece	23	23	23	31
4. Shown services for payment discipline provide						
10.	To the population household waste collect and take out to leave services show according to debtor debt	billion soums	16.9	10.1	8.1	5.7
11.	Shown services for mandatory payments to collect level	percent	66	100	100	100
12.	The level of contracts concluded by legal entities and individual entrepreneurs with service organizations for the use of services for the collection and removal of household waste	percent	30	58	72	86

1 Source: Resolution of the President of the Republic of Uzbekistan No. PQ-4845 dated September 29, 2020 "On measures to further improve the system of management of household and construction waste".

5. Public-private partnership projects done increase						
13.	Number of projects	piece		2	2	4
14.	Amount of investment to be made	million US dollars		7	7	9.7
15.	To be created new work places number	person		980	980	1 290
16.	Attraction attainable additional techniques number	piece		80	80	140
17.	Number of equipment to be installed	piece		5	5	12

The data in Table 1 show that the system for managing household waste in Namangan region in 2020–2022 has been consistently and gradually improved. In particular, the coverage of neighborhood citizen gatherings with waste collection and removal services has increased from 53 percent in 2020 to 100 percent by July 2021. This means that full coverage has been provided from 409 neighborhoods to 775. This indicator confirms the strengthening of organizational management mechanisms in the region, the expansion of service infrastructure in a short period of time, and the realistic fulfillment of target indicators set by local authorities. At the same time, the increase in the level of solid household waste recycling from 17.4 percent to 36 percent indicates the formation of a system focused not only on waste collection, but also on recycling.

Indicators on the infrastructure for collecting, sorting, processing and disposing of waste reveal the important role of the material and technical base in ensuring regional environmental safety. The number of solid waste collection points increased from 317 to 567, showing a 1.8-fold increase. At the same time, the level of provision of budgetary organizations with waste containers increased from 11 percent to 90.4 percent, which indicates the institutional strengthening of the coverage of environmental services. The reduction in the number of waste landfills from 19 to 11, the decrease in the share of landfills that are being closed, and the preservation of the number of landfills that are being rehabilitated indicate that the transition from an approach based on waste disposal to an environmentally safe and regulated infrastructure has been implemented.

Public-private partnership projects and financial discipline indicators are the main factors strengthening the economic sustainability of the waste management system. The reduction in the volume of receivables by population from 16.9 billion soums to 5.7 billion soums (a decrease of almost 66 percent) indicates a sharp improvement in payment discipline. The increase in the share of the private sector from 4 percent to 100 percent indicates the full implementation of market mechanisms in the field of waste management. The implementation of 4 projects within the framework of public-private partnership by 2022, the attraction of 9.7 million US dollars in investments and the creation of 1,290 new jobs scientifically confirm the possibility of turning waste-related work into a driver of not only environmental, but also socio-economic development (Table 2).

Table 2. Waste recycling indicators in Namangan region, tons[2]

No.	Enterprise name	Project-based power	202 3 - year again worked waste amount	Again usable waste type	Again work as a result removable product	Again work as a result taken product
1	« Abdurakhman Plast Invest» JSC	3 750	2838	Plastic	Clothing hanger	2270.4
2	« Turab» plaster invest « LLC	4 550	4015	Plastic	Raw material	3212
3	« Maqsudbek trade plast « LLC	2 100	1940	Plastic	Raw material	1540
4	« Polyethylene industry « LLC	5 760	5300	Plastic and polyethylene	Plastic products	5100
5	« The attic « Mechanical Engineering « LLC	576	570	Metal scrap	Metal items	550
6	« Namangan rubber plastic «SHK»	8,900	7095	Car tire	Conveyor tape	5676

2 Source: Data from the Namangan Regional Department of the State Committee of the Republic of Uzbekistan for Ecology and Environmental Protection

7	« Namangan paper « LLC	66,900	52822	Paper	Paper package	42257.6
8	« Valley pure paper « LLC	500	480	Paper	Farm paper	450
9	« Nostandard « LLC	5900	4455	Metal scrap	Armature	3564
10	«Universal box « LLC	1300	1089	Paper,	Box	871.2
11	« Plastex « LLC	9100	7975	Polyethylene	Plastic pipe	6380
12	« Faiz» Nam-Textile ‘’ LLC	3200	2618	Cotton fiber waste	Non-woven fabric	2094.4
13	« Intelligence « pure paper « LLC	6100	20658	Paper	Toilet paper	20451.4
14	« Namplastsavdo» LLC	4 500	3435	Polypropylene	Granule	2808
15	«BT-2001» LLC	3100	2607	Metal waste	Furniture	2085.6
16	« Faiz» Blessing trade « LLC	1450	1331	Polypropylene	Bag	1064.8
Total:		**127,686**	**119 228**			**100 375**

The data in Table 2 show that the waste processing sector in Namangan region has significant production and environmental potential in 2023. While the total design capacity of the 16 enterprises included in the table was 127,686 tons, in practice 119,228 tons of waste were processed, that is, the capacity utilization rate was about 93.4%. This indicator indicates that the waste processing infrastructure in the region is sufficiently formed and the existing production capacities are being used effectively. In particular, large enterprises engaged in paper waste processing, such as “Namangan Paper” LLC (52,822 tons) and “Zakovat Sof Paper” LLC (20,658 tons), provide a significant share of the total processed waste, indicating that this area is a leader in the region. This situation scientifically confirms the high volume of paper waste among the population and the broad potential for ensuring environmental safety through its recycling.

The volume and types of products obtained as a result of processing reveal the economic efficiency of waste processing. The fact that 100,375 tons of finished products were obtained from 119,228 tons of waste indicates an average recycling efficiency of 84.2 percent. The production of products such as raw materials, granules, plastic pipes and boxes from plastic, polyethylene and polypropylene waste (for example, 6,380 tons of products from 7,975 tons of waste at “Plastex” LLC) indicates the development of import-substituting production through the secondary use of resources. The production of fittings and furniture at enterprises processing metal waste (for example, “Nostandart” LLC and “BT-2001” LLC) indicates the involvement of industrial waste in economic turnover. In general, the results of the table scientifically confirm that waste recycling is emerging as an important organizational and economic mechanism for the production of new products, the creation of added value, and the strengthening of regional economic stability in the Namangan region, while ensuring environmental safety (Table 3).

Table 3. Efficiency indicators that can be achieved as a result of developing a green enterprise[3]

Group	Tool	K indicators
Ecology	Surroundings environment status good luck	- carbon dioxide emissions reduce ; - harmful from the effects protected natural borders ; - quality of air and land and water resources.
Economic	Production release factors (nature) and human capital increase	- an increase in production volume as a result of an increase in the factors of production by one unit.
	Overcoming market crises through innovation and green economy principles	- efficiency indicators of green technologies; - level of provision of green technologies.
Social	Natural disasters, food products prices unstable league and economic crisis to the circumstances flexibility	- from natural disasters seen losses (money) in unity); - from natural disasters damage seen population (people); - price from instability damage Number of people seen (persons)
	Green work create positions and poverty reduction	- green work places and their poverty reduction impact ; - work with a n b a n d i n g and depending on the availability of resources indicators

3 Source: Based on the author’s work

It systematically summarizes the indicators of environmental, economic and social efficiency that can be achieved as a result of the development of green enterprises. The indicators presented in the table reveal the role of green enterprises in increasing production efficiency, increasing flexibility to market fluctuations and ensuring social stability, not limited to their impact on the environment. In this regard, this table is an important analytical basis for assessing the development of green enterprises as a multifaceted organizational and economic mechanism for ensuring environmental security in the region (Table 3).

The performance indicators presented in demonstrate that the development of green enterprises, in addition to ensuring environmental safety, has a multifaceted impact on economic and social stability. In the ecological block, indicators such as reducing carbon dioxide emissions, protecting natural areas from harmful effects, and improving the quality of air, land, and water resources are distinguished as the main environmental results of green enterprises. These indicators allow for a quantitative assessment of environmental safety, which, through improved environmental conditions, helps to reduce health care costs and reduce economic losses in the long term. In this regard, when green enterprises work in an integrated manner with environmental monitoring systems, the effectiveness of early detection and management of environmental risks increases significantly.

Economic and social blocks reveal the strategic role of the development of green enterprises in strengthening the economic stability of the region. The increase in production volumes as a result of the increase in production factors (natural and human capital) indicates that green enterprises achieve high efficiency through the introduction of innovative and resource-saving technologies. At the same time, overcoming market crises through green innovations and increasing the level of provision with green technologies increases the flexibility of the economic system. Socially, the creation of green jobs reduces poverty, increases employment, and increases the population's protection against natural disasters and price instability. As a result, the efficiency indicators presented in the table allow us to scientifically substantiate the development of green enterprises as a sustainable and multi-level organizational and economic mechanism for ensuring environmental security in the region.

CONCLUSIONS AND SUGGESTIONS

This article provides an in-depth analysis of the organizational and economic foundations of the development of green enterprises in ensuring environmental safety in the region using the example of the Namangan region, based on empirical data. The target indicators of the waste management system for 2020–2023, recycling volumes, and indicators of environmental, economic and social efficiency were studied in relation to each other. The results obtained scientifically confirm that the development of green enterprises is an important organizational and economic mechanism that, while ensuring environmental safety, strengthens the economic stability of the region.

First, the results achieved in the field of waste collection and processing infrastructure have shown an increase in the level of environmental safety. In particular, in 2020–2022, the coverage of neighborhoods with waste collection services increased from 53% to 100%, and the share of solid household waste recycling increased from 17.4% to 36%. As a scientific proposal, it is advisable to include these indicators in the integrated index of regional environmental safety, and as a practical recommendation, it is advisable to reduce the tax burden by at least 10–15% for green enterprises with a recycling share of more than 30%.

Secondly, the economic efficiency of waste processing enterprises showed that green enterprises create high added value in the regional economy. In 2023, 119,228 tons of waste were processed by 16 enterprises and 100,375 tons of finished products were produced, which means an average technological efficiency of 84.2 percent. It is proposed to introduce a "waste-product" conversion coefficient when scientifically assessing the activities of green enterprises. As a practical recommendation, it is recommended to attract enterprises with this coefficient above 80 percent to public-private partnership projects as a priority.

Third, the social effectiveness of green enterprise development is reflected in employment and sustainability indicators. As a result of projects implemented within the framework of public-private partnerships, 1,290 new jobs were created by 2022, which indicates a significant expansion of employment in the waste management sector. As a scientific proposal, it is necessary to link the number of green jobs to indicators of regional social sustainability, and as a practical recommendation, it is necessary to direct at least 20–25% of vocational and retraining programs to the needs of green enterprises.

Fourth, according to the general conclusion, the development of green enterprises is a multi-level and long-term mechanism for ensuring environmental safety in the region. As a scientific proposal, it is proposed to introduce a single integrated assessment system that combines environmental (reduction of emissions), economic (added value and efficiency) and social (employment) indicators. As a practical recommendation, based on this system, increasing the share of green enterprises in the industrial structure of the region to at least 15-20 percent in the medium term (3-5 years), and increasing the volume of processing by at least 10 percent per year will serve to ensure environmental safety and economic stability.

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A REALIST–POSITIVIST FRAMEWORK FOR ANALYSING MERGERS AND ACQUISITIONS UNDER ECONOMIC POLICY UNCERTAINTY

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Abstract: This article articulates the research philosophy and epistemological foundations underpinning an empirical investigation of mergers and acquisitions (M&A) under conditions of economic policy uncertainty in emerging markets, with a particular focus on the BRICS economies. The study addresses growing methodological challenges associated with analysing corporate behaviour in institutionally volatile environments characterised by policy unpredictability, geopolitical risk, and regulatory change. Grounded in a realist–positivist paradigm, the article justifies the treatment of economic policy uncertainty, ownership structures, and M&A outcomes as objective and observable phenomena that can be systematically analysed using quantitative methods. The ontological position assumes that uncertainty manifests through measurable policy actions and institutional constraints, while the epistemological stance emphasises empirical observation, hypothesis testing, and econometric modelling as the primary means of knowledge generation. The paper adopts a deductive methodological logic, drawing on real options theory, institutional economics, and corporate finance theory to derive empirically testable assumptions regarding M&A initiation and deal completion under uncertainty. Particular attention is given to endogeneity concerns inherent in uncertainty research, motivating the use of instrumental variable techniques, robustness checks, and alternative model specifications. The novelty of the work lies in providing a coherent philosophical and methodological justification for cross-country econometric analysis of M&A activity in emerging markets, where uncertainty is structural rather than transitory. The article contributes to the literature by strengthening the conceptual foundations for empirical research on corporate strategy under uncertainty and by offering a rigorous framework applicable to policy-relevant analysis in reforming economies.

Key words: economic policy uncertainty, mergers and acquisitions, emerging markets, BRICS, positivist methodology, institutional uncertainty.

Annotatsiya: Ushbu maqolada rivojlanayotgan bozorlarda, xususan BRICS mamlakatlari misolida, iqtisodiy siyosatdagi noaniqlik sharoitida qo‘shilish va qo‘shib olish (M&A) jarayonlarini empirik tadqiq etishning falsafiy va epistemologik asoslari yoritiladi. Tadqiqot institutsional jihatdan beqaror muhitlarda korporativ xatti-harakatlarni tahlil qilish bilan bog‘liq metodologik muammolarni ko‘rib chiqadi, bunday muhitlar siyosiy qarorlarning oldindan aytib bo‘lmasligi, geosiyosiy xatarlar va tartibga solishdagi o‘zgarishlar bilan tavsiflanadi. Maqola realist-pozitivistik paradigma asosida iqtisodiy siyosat noaniqligi, mulkchilik tuzilmalari va M&A bitimlari natijalarini obyektiv va kuzatiladigan hodisalar sifatida talqin qiladi hamda ularni miqdoriy usullar orqali tizimli tahlil qilish imkonini asoslaydi. Ontologik yondashuvga ko‘ra, noaniqlik o‘lchab bo‘ladigan siyosiy qarorlar va institutsional cheklovlar orqali namoyon bo‘ladi, epistemologik pozitsiya esa empirik kuzatuv, gipotezalarni sinash va ekonometrik modellashtirishni ilmiy bilimlarni shakllantirishning asosiy vositasi sifatida belgilaydi. Tadqiqot deduktiv metodologik mantiqqa asoslanib, real opsionlar nazariyasi, institutsional iqtisodiyot va korporativ moliya nazariyasidan foydalangan holda noaniqlik sharoitida M&A bitimlarini boshlash va yakunlashga doir empirik tekshiriladigan farazlarni ishlab chiqadi. Shuningdek, noaniqlik tadqiqotlariga xos bo‘lgan endogenlik muammolariga alohida e’tibor qaratilib, instrumental o‘zgaruvchilar, barqarorlik tekshiruvlari va muqobil model spetsifikatsiyalaridan foydalanish zarurati asoslab beriladi. Maqolaning ilmiy yangiligi rivojlanayotgan bozorlarda noaniqlik vaqtinchalik emas, balki strukturaviy xususiyatga ega bo‘lgan sharoitda M&A faoliyatini davlatlararo ekonometrik tahlil qilish uchun izchil falsafiy va metodologik asos yaratishda namoyon bo‘ladi hamda tadqiqot noaniqlik sharoitida korporativ strategiyani empirik o‘rganishning konseptual asoslarini mustahkamlaydi va islohotlar olib borilayotgan iqtisodiyotlar uchun siyosiy ahamiyatga ega tahlillarni amalga oshirishga mos qat’iy ilmiy doirani taklif etadi.

Kalit so‘zlar: iqtisodiy siyosat noaniqligi, qo‘shilish va qo‘shib olish, rivojlanayotgan bozorlar, BRICS, pozitivistik metodologiya, institutsional noaniqlik.

Аннотация: В статье раскрываются философия исследования и эпистемологические основания, лежащие в основе эмпирического анализа процессов слияний и поглощений (M&A) в условиях неопределённости экономической политики на развивающихся рынках, с особым акцентом на экономики стран БРИКС. Исследование направлено на решение возрастающих методологических проблем, связанных с анализом корпоративного поведения в институционально нестабильных средах, характеризующихся непредсказуемостью экономической политики, геополитическими рисками и регуляторными изменениями. Опираясь на реалистско-позитивистскую парадигму, статья обосновывает рассмотрение неопределённости экономической политики, структур собственности и результатов сделок M&A как объективных и наблюдаемых явлений, поддающихся систематическому количественному анализу. Онтологическая позиция исходит из того, что неопределённость проявляется через измеримые политические решения и институциональные ограничения, тогда как эпистемологический подход акцентирует внимание на эмпирическом наблюдении, проверке гипотез и эконометрическом моделировании как основных способах получения научного знания. В работе используется дедуктивная методологическая логика, основанная на теории реальных опционов, институциональной экономике и теории корпоративных финансов, что позволяет сформулировать эмпирически проверяемые предположения относительно инициирования сделок M&A и их завершения в условиях неопределённости. Особое внимание уделяется проблемам эндогенности, характерным для исследований неопределённости, что обосновывает применение инструментальных переменных, процедур проверки устойчивости результатов и альтернативных спецификаций моделей. Научная новизна статьи заключается в формировании целостного философского и методологического обоснования межстранового эконометрического анализа активности M&A на развивающихся рынках, где неопределённость носит структурный, а не временный характер. Работа вносит вклад в развитие научной литературы, укрепляя концептуальные основы эмпирических исследований корпоративной стратегии в условиях неопределённости и предлагая строгую аналитическую рамку, применимую для разработки экономической политики в странах с реформируемой экономикой.

Ключевые слова: неопределённость экономической политики, слияния и поглощения, развивающиеся рынки, БРИКС, позитивистская методология, институциональная неопределённость.

INTRODUCTION

The past two decades have been marked by heightened economic policy uncertainty, geopolitical tensions, and institutional volatility, fundamentally reshaping corporate investment behaviour in emerging markets. In the BRICS economies—Brazil, Russia, India, China, and South Africa—firms operate in environments characterised by recurrent policy shifts, regulatory intervention, sanctions exposure, and fluctuating access to global capital markets, which have intensified the complexity of strategic decision-making and increased the importance of understanding how uncertainty affects corporate consolidation and restructuring processes. Within this context, mergers and acquisitions (M&A) remain a critical mechanism for growth, market expansion, financial restructuring, and technological upgrading, playing a central role in industrial consolidation, cross-border investment, and the reallocation of corporate control across BRICS economies. However, persistent economic policy uncertainty (EPU) and geopolitical risk have altered both the incentives and feasibility of such transactions, influencing not only the likelihood of deal initiation but also completion rates, ownership structures, and transaction outcomes. Despite a growing body of international literature on uncertainty and corporate investment, empirical evidence on how EPU shapes M&A activity across major emerging economies remains fragmented and uneven, as existing studies are often limited to single-country settings or focus predominantly on developed markets, providing limited insight into the heterogeneous institutional environments and ownership regimes characteristic of the BRICS bloc. This creates a clear need for a comparative, firm-level analysis that systematically examines how uncertainty interacts with financial characteristics and institutional factors to influence M&A outcomes. The object of the research is M&A activity undertaken by firms operating in BRICS economies under conditions of economic policy uncertainty, while the subject of the research is the impact of economic policy uncertainty, ownership structure, and firm-level financial characteristics on the initiation and completion of M&A transactions. The aim of the study is to analyse how economic policy uncertainty influences M&A activity and deal outcomes in BRICS economies and to identify the mechanisms through which uncertainty, leverage, and state involvement shape corporate consolidation decisions in emerging markets. To achieve this aim, the study reviews theoretical and empirical literature on economic policy uncertainty, institutional volatility, and corporate investment behaviour, examines global and emerging-market evidence on the relationship between uncertainty and M&A activity, analyses firm-level financial characteristics, including leverage, as determinants of M&A initiation and completion, assesses the role of ownership structure, particularly state involvement, in moderating M&A behaviour under uncertainty, and conducts a comparative econometric analysis of M&A transactions across BRICS economies over the period 2004–2024. The relevance of this study lies in the limited comparative evidence on M&A behaviour under uncertainty in large emerging economies, and by focusing on BRICS countries—where uncertainty is structural rather than transitory—the research

contributes to a deeper understanding of corporate strategy in institutionally volatile environments. The findings are expected to provide valuable insights for academics, policymakers, and practitioners, as well as offer lessons for other reforming economies, including Uzbekistan, where privatisation, corporate restructuring, and exposure to external shocks increasingly shape investment dynamics.

LITERATURE REVIEW

Research on mergers and acquisitions (M&A) under conditions of economic and political uncertainty has expanded substantially in recent years, with a growing body of theoretical and empirical studies examining how macro-level shocks shape corporate consolidation decisions. Evidence from developed economies generally indicates that heightened economic policy uncertainty (EPU) suppresses investment activity and reduces both the frequency and value of M&A transactions, as uncertainty increases the option value of waiting and leads firms to postpone irreversible investment decisions, including acquisitions, particularly when financing constraints are binding and asset redeployability is limited [1], [2]. In contrast, findings from emerging markets reveal considerable heterogeneity in the relationship between uncertainty and M&A behaviour, as evidence from China suggests that policy uncertainty does not uniformly deter acquisition activity: while EPU reduces overall M&A volume, firms with stronger balance sheets or strategic restructuring motives may increase acquisition activity during uncertain periods [3]. Similarly, emerging-market firms can exploit uncertainty in target countries as an opportunity to acquire undervalued assets, highlighting the role of institutional arbitrage [4], while studies from India and Brazil report non-linear and context-dependent effects of uncertainty on corporate transactions, reflecting differences in institutional maturity, financing structures, and state involvement [5], [6]. A parallel stream of research emphasises the role of ownership structure and corporate governance in shaping M&A outcomes under uncertainty, showing that state-owned enterprises (SOEs) behave systematically differently from private firms, particularly in emerging economies. Evidence from Russia and China indicates that SOEs are less responsive to market-based incentives and more constrained by political objectives, resulting in lower acquisition intensity and longer deal completion times during periods of uncertainty [7]. State participation alters deal motivation, valuation, and post-merger integration, often weakening efficiency-driven outcomes, whereas private firms operating under stronger governance frameworks exhibit greater flexibility in responding to uncertainty shocks [8]. Financial characteristics represent another critical determinant of M&A behaviour, with empirical studies demonstrating that leverage plays a dual role under uncertainty: on the one hand, high debt levels increase financial risk and constrain acquisition capacity, while on the other hand, leveraged firms are more likely to engage in M&A as a mechanism for restructuring, asset redeployment, or risk diversification [9], [10], a motive that is particularly pronounced in emerging markets where capital markets are underdeveloped and external financing is costly. Macroeconomic volatility further interacts with institutional conditions to shape M&A dynamics, as studies on geopolitical risk and sanctions show that political shocks significantly reduce cross-border M&A activity and alter deal structure, financing choices, and partner selection [11], with the impact of geopolitical risk on financial markets varying markedly across BRICS countries due to differences in institutional credibility and policy transmission mechanisms [12]. Sanctions, in particular, materially distort M&A flows and increase transaction risk, especially in politically exposed economies such as Russia [13]. Despite the expanding literature, comparative firm-level evidence on M&A under uncertainty across BRICS economies remains limited, as existing studies are predominantly single-country or sector-specific and often focus on developed markets, offering limited insight into the interaction between uncertainty, ownership structure, and financial constraints in large emerging economies. This gap is particularly salient given the structural nature of uncertainty in BRICS countries, where policy shifts, geopolitical tensions, and institutional change are persistent rather than transitory. Overall, the literature suggests that the effects of economic policy uncertainty on M&A activity are highly context-dependent and shaped by institutional quality, ownership regimes, and firm-level financial characteristics, yet an integrated cross-country analysis that systematically examines these mechanisms within the BRICS bloc remains lacking. The present study addresses this gap by providing a comparative econometric assessment of how uncertainty influences M&A initiation and completion across BRICS economies, thereby contributing to a more nuanced understanding of corporate strategy under conditions of institutional volatility.

RESEARCH METHODOLOGY

This study adopts a structured quantitative research design that combines comparative econometric analysis, firm-level modelling, and institutional contextualisation to examine how economic policy uncertainty (EPU) influences mergers and acquisitions (M&A) activity across BRICS economies (Brazil, Russia, India, China, and South Africa) [1], [2]. The methodological framework integrates three interrelated components, beginning with a

comparative econometric analysis based on firm-level M&A transaction data merged with macroeconomic and institutional indicators. M&A transactions over the period 2004–2024 are analysed across BRICS countries to identify systematic patterns in deal initiation and completion under varying levels of economic policy uncertainty [3]. This cross-country approach allows the study to capture institutional heterogeneity and to compare how firms operating under different ownership regimes and regulatory environments respond to uncertainty shocks [4]. The analysis further employs a multivariate modelling strategy to estimate the probability of M&A initiation and deal completion, using limited dependent variable models, including probit and instrumental-variable probit specifications, to assess the impact of EPU while controlling for firm-specific financial characteristics such as leverage, size, and profitability, as well as ownership structure distinguishing state-owned and private firms [5], [6]. This modelling framework enables the isolation of marginal effects of uncertainty and addresses potential endogeneity between policy uncertainty and corporate investment behaviour through robustness checks and alternative model specifications [7]. In addition, the study incorporates an institutional contextualisation component that interprets econometric results within the broader political and economic environments of BRICS economies, linking empirical findings to differences in governance quality, state involvement, sanctions exposure, and capital market development in order to explain cross-country variation in the effects of uncertainty on M&A activity [8], [9]. This contextualisation enhances the interpretability of the results and ensures that conclusions reflect structural institutional characteristics rather than purely statistical correlations. Overall, the chosen methodology enables the identification of cross-country similarities and differences in M&A behaviour under uncertainty, highlights the role of ownership structure and financial constraints in shaping corporate consolidation decisions, and uncovers the mechanisms through which economic policy uncertainty affects deal outcomes in emerging markets [10], [11], thereby contributing to a more comprehensive understanding of corporate strategy in environments characterised by persistent policy and geopolitical volatility [12].

ANALYSIS AND RESULTS

This section presents a structured analysis of how economic policy uncertainty (EPU), ownership structure, and firm-level financial characteristics shape mergers and acquisitions (M&A) activity across BRICS economies. Given the heterogeneity of institutional environments and the structural nature of uncertainty in these countries, the analysis adopts a comparative framework that integrates econometric results with cross-country institutional interpretation [1], [2].

A substantial body of empirical evidence confirms that heightened economic policy uncertainty exerts a statistically significant and economically meaningful dampening effect on M&A activity. The baseline probit estimates indicate that increases in EPU are associated with a lower probability of deal initiation and completion, consistent with real options theory and prior findings for developed markets [3], [4]. This effect is most pronounced during periods of moderate uncertainty, when firms retain discretion to postpone investment decisions rather than exit the market entirely.

However, comparative analysis across BRICS economies reveals considerable heterogeneity in the magnitude and significance of the EPU effect. In relatively market-oriented environments such as India and South Africa, policy uncertainty strongly discourages acquisitions, reflecting higher sensitivity to financing costs and investor sentiment [5]. In contrast, in more state-influenced systems such as China and Russia, the effect of EPU is weaker or statistically insignificant in certain specifications, suggesting that government involvement, policy coordination, and strategic state objectives partially insulate firms from market-based uncertainty shocks [6], [7].

The cross-country comparison can be summarised as follows:

Country	EPU Effect on M&A	Institutional Characteristics
Brazil	Negative and significant	Fiscal volatility; commodity exposure
Russia	Weak or conditional	High state involvement; sanctions exposure
India	Strongly negative	Market-oriented governance; capital-market sensitivity
China	Mixed	State coordination; policy-guided consolidation
South Africa	Negative and significant	Institutional transparency; investor-driven markets

These results indicate that economic policy uncertainty operates through institutional transmission mechanisms rather than exerting a uniform macroeconomic constraint across emerging economies.

Ownership structure emerges as a critical moderating factor in shaping M&A outcomes. Transactions involving state-owned enterprises (SOEs) exhibit significantly lower completion probabilities, particularly during

periods of elevated uncertainty [8]. This pattern reflects additional bureaucratic procedures, political oversight, and non-commercial objectives that slow decision-making and reduce transaction flexibility. Empirical evidence from Russia and China confirms that SOE involvement alters deal motivation, valuation, and post-merger integration, often weakening efficiency-driven outcomes [9], [10]. By contrast, privately owned firms demonstrate greater responsiveness to market signals and a higher likelihood of completing transactions under comparable uncertainty conditions.

Firm-level financial characteristics further condition M&A behaviour. The results indicate that leverage plays a dual role. While high debt levels increase financial risk, leveraged firms are more likely to complete acquisitions, consistent with restructuring, asset redeployment, and risk-diversification motives [11], [12]. This effect is particularly pronounced in BRICS economies with less developed capital markets, where access to external finance is highly sensitive to macroeconomic volatility.

Macroeconomic and geopolitical shocks exert additional influence on M&A dynamics. Periods of heightened geopolitical risk and sanctions exposure are associated with sharp declines in cross-border M&A, longer deal completion times, and a shift toward domestic consolidation [13]. At the same time, comparative evidence suggests that uncertainty can accelerate strategic consolidation among firms seeking to internalise risk and secure market positions, especially in state-coordinated or policy-driven sectors [6].

These dynamics can be conceptualised as follows:

Outcome under High Uncertainty	Low Financial Flexibility Firms	High Leverage / Strategic Firms
M&A initiation	Strong decline	Moderate decline
Deal completion	Low probability	Higher probability
Cross-border activity	Sharp contraction	Selective continuation
Strategic consolidation	Limited	More pronounced

The findings highlight that economic policy uncertainty does not uniformly suppress mergers and acquisitions activity; rather, it redistributes transactions toward firms characterised by specific ownership structures and financial profiles.

Synthesising the econometric evidence across BRICS economies reveals several structural constraints that shape M&A performance under conditions of uncertainty:

• Persistent policy and regulatory volatility, which increases the option value of waiting and delays irreversible investment decisions.

• High levels of state participation in corporate ownership, which reduce transaction flexibility and prolong decision-making processes.

• Uneven access to external finance, amplifying the role of leverage in shaping acquisition behaviour.

• Exposure to geopolitical risk and economic sanctions, particularly pronounced in Russia and China.

• Institutional heterogeneity across countries, limiting the direct transferability of empirical results within the BRICS bloc.

The key results of the study can be summarised as follows:

• Economic policy uncertainty generally reduces the likelihood of M&A initiation and deal completion across BRICS economies.

• The impact of uncertainty is highly heterogeneous and mediated by institutional frameworks and ownership structures.

• State ownership functions as a significant deterrent to deal completion under conditions of heightened uncertainty.

• Financial leverage increases the probability of M&A completion, consistent with restructuring, consolidation, and risk-reallocation motives.

• Uncertainty reshapes, rather than eliminates, M&A activity by reallocating transactions toward firms with particular financial and governance characteristics.

Overall, the analysis demonstrates that M&A activity in BRICS economies is governed by a complex interaction between macro-level uncertainty and firm-level attributes. These findings contribute to a deeper understanding of corporate strategy under institutional volatility and offer relevant insights for other reforming economies, including Uzbekistan, where privatisation processes, governance reforms, and exposure to external shocks increasingly shape the investment environment

CONCLUSION AND SUGGESTIONS

The findings of this study demonstrate that economic policy uncertainty (EPU) constitutes a fundamental determinant of mergers and acquisitions (M&A) activity in BRICS economies, shaping not only the likelihood of deal initiation but also transaction completion and strategic orientation [1], [2]. The results indicate that heightened policy uncertainty generally discourages M&A activity by increasing financing costs, amplifying risk premiums, and raising the option value of waiting [3], [4]. However, the impact of uncertainty is not uniform across countries or firms and is strongly conditioned by institutional environments, ownership structures, and firm-level financial characteristics [5]. Comparative evidence across BRICS economies reveals pronounced heterogeneity in how firms respond to uncertainty: in relatively market-oriented systems such as India and South Africa, policy uncertainty exerts a strong negative effect on M&A activity, reflecting greater sensitivity to investor sentiment and capital market conditions [6], whereas in more state-influenced economies such as China and Russia, the deterrent effect of uncertainty is weaker or conditional, suggesting that government coordination, strategic state objectives, and access to state-backed financing partially buffer firms from market-based uncertainty shocks [7], [8]. These findings reinforce the view that uncertainty operates through institutional transmission mechanisms rather than as a uniform macroeconomic constraint [9]. Ownership structure emerges as a critical moderating factor, as transactions involving state-owned enterprises (SOEs) exhibit significantly lower completion probabilities, particularly during periods of elevated uncertainty [10], reflecting additional bureaucratic constraints, political oversight, and non-commercial objectives that slow decision-making and reduce transaction flexibility [11], while private firms display greater adaptability and adjust acquisition strategies more dynamically in response to changing policy conditions [12]. Firm-level financial characteristics further condition M&A outcomes, with the analysis indicating that higher leverage increases the likelihood of deal completion, supporting the interpretation that financially constrained firms may engage in M&A as a restructuring or risk-diversification strategy rather than purely as an expansionary investment [13], [14], an effect that is especially pronounced in BRICS economies with less developed capital markets, where external financing is more sensitive to macroeconomic volatility [15]. Beyond economic policy uncertainty, geopolitical risk and sanctions exposure exert additional influence on M&A dynamics, as periods of heightened geopolitical tension are associated with sharp declines in cross-border M&A, longer deal completion times, and a reorientation toward domestic consolidation [16], [17], while at the same time uncertainty can accelerate strategic consolidation among firms seeking to internalise risks, secure market positions, or exploit valuation disparities created by institutional shocks [18]. Taken together, these findings highlight several structural challenges shaping M&A activity in BRICS economies, including persistent policy and regulatory volatility that increases investment irreversibility concerns [3], high levels of state participation in corporate ownership that reduce transaction speed and flexibility [10], [11], uneven access to external finance that amplifies the role of leverage in acquisition decisions [13], exposure to geopolitical risk and sanctions, particularly in politically sensitive economies [16], [17], and institutional heterogeneity that limits the generalisability of country-specific policy responses [9]. The policy implications are therefore substantial, as improving policy transparency and regulatory predictability can materially enhance M&A efficiency by reducing uncertainty-induced delays and transaction failures [1], [2], clarifying the role of the state in corporate control—particularly in SOEs—can improve deal completion rates and attract private and foreign investors [10], strengthening capital market development and access to long-term financing can reduce the distortionary effects of uncertainty on corporate restructuring decisions [14], [15], and recognising that uncertainty reallocates rather than eliminates M&A activity is essential for assessing long-term implications for market concentration and competition [18]. Overall, the analysis demonstrates that M&A activity in BRICS economies is shaped by a complex interaction between macro-level uncertainty and firm-level characteristics, and understanding these interactions is essential for designing policies that support efficient corporate restructuring under conditions of persistent uncertainty [5], [9], while also offering broader lessons for other emerging and transition economies, such as Uzbekistan, where privatisation, institutional reform, and exposure to external shocks increasingly define the investment landscape [19].

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DEVELOPING MATHEMATICAL MODELS TO SIMULATE THE DYNAMIC BEHAVIOR OF SEPARATION PROCESSES, CONSIDERING THE IMPACT OF EXTERNAL FACTORS

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Abstract: This study proposes a dynamic mathematical model for simulating separation processes in distillation columns under transient operating conditions. Due to the high inertia and structural complexity of column contact devices, experimental analysis of dynamic behavior is often limited. To overcome this challenge, the separation column is modeled as a distributed system composed of lumped-parameter elements, including trays, reboilers, condensers, and reflux accumulators. Each element is described using material and energy balance equations formulated as systems of ordinary differential equations.

The model accounts for time-dependent variations in flow rates, component concentrations, temperature, pressure, and phase equilibrium during process disturbances. A set of simplifying assumptions is applied to reduce computational complexity while preserving the essential physical characteristics of the separation process. Dynamic calculations are performed discretely over time, enabling the analysis of transient responses caused by control actions.

The model incorporates PID-based control strategies for key variables such as reboiler heat input, reflux rate, bottom product flow, and condenser cooling. The proposed approach can be effectively used for process optimization, control system design, and the development of digital twins and operator training simulators for industrial separation columns.

Key words: separation column, dynamic mathematical model, transient processes, automatic control, mass and energy balance, rectification, process optimization.

Annotatsiya: Ushbu tadqiqot o‘tkinchi ishlash sharoitlarida distillatsiya ustunlaridagi ajratish jarayonlarini modellashtirish uchun dinamik matematik modelni taklif etadi. Ustun kontakt qurilmalarining yuqori inertsiyasi va tuzilishining murakkabligi tufayli dinamik xatti-harakatlarni eksperimental tahlil qilish ko‘pincha cheklangan bo‘ladi. Ushbu muammoni hal qilish uchun ajratish ustuni tarelkalar, qayta qaynatgichlar, kondensatorlar va qaytarma oqim to‘plagichlarini o‘z ichiga olgan yig‘ilgan parametrli elementlardan iborat taqsimlangan tizim sifatida modellanadi. Har bir element oddiy differensial tenglamalar tizimi ko‘rinishida tuzilgan modda va energiya balansi tenglamalari yordamida tavsiflanadi.

Model jarayon buzilishlari paytida oqim tezligi, komponentlar konsentratsiyasi, harorat, bosim va faza muvozanatining vaqtga bog‘liq o‘zgarishlarini hisobga oladi. Ajratish jarayonining muhim fizik xususiyatlarini saqlagan holda hisoblash murakkabligini kamaytirish uchun soddalashtiruvchi farazlar majmui qo‘llaniladi. Dinamik hisob-kitoblar vaqt bo‘yicha diskret tarzda amalga oshiriladi, bu esa boshqaruv harakatlari natijasida yuzaga keladigan o‘tkinchi javoblarni tahlil qilish imkonini beradi.

Model qayta qaynatgichning issiqlik kirishi, qaytarma oqim tezligi, pastki mahsulot oqimi va kondensatorni sovutish kabi asosiy o‘zgaruvchilar uchun PID asosidagi boshqaruv strategiyalarini o‘z ichiga oladi. Taklif etilgan yondashuv jarayonlarni optimallashtirish, boshqaruv tizimlarini loyihalash, sanoat ajratish ustunlari uchun raqamli egizaklar hamda operatorlarni o‘qitish simulyatorlarini ishlab chiqishda samarali qo‘llanilishi mumkin.

Kalit so‘zlar: ajratish kolonnasi, dinamik matematik model, o‘tkinchi jarayonlar, avtomatik boshqaruv, modda va energiya balansi, rektifikatsiya, jarayonni optimallashtirish.

Аннотация: В данном исследовании предлагается динамическая математическая модель для моделирования процессов разделения в дистилляционных колоннах в нестационарных условиях эксплуатации. Из-за высокой инерционности и структурной сложности контактных устройств колонн экспериментальный анализ динамического поведения часто ограничен. Для преодоления этой проблемы разделительная колонна моделируется как распределенная система, состоящая из элементов с сосредоточенными параметрами, включая тарелки, кипятильники, конденсаторы и емкости орошения. Каждый элемент описывается с помощью уравнений материального и энергетического баланса, сформулированных в виде систем обыкновенных дифференциальных уравнений.

Модель учитывает зависящие от времени изменения расходов, концентраций компонентов, температуры, давления и фазового равновесия при возмущениях процесса. Применяется ряд упрощающих допущений для снижения вычислительной сложности при сохранении существенных физических характеристик процесса разделения. Динамические расчеты выполняются дискретно во времени, что позволяет анализировать переходные процессы, вызванные управляющими воздействиями.

Модель включает стратегии управления на основе ПИД-регуляторов для ключевых переменных, таких как тепловая нагрузка кипятильника, расход орошения, расход кубового продукта и охлаждение конденсатора. Предложенный подход может эффективно использоваться для оптимизации процессов, проектирования систем управления и разработки цифровых двойников и тренажеров для обучения операторов промышленных разделительных колонн.

Ключевые слова: разделительная колонна, динамическая математическая модель, переходные процессы, автоматическое управление, материальный и тепловой баланс, ректификация, оптимизация процесса.

INTRODUCTION

Separation columns play a pivotal role in modern chemical, petrochemical, and process industries, serving as core units for the purification and fractionation of multicomponent mixtures. The efficiency and economic viability of these processes largely depend on the stability and controllability of mass and heat transfer occurring within the column. As industrial separation systems grow in scale and complexity, the demand for high product purity, reduced energy consumption, and reliable operation under varying conditions has intensified. This places increased emphasis on understanding not only steady-state performance, but also the dynamic behavior of separation columns during transient and disturbed operating modes.

In practical operation, separation columns are subject to frequent disturbances caused by fluctuations in feed flow rate, composition, temperature, and pressure, as well as by changes in utility conditions and control actions. Due to the large number of contact devices—such as trays or packing elements—and the significant holdup of material within the column, these systems exhibit pronounced inertia. This inertia complicates experimental investigation of transient regimes and limits the applicability of purely empirical approaches for control system design. As a result, mathematical modeling has become an indispensable tool for analyzing column dynamics and supporting the development of effective automation and optimization strategies.

Dynamic modeling of separation columns is inherently challenging, as rigorous descriptions typically lead to systems of nonlinear partial differential equations with distributed parameters. While such models offer high accuracy, their computational complexity often makes them impractical for control-oriented studies and real-time applications. Therefore, there is a strong motivation to develop reduced-order dynamic models that balance physical fidelity with computational efficiency. Representing a separation column as a sequence of lumped-parameter elements with time delays provides a pragmatic framework for capturing essential dynamic interactions while remaining suitable for control analysis.

In this context, the present study focuses on the development of a dynamic mathematical model of a separation column that enables the analysis of transient processes and control behavior under non-steady-state conditions. The proposed approach is based on material and energy balances for individual contact devices, supplemented by phase equilibrium relationships and simplified hydrodynamic assumptions. By integrating dynamic control loops for key process variables, the model creates a foundation for evaluating controllability, stability, and optimization potential. Such a modeling framework is particularly relevant for the design of advanced automatic control systems, digital twins, and training simulators, where accurate yet computationally tractable representations of separation processes are essential.

REVIEW OF LITERATURE ON THE SUBJECT

Recent research on separation and rectification processes demonstrates a clear shift toward advanced modeling, optimization, and intelligent control methods aimed at improving efficiency, stability, and product

quality. Kozhakhmetova et al. (2024) analyze the operation of a distillation column in a catalytic cracking unit using fuzzy input information, showing that uncertainty-aware modeling improves decision-making under incomplete or imprecise process data. Their results confirm that fuzzy-based approaches are particularly effective for complex industrial columns where classical deterministic models may not fully capture operational variability.

Simulation-driven optimization remains a dominant research direction. Yang et al. (2024) investigate the rectification of tetrafluoroethylene through detailed process simulation and optimization, demonstrating how parametric adjustments can significantly enhance separation efficiency and reduce energy consumption. Their work highlights the importance of combining rigorous thermodynamic models with numerical optimization to identify optimal operating regimes. Similarly, Seferlis and Grievink (2001) propose collocation-based models for the optimal design and sensitivity analysis of reactive distillation units, emphasizing that dynamic interactions between reaction and separation must be considered at the design stage to ensure robust operation.

The influence of structural and operational parameters on rectification performance is addressed by Anokhina and Timoshenko (2023), who study the effect of side-draw quantity and level on extractive rectification agent consumption in systems with partially integrated heat and material flows. Their findings reveal strong nonlinear relationships between tray configuration, internal flows, and solvent demand, reinforcing the need for dynamic models capable of capturing transient and coupled effects in complex column systems.

Energy and enthalpy-based modeling approaches also play a significant role in separation process analysis. Cardoso and Salcedo (2010) introduce transformed enthalpy surfaces for multireactive systems, applying this concept to reactive distillation of MTBE. Their methodology provides valuable insight into heat–mass interaction mechanisms and supports the development of energy-efficient control and optimization strategies for integrated separation–reaction processes.

From a control perspective, the application of intelligent and fuzzy logic methods has gained increasing attention. Avazov and Abdullaeva (2024) demonstrate the practical implementation of fuzzy control for rectification processes, showing improved stability and adaptability compared to conventional control schemes. Their work confirms that fuzzy controllers are well suited for nonlinear, multivariable separation systems subject to disturbances and parameter uncertainty.

Although originating from computer science, the concept of separation and non-interference discussed by Karbyshev et al. (2018) provides a valuable theoretical perspective for complex systems modeling, emphasizing modularity and independence of subsystems. This idea aligns with modern approaches to representing separation columns as interconnected but locally describable elements, facilitating scalable dynamic modeling.

Overall, the reviewed studies confirm that effective analysis and control of separation columns require a combination of dynamic mathematical modeling, thermodynamic rigor, optimization techniques, and intelligent control strategies. These works collectively justify the development of integrated dynamic models that balance physical accuracy with computational feasibility and support advanced automation and optimization of industrial separation processes.

RESEARCH METHODOLOGY

The research methodology is based on the collection of input data from published scientific sources, process design documentation, and operational parameters of separation columns. Mathematical modeling is used to generate time-dependent datasets, which are analyzed through numerical simulation and sensitivity analysis to evaluate transient behavior, control responses, and the influence of key technological variables.

ANALYSIS AND RESULTS

For accurate separation of mixture components, columns requiring a substantial quantity of contact devices are indispensable. However, the inherent inertia of these devices presents a challenge for experimentally investigating their dynamic behaviors, a crucial step in selecting and designing automation systems. Addressing challenges related to optimal control and process optimization within separation processes necessitates the application of mathematical modeling techniques and their derived results.

Several mathematical models have been created to represent the separation process [1-3]. However, capturing the dynamic behavior of these processes within automatic control systems often results in intricate systems of nonlinear partial differential equations. To circumvent this complexity, researchers focus on either static optimization of the process or simplifying the model using reasonable assumptions.

A distributed separation column can be viewed as a system composed of individual components, each modeled as a lumped parameter system with inherent delays. These components include trays, boilers, condensers, and packing sections, each possessing a unique separation capacity for the fluids flowing through

them. Mathematical representations of these components are developed using systems of ordinary differential equations. These equations encompass balance relationships and nonlinear expressions that capture the dynamics of fluid flow, heat transfer, and mass transfer within each component.

Due to external disruptions, the separation process moves away from its state of dynamic balance. This shift causes alterations in the composition of both the liquid and vapor phases, along with changes in their flow rates, enthalpy, temperature, and pressure within each contacting device, the column base, and the reflux accumulator.

Technological artifacts, exemplified by separation columns, possess distinctive traits. These include multidimensionality, intricate interconnections between parameters, the spatial and temporal distribution of these parameters, and the prevalence of substantial disturbances. Modeling and computational analysis of such objects necessitate consideration of these inherent properties.

To streamline calculations and address the many variables influencing the separation process, which fluctuate over time, the dynamic model of the separation column employs the following assumptions:

Because the liquid on the trays combines immediately, we can treat the tray as a system with aggregated characteristics.

The impact of hydraulic delay on both liquid and vapor flow is disregarded in this analysis.

Thermal energy is not emitted by the device.

The liquid and vapor phases exist in a state of balance.

The operating characteristics of the separation column are intrinsically linked to the nature of the substances being separated within it.

The duration needed for hydrodynamic conditions and phase equilibrium to stabilize within the column is insignificant compared to the time necessary for concentration establishment.

Within the context of modeling, a separation column is viewed as a collection of basic components, each functioning similarly to a single tray, reboiler, condenser, or the reflux gathering point at the column's summit.

The diagram in Figure 1. provides a visual representation of the key material and thermal (heat) transfers occurring within the column's contact zone (Figure 1).

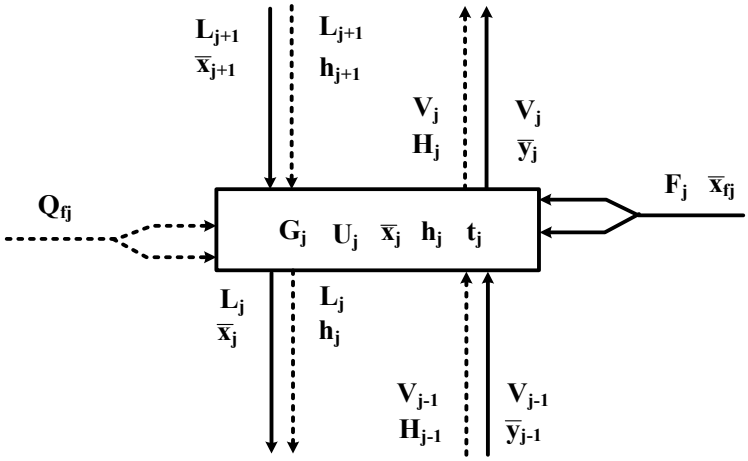

Figure 1. Visual representation of how materials and energy move through the separation column's contacting unit

The calculation of the transition process unfolds step-by-step at designated moments in time, with each point separated by a time difference denoted as Δτ:

$$\tau[k+1] = \tau[k] + \Delta\tau = (k+1) \cdot \Delta\tau;$$

where τ[0] = 0; k is an integer; k=0, 1, ..., m.

The key factors influencing this process, which are carefully regulated, include flow rate F_j, concentration f_j, feed temperature t_j, and pressure within the feed pipe P_j, all of which are time-dependent variables.

At a specific point in time, denoted as τ[k], the parameters of the contact device illustrated in Figure 1. are precisely defined. These parameter values are established either at the very beginning (τ[0]) through the use of a static model or by simulating the device's behavior during transient phases.

$$V_{j-1}[k+1]\bar{y}_{j-1}[k+1]H_{j-1}[k+1]L_{j+1}[k]\bar{x}_{j+1}[k]h_{j+1}[k]$$

The column's calculations progress in a single direction, moving upwards from the bottom. Consequently, at time τ[k+1], as the calculation reaches the j-th tray, the properties of the vapor exiting the contacting

device situated beneath are already determined. However, to determine the liquid flow entering the tray, the characteristics of the liquid at an earlier time, τ[k], must be employed.

$$\tau[k+1]:\ L_j[k+1],\ V_j[k+1],\ \overline{x}_j[k+1],\ \overline{y}_j[k+1],\ h_j[k+1],$$
$$H_j[k+1], G_j[k+1],\ t_j[k+1]$$

These calculations determine the features and attributes of the flows exiting the plate, along with the temperature and volume of liquid remaining within it at a later point.

Within the established mathematical model, every contact device is treated as a possible source plate, taking into consideration the influence of dynamic control maneuvers on the process:

$$\begin{cases} F_j = q \cdot F, & j = N_{f,1}, \\ F_j = (1-q) \cdot F, & j = N_{f,2}, \\ F_j = 0, & j \neq N_{f,1}, \neq N_{f,2}. \end{cases} \quad (1)$$

Every plate is supplied with liquid from the device situated above it and vapor from the section below. The liquid, determined by its composition, and the vapor, whose characteristics are influenced by the mass transfer efficiency within the device, leave the plate. The comprehensive material balance for the contact device can be summarized as:

$$\frac{dG_j}{d\tau} = L_{j+1} + V_{j-1} + F_j - L_j - V_j. \quad (2)$$

Material balance equation by components:

$$\frac{d(G_j \cdot x_{j,i})}{d_\tau} = L_{j+1} \cdot x_{j+1,i} + V_{j-1} \cdot y_{j-1,i} + F_j \cdot x_{f,j,i} - L_j \cdot x_{j,i} - V_j \cdot y_{j,i} \quad (3)$$

The left side of expression (3):

$$\frac{d(G_j \cdot x_{j,i})}{d\tau} = G_j \cdot \frac{dx_{ji}}{d\tau} + x_{j,i} \cdot \frac{dG_j}{d\tau}. \quad (4)$$

By inserting equations (4) and (2) into equation (3), we derive the formula for determining the concentration of the liquid-phase components.

$$G_j \cdot \frac{dx_{j,i}}{d\tau} = L_{j+1} \cdot (x_{j+1,i} - x_{j,i}) + V_{j-1} \cdot (y_{j-1,i} - x_{j,i}) + V_j \cdot (x_{j,i} - y_{j,i}) + F_j \cdot (x_{f,j,i} - x_{ji}).$$

(5)

The time constant for the column contact device is represented by the following expression:

$$T_j = \frac{G_j}{L_{j+1} + V_{j-1} - V_j + F_j} \quad (6)$$

The heat balance equation resembles equation (5), but instead of considering heat loss to the surroundings, it focuses on the heat stored within the liquid on the plate, specifically as a change in its enthalpy.

$$G_j \frac{dh_j}{d-} - L_{j-1} - (h_{j-1} - h_j) - V_{j1} - (H_{j1} - h_j) - V_j - (h_j - H_j) - F_j - (h_{f,j} - h_j).$$

(7)

The tray's structural configuration plays a crucial role in determining how much substance changes within the column's contact device during dynamic operation. When analyzing the feed tray of a separation column, it's generally accepted that the liquid level remains constant. Under these circumstances, the vapor phase contribution to the liquid can be disregarded, the liquid volume on the tray is steady, and the substance amount is:

$$G = \frac{\pi \cdot d^2 \cdot U \cdot \rho}{4 \cdot \mu}. \quad (8)$$

The determination of a liquid mixture's density and molar mass relies on the concept of additivity, along with the evaluation of individual component densities and molar masses. The relationship between the density of a pure component (i) and temperature (t) exhibits a linear trend, expressible as:

$$\rho_i = \rho_{i,1} \cdot t + \rho_{i,2} \quad (9)$$

Mixture density:

$$\rho = \frac{1}{\sum_{i=1}^{n}\left(\frac{x_i}{\rho_i}\right)} = \frac{1}{\sum_{i=1}^{n}\left(\frac{x_i}{\rho_{i,1}\cdot t+\rho_{i,2}}\right)} \quad (10)$$

The molar mass of a pure substance remains a fixed value. In contrast, the molar mass of a mixture:

$$\mu = \sum_{i=1}^{n}(\mu_i \cdot x_i). \quad (11)$$

Based on equations (10) and (11), the quantity of substance within the contact device can be represented by this equation:

$$G_j = \frac{\pi \cdot d_j^2 \cdot U_j}{4 \cdot \sum_{i=1}^{n}(\mu_i \cdot x_{j,i}) \cdot \sum_{i=1}^{n}\left(\frac{x_{j,i}}{\rho_{i,1}\cdot t_j+\rho_{i,2}}\right)}. \quad (12)$$

The quantity of substance present is determined based on the liquid phase composition at a specific point in time. The U_j values serve as tuning parameters within the dynamic model.

Our calculations rely on the vapor composition and the assumption that mass transfer coefficients remain constant in both the liquid $\beta_{x,j}$ and vapor $\beta_{y,j}$ phases.

$$m_j = \frac{\partial y_j^*(\overline{x})}{\partial x_j}, \quad (13)$$

$$K_{y,j} = \frac{S}{\frac{1}{\beta_{y,j}} + \frac{m_j}{\beta_{x,j}}}, \quad (14)$$

$$\eta_j = 1 - e^{-\frac{K_{y,j}}{V_{j-1}}}, \quad (15)$$

$$y_{j,i} = y_{j-1,i} + (y_{j,i}^* - y_{j-1,i}) \cdot \eta_{j,i} \quad (16)$$

$\overline{y}_j^*$ The makeup of the vapor phase at equilibrium is calculated using a phase equilibrium model [4], and can be represented as a generalized equation that depends on both the liquid phase composition and the pressure within the contacting equipment:

$$\overline{y}_j^* = f(\overline{x}_j, P_j) \quad (17)$$

We determine the temperature within the contact device concurrently with equation (17) through the application of iterative computational techniques.

$$t_j = f(\overline{x}_j, P_j) \quad (18)$$

Considering equation (18), we determine the enthalpy of both the liquid and vapor phases, analyzing how these values change based on their composition and the pressure exerted on the plate.

$$h_j = f(\overline{x}_j, P_j), \quad (19)$$

$$H_j = f(\overline{y}_j, P_j) \quad (20)$$

The column can receive feed in various phases: subcooled liquid, boiling liquid, a blend of vapor and liquid, condensing vapor, or superheated vapor. The specific phase of the feed directly influences the enthalpy of the incoming stream [5]:

$$h_{f,j} = f(\overline{x}_{f,j}, P_{f,j}, t_{f,j}) \quad (21)$$

The expressions provided, numbered (1) through (21), enable the calculation of dynamic modes for each individual contact device within the column. Based on these expressions, we outline the following algorithm to determine the required values:

$$h_{f,j}[k+1]$$

1) Before allowing the feed stream to enter the simulated plate, a specific criterion is evaluated. Upon fulfillment of this criterion, both the enthalpy of the feed (21) and the column's heat demand are determined.

2) The level of liquid within the contact device is measured (5);

$$x_{j,i}[k+1] = x_{j,i}[k] +$$

$$+\Delta\tau \cdot \frac{L_{j+1}[k] \cdot \left(x_{j+1,i}[k] - x_{j,i}[k]\right) + V_{j-1}[k] \cdot \left(y_{j-1,i}[k] - x_{j,i}[k]\right)}{G_j[k]} +$$

$$\Delta\tau \cdot \frac{V_j[k] \cdot \left(x_{j,i}[k] - y_{j,i}[k]\right) + F_j[k] \cdot \left(x_{f,j,i}[k] - x_{j,i}[k]\right)}{G_j[k]}.$$

3) By analyzing the composition and pressure within the contact device, one can ascertain the enthalpy of the liquid phase;

$$h_j[k+1], \qquad (2.19)$$

$$t_j[k+1]\overline{y}_j[k+1]$$

4) The parameters influencing the equilibrium state of the process are identified, including the equilibrium phase conditions, temperature, the effectiveness of the contact device for binary separations, and the composition of the vapor exiting each plate;

$$H_j[k+1]$$

5) The enthalpy of the vapor phase is directly influenced by its constituent components.

$$\overline{x}_j[k]t_j[k]\overline{x}_j[k+1]t_j[k+1]$$

6) Leveraging the provided molar masses (11) and density (10), the calculation of the liquid mixture's properties is performed;

7) The quantity of material within the contact device is controlled by ensuring the liquid level on the plate remains steady.

$$\Delta U_j = U_j;$$

8) Using the overall material balance equation (2), we can calculate the remaining unknown value: the rate at which liquid flows out of the plate.

$$L_j[k+1] = L_{j+1}[k] + V_{j-1}[k] + F_j[k] - V_j[k] - \frac{G_j[k+1] - G_j[k]}{\Delta\tau}.$$

Alternatively, considering equation (22), we can express it as:

$$L_j[k+1] = L_{j+1}[k] + V_{j-1}[k] + F_j[k] - V_j[k] - \frac{G_j[k] \cdot \left(\frac{\mu_j[k] \cdot \rho_j[k+1]}{\mu_j[k+1] \cdot \rho_j[k]} - 1\right)}{\Delta\tau}.$$

For each contact device, these calculations are performed step-by-step, starting at the base of the separation column and progressing upwards. Subsequently, the value of k is augmented by one, and the entire calculation sequence is replicated for the subsequent time point.

To determine the design parameters for a column reboiler, one must first ascertain the flow rate and properties of the streams exiting the bottom of the column. Additionally, the temperature, volume, and liquid level within the vessel at the subsequent time interval, τ[k+1], need to be established.

$$W[k+1], V_0[k+1], \overline{x}_0[k+1], y_0[k+1], h_0[k+1], H_0[k+1], G_0[k+1],$$
$$U_0[k+1],\ t_0[k+1]$$

.

$$Fl[k+1], D[k+1], \overline{x}_d[k+1], \overline{x}_{fl}[k+1], t_{fl}[k+1], h_d[k+1], h_{fl}[k+1],$$
$$F_{m3}[k+1], G_d[k+1], U_d[k+1].$$

During the reflux condenser calculation, key factors considered include the flow rate and properties of the streams leaving the reflux drum, the coolant flow rate feeding the condenser, and the quantity and level of the substance present in the reflux accumulator at the point in time denoted by τ[k+1].

Constructing the system of equations for the column reboiler and reflux condenser (equations 2-21) is a straightforward process, analogous to modeling the contact device, so a detailed explanation will be omitted.

The separation column's transition processes adhere to the fundamental principles of matter and energy

conservation. Any alteration in process parameters will shift the column from a stable, steady-state operation to a dynamic state. Achieving a new equilibrium state necessitates deliberate adjustments to the material and energy streams within the apparatus.

Therefore, managing the separation process necessitates both conventional control measures and dynamic actions. Dynamic actions are implemented at the column's extremities, and the dynamic models of the reboiler and reflux condenser require augmentation with models encompassing the relevant circuits designed to fine-tune process variables.

Crucially, the primary traditional control mechanisms for this process involve adjusting the heat input to the reboiler and the reflux rate fed into the column. These adjustments directly influence the column's liquid and vapor loading, its overall productivity, and the final cost of the produced product. Determining the ideal values for these influences involves employing a predictive mathematical model based on nonlinear statics, utilizing algorithms designed for optimizing the separation process [6-7].

Keeping the material balance stable at the column's base requires adjusting the reboiler vessel's liquid level by modifying the flow rate of the product exiting the bottom. The transfer function governing the Uw-W control loop exhibits characteristics of an integrating element:

$$W_0(s) = -\frac{1}{T_{w,o} \cdot s}. \quad (24)$$

We can represent this using a time constant:

$$T_{w,0} = \frac{\pi \cdot d_w^2 \cdot \rho_0}{4 \cdot \mu_0}.$$

Equation (24) employs a "minus" sign to show that the amount of product in the vessel is inversely proportional to the cubic product flow rate. The factor multiplying this relationship is not constant, since the molar mass and density of the cubic product fluctuate based on its makeup and temperature.

We express the allowable starting condition in the following manner:

$$\Delta U_0[k+1] = U_0[k+1] - U_{0,z} \quad (25)$$

Based on the given requirement, when employing a PID controller, the control action components are expressed as:

$$u_p[k+1] = K_p \cdot \Delta U_0[k+1], \quad (26)$$

$$u_i[k+1] = u_i[k] + K_p \frac{\Delta\tau}{T_i} \cdot \Delta U_0[k+1], \quad (27)$$

$$u_d[k+1] = K_p \frac{T_d}{\Delta\tau} \cdot (\Delta U_0[k+1] - \Delta U_0[k]). \quad (28)$$

Considering both the received negative feedback and the inherent negative transfer function, we can re-define the cubic product flow rate using the updated equation (24) as shown below:

$$W[k+1] = W[k] + u_p[k+1] + u_i[k+1] + u_d[k+1]. \quad (2.29)$$

The process of U_d involves dispensing the necessary volume of D distillate. The time constant, which defines the integrating element's reflux capability, is represented as follows:

$$T_{d,0} = \frac{\pi \cdot d_d^2 \cdot \rho_d}{4 \cdot \mu_d}$$

$F_{m3} Q_d$ Adjusting the cooling agent flow rate within the condenser controls the pressure at the top of the column. When the cooling agent flow increases, more heat is dissipated from the vapor product at the column's upper section, leading to increased condensation and a subsequent decrease in pressure within the system.

Elevated pressure within the column stems from the buildup of vapor within its spaces between the plates. We express the time constant as:

$$T_{P,0} = \frac{(N+1) \cdot S \cdot h_y \cdot (H_N - h_d)}{R \cdot T_N \cdot \Delta h_{m3}}. \quad (30)$$

$T_N P_N \overline{y}_N$ The value of T in equation (30) is determined by finding the condensation temperature of the vapor mixture, which has a composition of x, under the specified temperature T and pressure P.

$F_{m3}(\tau)$ To maintain control over the distillate level and pressure within the column's upper section, a

PID controller is employed. The determination of D (τ) and ω values is carried out using equations (25) to (29).

F_{m3} Based on the usage of the cooling agent, we calculate the rate at which steam condenses:

$$V_{N,cond}[k+1] = G_d[k] \cdot \frac{h_d[k+1]-h_d[k]}{\Delta\tau\cdot(H_N[k]-h_d[k])} + F_{m3}[k] \cdot \frac{h_{m3}[k]-h_{m4}[k]}{H_N[k]-h_d[k]}. \quad (31)$$

Equations (23) and (31), corresponding to the final column plate and the reflux condenser respectively, enable the calculation of the substance quantity variation within each inter-plate space of the column.

The pressure within each contact device is represented using the following formula during the computation process.

$$P_j[k+1] = P_j[k] + \frac{\Delta G_{y,j}[k+1] \cdot R \cdot T_j[k+1]}{S \cdot h_y}.$$

This dynamic model enables the investigation of how the column behaves during temporary changes brought about by control measures.

CONCLUSIONS AND SUGGESTIONS

In this study, a dynamic mathematical model of a separation column was developed to analyze transient operating modes and control behavior under non-steady-state conditions. The proposed modeling approach represents the separation column as a distributed system composed of lumped-parameter elements, including trays, a reboiler, a condenser, and a reflux accumulator. This structure makes it possible to adequately describe the dynamic interactions between material and energy flows within the column.

The model is based on rigorous material and energy balance equations that account for time-dependent changes in flow rates, component compositions, temperature, pressure, and phase equilibrium. The introduction of reasonable simplifying assumptions significantly reduces computational complexity while preserving the essential physical characteristics of the separation process. Step-by-step time discretization enables accurate simulation of transient responses caused by external disturbances and control actions.

The integration of PID control loops for key technological variables—such as reboiler heat input, reflux flow rate, bottom product withdrawal, and condenser cooling - allows the evaluation of controllability, stability, and process dynamics. The results demonstrate that dynamic control actions applied at the column boundaries play a decisive role in restoring steady-state operation and ensuring product quality.

The developed model provides a reliable basis for the design and optimization of automatic control systems, predictive analysis of separation efficiency, and energy consumption assessment. Moreover, it can be effectively applied in the creation of digital twins and computer-based training simulators for industrial separation processes, contributing to improved operator training and enhanced process safety and efficiency.

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THEORETICAL FOUNDATIONS OF IMPLEMENTING DIGITAL TECHNOLOGIES IN THE TRANSFORMATION OF BANKS

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Abstract: Maqolada banklarni transformatsiyalash jarayonida zamonaviy texnologiyalarni joriy etishning nazariy jihatlari xorijiy iqtisodchi olimlarning ilmiy qarashlari asosida tahlil qilinadi. Shuningdek, bank tizimining rivojlanishi klassik va raqamli rivojlanish nazariyalari kesimida o‘rganilib, har bir yondashuvning o‘ziga xos afzalliklari yoritib beriladi. Tadqiqot natijasida bank transformatsiyasiga doir mualliflik ta’riflari ishlab chiqildi va ilmiy asoslangan xulosalar shakllantirildi.

Key words: transformatsiya, klassik yondashuv, raqamli yondashuv, raqamli texnologiyalar, internet-banking.

Annotatsiya: The article analyzes the theoretical aspects of implementing modern technologies in the process of bank transformation based on the scientific views of foreign economists. In addition, the development of the banking system is examined at the intersection of classical and digital development theories, highlighting the specific advantages of each approach. As a result of the study, original definitions of bank transformation were developed, and scientifically grounded conclusions were formulated.

Kalit so‘zlar: transformation, classical approach, digital approach, digital technologies, internet banking.

Аннотация: В статье на основе научных взглядов зарубежных экономистов проанализированы теоретические аспекты внедрения современных технологий в процессе трансформации банков. Также развитие банковской системы изучено на стыке классических и цифровых теорий развития, при этом освещены характерные преимущества каждого подхода. В результате исследования разработаны авторские определения банковской трансформации и сформированы научно обоснованные выводы.

Ключевые слова: трансформация, классический подход, цифровой подход, цифровые технологии, интернет-банкинг.

INTRODUCTION

The development of Uzbekistan’s economy and the processes of globalization necessitate the implementation of new strategies and transformation approaches in the banking sector. Transformation processes play a crucial role in improving banks’ operations, enhancing their competitiveness, and ensuring the provision of efficient services to customers.

Today, banks are actively pursuing the modernization of their activities, the adoption of digital technologies, and the application of innovative approaches to customer service. These processes require a comprehensive reconsideration of banks’ internal structures, service delivery mechanisms, and business models.

LITERATURE REVIEW

Over the past decade, the role of digitalization in transforming the banking system aimed at increasing technological capacity has become the subject of extensive academic debate. Researchers have assessed the necessity and significance of introducing innovations into the banking sector, as well as their positive impact on national economic development.

In particular, issues related to the digitalization of financial processes have been addressed in the scientific works of T.Yu. Popova, B. Graham, L.V. Koch, L.A. Zubchenko, R. Zingales, Z. Bodie, R. Merton, and H. Minsky. In Russian economic science, however, a unified and generally accepted definition of the term “banking innovations” under the conditions of the digital economy has not yet been fully formed, while scholarly research in this direction continues to develop.

This concept encompasses a set of measures implemented in practice, characterized by advanced technological features intended for specific groups of users of innovative technologies. Economists interpret the introduction of innovations in the banking sector within the framework of four main approaches, according to which these approaches include the following.

Within the first approach, banking innovations introduced in the context of the digital economy are considered a key source for the development and implementation of modern banking products. According to E.F. Zhukov, “banks and financial institutions analyze innovations with the single objective of forming additional financial funds and resources that contribute to the growth of final profits by subsequently applying them to existing financial instruments, operating product lines, and permitted financial operations” [1].

In the Financial and Credit Encyclopedic Dictionary edited by A.G. Gryaznova, financial innovation is defined as a newly developed financial product or financial instrument. This conceptual approach applies to all segments of the global financial market and, since the last quarter of the twentieth century, has identified products and technologies directly introduced, particularly in the secondary mortgage financial market, aimed at securitizing assets for future use [2].

According to L.V. Koch, “a banking innovation is an innovation developed directly for end users, applied by customers themselves, and transformed into a modern form based on previous technological advancements” [3].

The second approach defines the segment toward which banking innovations are directed under the conditions of economic digitalization. It characterizes the transformation of traditional technological processes through the introduction of more advanced methodologies and methods that, based on existing financial and technological solutions and software platforms, ensure the formation of final data in carrying out financial operations. These operations include one or several aggregated procedures such as analysis, accounting, control, planning, budgeting, and other related activities. The reformatting of banking innovations applied within financial and technological processes has significantly enhanced the essence of the operational infrastructure and the role of the processes occurring within it in banking practice. This can be clearly interpreted as a manifestation of the digital era in the context of global financial markets.

According to D.A. Nazipov, a high level of integration between information and banking innovations aimed at expanding the customer base, as well as the openness of digital processing, ensures an increase in the economic efficiency and profitability of financial institutions through the adoption of digital technologies. This confirms the relevance of research focused on studying and addressing the scientific and methodological issues of introducing digital processes and digitally transforming existing banking technologies in the environment of digital and telecommunication technologies [4].

The third approach considers banking innovations in the digital economy directly through the established business processes of financial and credit institutions. The globalization of the world economy and financial markets is driven by the decisive role of the global Internet network and by the formation of an electronic communication environment characterized by a substantial increase in the volume of data being processed and transmitted. This, in turn, enables the creation of a financial ecosystem for banks that facilitates solving emerging banking processing tasks and transitioning to innovative ways of organizing business processes.

Popova T.Yu. describes the process of developing and pilot implementation of digital innovations in the banking sector as complex, multi-stage, multi-level, and highly cost-intensive [5]. Therefore, the introduction of digital innovations initially began in the largest banks of Russia, as well as within the framework of state support for digitalization projects.

The fourth approach encompasses the introduction and improvement of organizational and managerial forms of interaction. It is driven by the need to distribute functional responsibilities through outsourcing, innovatively update banking products, diversify services, and develop administrative and financial management instruments within credit institutions. All of these processes are grounded in competition emerging in specific directions, including:

- the formation of customer-oriented products and services;
- achieving universality across the spectrum of financial activities;
- ensuring integration into global globalization processes;
- implementing possible organizational consolidation in various areas;
- expanding opportunities to transform banking processing and the technological forms of business.

The diversity of interpretations regarding the essence of banking innovations is explained by the absence of a single unified criterion-based approach. Within the first approach, banking innovations are viewed as a source for developing and introducing additional banking products, whereas the second and third approaches emphasize the specific features of their development and subsequent application. The fourth approach implies a direct transformation of the functions performed by commercial banks in the global financial market and, in essence, represents an innovative process manifested under the conditions of further development of institutional and organizational forms characterized by banking technologies.

The digitalization of the banking sector enables banks to implement a differentiated approach to customers, taking into account the characteristics of various customer groups, and to tailor banking product offerings as closely as possible to individual consumer needs. The introduction of innovative technologies is aimed at creating the most convenient and transparent banking services regardless of time and location, as well as at increasing service efficiency through improvements in the quality of established banking services. Such development of the banking sector indicates that competition in the banking environment will ultimately intensify in the context of forming the most convenient and customer-oriented banking products.

A.I. Serebrennikova and N.E. Sokolinskaya, who have conducted research on the problems of transforming and digitalizing banking activities in modern conditions, note the complexity of the transformation period and emphasize the necessity of modernization and innovation in banking practice. They argue that such transformation is accompanied by increased attention to the risks inherent in the banking sector [6].

Foreign authors X. Ma, Q. Meng, D. Yang, and H. Wang examine the impact of digital technologies on various sectors of the economy (industry, the financial sector, and public services) and identify the country-specific features of digital transformation in China [7]. The issue of transforming business models in the context of digital transformation has been studied in the works of P. Weill and S. Woerner [8]. The studies of foreign scholars devoted to modern aspects of transforming banking activities make it possible to identify a number of common features in the digitalization processes of financial institutions in the Republic of Uzbekistan and to reveal challenges common to many countries, particularly from the perspective of information security. In the works of M.S. Leighton, J.S. Hurwitz, A.F. Nugent, F. Halper, and M.A. Kaufman, it is emphasized that “technological changes are inevitably interconnected with changes in the regulatory environment for the activities of credit institutions” [9].

The Uzbek economist N.Kh. Jumaev notes that in the digital economy, the use of IT makes it possible to reduce costs, thereby achieving optimization and increased efficiency. He emphasizes that modern scientific approaches and innovations acquire particular importance and priority in the digital economy, and that high-technology, knowledge-intensive sectors tend to develop most dynamically under such conditions [10].

Despite the ongoing development of information and communication technologies, a number of factors may hinder the growth of the internet banking sector within the banking system. These include a lack of trust among individuals in internet services, security concerns, inconvenience of network access, customers’ reluctance to conduct large transactions, and the complexity of the interfaces of many internet banking systems. Internet banking is a general term for remote banking service technologies, whereby access to accounts and operations can be carried out at any time of the day from any computer connected to the Internet. To perform transactions, customers are not required to download special software components of the system; the use of a web browser alone is sufficient.

According to economist V. Spilnichenko, “remote banking services represent a set of services that allow customers, at their own discretion, to carry out account operations and obtain information services without visiting a bank branch. A remote banking service system is the interaction between the customer and the bank’s information database through telecommunication systems” [11]. N.I. Kulikov and Yu.V. Kudryavtseva, in their research conclusions, emphasize that in the Russian banking services market, online services continue to develop even under conditions of economic stagnation, and although a full transition to this system may still be premature, it is inevitable within the next three to five years [12]. According to the approach of L.A. Samsonova, in the conditions of intense competition in the banking sector, especially amid the growth of consumer culture among individuals, banks are compelled to adapt to increasingly demanding conditions. In such circumstances, banks that provide remote services to their customers gain a clear competitive advantage. In the competitive struggle, only those banks that completely restructure their activities in line with the new requirements of banking business and modern information technologies will ultimately succeed [13].

RESEARCH METHODOLOGY

In the course of the study, the methods of scientific abstraction, the principle of objectivity, observation, comparative analysis, and logical generalization were extensively applied.

ANALYSIS AND RESULTS

In recent years, the use of "digital banking" instruments in the banking and financial sector has been expanding steadily. The term digital banking refers to the transition to an online banking system in which banking services are provided via the Internet.

Online or Internet banking, in turn, is understood as an electronic payment system that enables customers of a bank or other financial institution to perform a range of financial transactions through the institution's website. This system creates opportunities for both banks and customers to carry out banking services in a more convenient, faster, and more transparent manner (Table 1).

Table 1. Digital Banking Service Model[1]

Evaluation parameters of banking service models	Evaluation criteria	Description of digital banking services	Key directions of banking service transformation
Structure of money supply	Dominant form of money circulation	Cashless	Maximizing electronic interaction with customers
Security	Applied authentication methods	Physical electronic, password-based biometric, combined	Modernization of methods for ensuring banking service security
Technologies	Methods of customer data storage	Centralized data center (data center), 2000s technologies	Optimization of digital IT architecture and data management
	Accessibility of data	Within the country	
	Form of computer network	Internet	
	Approach to customer data processing	Using *big data* tools	
	Speed of data processing	At the level of seconds	
Organizational structure	Number of departments	9	Increasing the role of automation in banking activities
	Emergence of a new department	Banking automation department (IT)	
	Degree of departmental reorganization	Establishment and expansion of the automation department, reduction of workload in other departments	
	Ratio of front/back offices	20/80	
Customer interaction	Emergence of new service channels	Not available	Optimization of banking service channels
	Forms of service channels	Branch, telephone banking, terminal banking, internet banking, TV banking, mobile banking	
	Sales organization approach	Omnichannel	
	Degree of interaction between channels	High level	Increasing customer orientation of banking services
	Dominant form of customer contact	Remote	
	New means of customer communication	Wireless networks	
	Modern methods of customer interaction	Social media, web applications, video communication	

1 Compiled by the author.

The “digital bank” system is based on a high degree of process automation, the provision of services through web platforms, the use of application programming interfaces (APIs) that ensure the delivery of inter-institutional banking products, as well as the availability of opportunities for customers to access financial information via computers, mobile phones, and ATMs.

Digital banking services possess a number of distinctive features (Table 1):

•the dominant form of money circulation is cashless, which implies maximizing electronic interaction with customers;

•the use of physical electronic, password-based biometric, and combined authentication methods aimed at modernizing approaches to ensuring the security of banking services;

•optimization of digital IT architecture and data management within the country through centralized data centers and big data tools via the Internet;

•enhancement of the role of automation in banking services as a result of the emergence and expansion of automation departments and the reduction of workloads in other departments;

•extensive use of social media, web applications, and video communication in customer interaction.

Along with numerous advantages, the digitalization of the banking sector also entails certain significant challenges. In particular, further development of digital banking requires substantial investment. Large banks, unlike smaller ones, have greater financial capacity to attract highly qualified personnel, acquire new technologies, and introduce artificial intelligence and biometric solutions into their operations. Therefore, large banks find it easier to compete in the field of digitalization with smaller financial institutions. This situation, in turn, may create the risk of market pressure on small and emerging banks, highlighting the importance of policies aimed at supporting balanced competition and inclusive sectoral development.

Another challenge is that elderly bank customers are not yet fully prepared to abandon personal communication with bank staff. They tend to use digital products only when there is no urgent need and prefer visiting bank offices in person rather than interacting with automated systems. Moreover, many of them lack sufficient financial and digital literacy skills required to use digital services effectively. At the same time, raising awareness of the importance of digital transformation, improving digital competencies, and strengthening cybersecurity measures can significantly mitigate these challenges.

The digitalization of banks is implemented mainly in two directions: the introduction of product innovations and process innovations. The first direction of development is based on the creation of innovative banking products, such as credit brokerage services that allow customers to apply online for consumer loans or mortgages without the involvement of specialists; biometric identification enabling remote confirmation of banking operations; cashback services; and bonus programs for loyal customers, among others.

The second direction of digitalization — process innovations — is primarily aimed at minimizing the costs associated with supporting banking operations. The use of artificial intelligence implies the optimization of banking services by reducing intermediary interactions with customers and by providing a wide range of services designed to meet the needs of all segments of the population.

In customer service, banks seek to reduce direct contacts with front-office representatives typical of the traditional banking system and to shift toward remote modes of interaction, optimize human resources, and integrate such processes as customer data storage and access into a digital ecosystem. For consumers, the openness of financial services implies the availability of multiple sales and service channels, including offline, online, mobile applications, and others.

In particular, under the conditions of the COVID-19 pandemic in 2020, special attention was paid to the use of innovations and the continuous modernization of customer service, which accelerated the digitalization of the banking sector and the development of digital technologies. With the onset of the pandemic, opportunities for personal interaction were sharply limited, many services were initially unavailable online, and this required banks to make rapid and adaptive decisions. As a result, the demand model changed, followed by a transformation in approaches to maintaining customer loyalty. Isolation also increased the relevance of applications that allow customers to access multiple services remotely in a single digital environment.

Users have responded positively to new convenient non-financial solutions offered by banks and have increasingly adapted to using ecosystems built around a single brand. Therefore, in the near future, accelerated and sustainable development of the banking sector can be expected through the deployment of large-scale ecosystems based on modern digital technologies.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, it can be stated that the introduction of innovative services and technologies in commercial banks requires a comprehensive approach and clearly defined mechanisms to ensure the successful transformation of banking activities. This implies the development of a well-grounded transformation strategy,

the formulation of goals and priorities for innovation, and the establishment of concrete action plans. In this process, particular importance should be attached to effective cooperation with fintech companies and startups for the implementation of new technologies and services; the organization of training programs and professional development courses for employees in modern technologies and working methods; the use of data analytics to study customer needs and the systematic collection of feedback in order to continuously improve product innovations; and the adoption of biometric technologies (fingerprints, facial recognition, and other biometric data) to enhance the security and convenience of customer authentication. The implementation of these measures will enable banks to successfully introduce innovative services and technologies, improve customer experience, optimize business processes, and further strengthen their competitiveness in the financial market. At the same time, the active development of digitalization in the banking sector increases the demand for highly qualified specialists possessing the necessary knowledge and skills in digital technologies, and may also require existing staff to adapt to new conditions through continuous training and organizational change. Nevertheless, these challenges can be effectively addressed through systematic capacity building, motivation, and efficient management. Overall, the transition to digital services necessitates consideration of several key factors, including the rapid development of digital and innovative technologies in the external environment; the qualitative transformation of customers' needs, particularly the growing demand for remote access to services, high-quality information support, and security; the intensification of competition in the banking sector and the strengthening of competition for consumers of banking services; and the consistent improvement of service quality through the active development and application of digital technologies.

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ON THE ISSUE OF RESEARCH AND DEVELOPMENT OF A SLAG-FORMING BASE FOR ELECTRODE COATINGS FOR WEAR-RESISTANT SURFACING

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Abstract: This article describes the development of a slag-forming base for electrode coatings for wear-resistant surfacing in the $CaO–SiO_2–Al_2O_3$ system, as well as the study of the influence of Na_2O and K_2O contents in this slag system on slag density, viscosity, hiding power, and the separability of the slag crust.

Key words: Manual arc surfacing, electrode, ferroalloys, marble, pegmatite, ternary phase diagram, slag, viscosity, density, separability of the slag crust.

Annotatsiya: Mazkur maqolada $CaO–SiO_2–Al_2O_3$ tizimida yeyilishga chidamli qoplama payvandlash uchun elektrod qoplamalari tarkibida shlak hosil qiluvchi asosni ishlab chiqish, shuningdek, ushbu shlak tizimida Na_2O va K_2O miqdorining shlakning zichligi, qovushoqligi, yopish qobiliyati hamda shlak qobig‘ining ajraluvchanligiga ta’siri tadqiq etilgan.

Kalit so‘zlar: Qo‘lda yoyli qoplama payvandlash, elektrod, ferroqotishmalar, marmar, pegmatit, uch komponentli faza diagrammasi, shlak, qovushoqlik, zichlik, shlak qobig‘ining ajraluvchanligi.s

Аннотация: В статье описана разработка шлакообразующей основы для покрытий электродов, предназначенных для износостойкой наплавки в системе $CaO–SiO_2–Al_2O_3$, а также исследовано влияние содержания Na_2O и K_2O в данной шлаковой системе на плотность, вязкость, укрывистость шлака и отделяемость шлаковой корки.

Ключевые слова: Ручная дуговая наплавка, электрод, ферросплавы, мрамор, пегматит, тройная фазовая диаграмма, шлак, вязкость, плотность, отделяемость шлаковой корки.

INTRODUCTION

Metal surfacing on the surface of a part makes it possible to impart the required mechanical and physicochemical properties, thereby increasing operational reliability and service life while reducing overall costs.

Surfacing operations are used to form surface layers on parts with specified properties, as well as to restore the original dimensions of worn components. For example, surfacing enables the manufacture of parts from structural, relatively low-cost steels, on the working surfaces of which wear-resistant, heat-resistant, or other special alloys are deposited.

During surfacing, it is generally necessary to ensure minimal penetration of the base metal and limited mixing between the base and deposited metals in order to preserve the mechanical properties of the deposited layer.

At the same time, the deposited metal must be firmly bonded to the base metal and should be free from pores, slag inclusions, crack shells, and other defects.

LITERATURE REVIEW

The wear of parts is the result of the wear process, which involves the destruction and separation of material from the surface of a solid and/or the accumulation of residual deformation during friction. This process occurs in a friction pair, that is, a combination of two movably сопряжённых surfaces under real operating conditions, and is manifested in a gradual change in the size and/or shape of the body. The mechanisms of surface destruction during friction are diverse, which is associated with the combined action of mechanical, physicochemical, electrochemical, and other processes, as well as environmental conditions such as temperature and humidity [1–2].

The main factors determining surface damage and wear include plastic deformation; destruction of microroughness and oxide films due to the penetration of surface asperities of one part into the mating surface of another and their relative displacement; adhesive bonding and transfer of metal from one surface to another; hydrogenation and oxidation processes; and the rupture of seizure bridges, among others [3].

Production surfacing is applied to obtain new bimetallic (multilayer) products. Such products consist of a base metal that provides the required structural strength and a deposited working layer with special properties, including wear resistance, heat resistance, and corrosion resistance [4].

Recovery surfacing is used to restore the original dimensions of worn or damaged parts. In this case, the deposited metal may be similar in composition and properties to the base metal (dimensional restoration) or may differ from it in order to enhance performance characteristics, such as wear resistance (restorative wear-resistant surfacing) [5, 6].

RESEARCH METHODOLOGY

In the vast majority of cases, electrodes for surfacing are provided with basic coatings. Owing to the low hydrogen content in the deposited metal, such coatings ensure improved resistance to cracking during surfacing of parts made of high-carbon steels and hard alloys.

The developed composition of the electrode coating for wear-resistant surfacing includes the following components, wt.%: marble — 26–28; pegmatite — 14–16; graphite — 9–11; ferrosilicomanganese — 10–12; ferrochrome — 25–27; and ferrotitanium — 10–12.

ANALYSIS AND RESULTS

The slag system of electrodes for wear-resistant surfacing is formed by oxides of calcium (from marble), silicon, and aluminum (from pegmatite), which together ensure the formation of a stable slag with the required physicochemical properties (Figure 1).

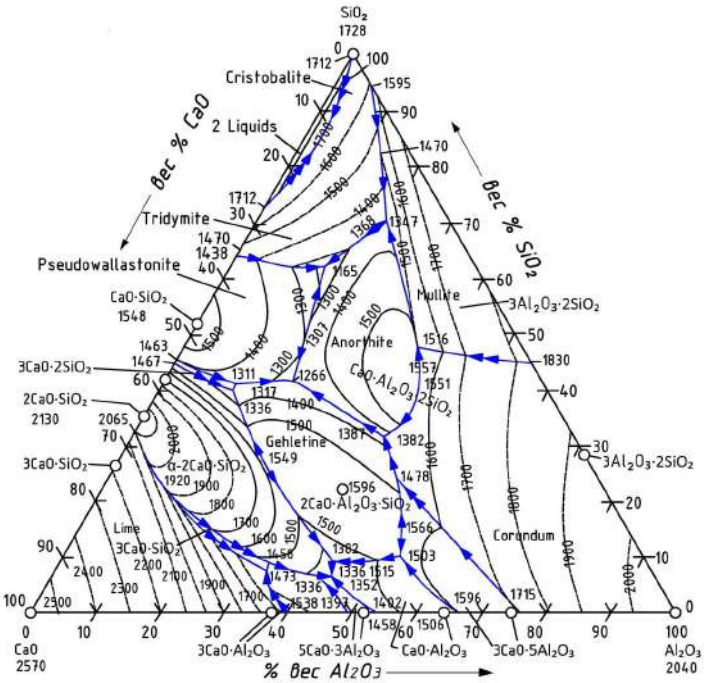

Figure 1. Ternary diagram of the $CaO–SiO_2–Al_2O_3$ system

In the $CaO–SiO_2–Al_2O_3$ system, a minimum melting temperature of about 1300 °C is observed at compositions of approximately 50 % SiO_2, 30 % CaO, and 20 % Al_2O_3. Several chemical compounds are formed in this system, including two ternary compounds: $CaO·Al_2O_3·SiO_2$, containing 20 % CaO, 37 % Al_2O_3, and 43 % SiO_2 and melting at 1550 °C, and $2CaO·Al_2O_3·SiO_2$, containing 41 % CaO, 37 % Al_2O_3, and 22 % SiO_2 and melting at 1590 °C.

The system under consideration is characterized by a wide region of melts with melting temperatures not exceeding 1600 °C, which ensures the broad applicability of slags based on the $CaO–SiO_2–Al_2O_3$ system. Slags of this system containing 48–54 % CaO tend to disintegrate into powder upon cooling.

The mineralogical composition of the slag and its structure significantly influence its physical and technological properties.

In this study, the effect of Na_2O and K_2O oxide additives (with contents of 7.08 % and 4.15 % in pegmatite, respectively) on the properties of slags belonging to the $CaO–SiO_2–Al_2O_3$ system was investigated. The influence of these additives on slag density, viscosity, and surface tension was analyzed. In parallel, the effect of the slag's physical state on welding and technological characteristics, such as slag covering power and its separability, was also examined (Figure 2).

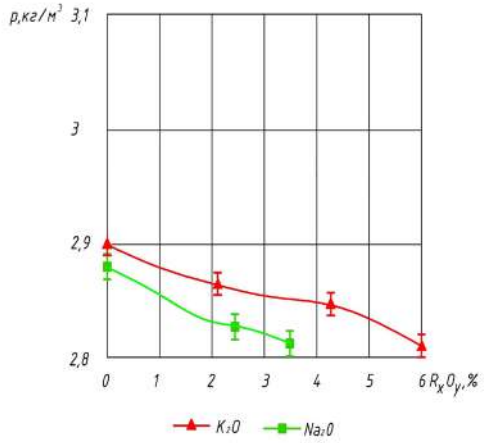

Figure 2. Dependence of the density of surfacing slag of the $CaO–SiO_2–Al_2O_3$ system on the Na_2O and K_2O content

As shown in Figure 2, the addition of sodium and potassium oxides leads to a noticeable decrease in slag density, indicating their effective role in modifying the physical properties of the slag.

The viscosity of the slag was determined using viscometry methods. This method is based on the law of fluid flow in the gap between two coaxial bodies, one of which rotates while the other remains stationary. The viscosity is calculated from the measured torque at a given angular velocity. Slag viscosity measurements were carried out using a rotational viscometer with a rotating working element immersed in the molten slag.

The dependence of slag viscosity on the Na_2O and K_2O contents in the initial slag at T = 1700 K is presented in Figure 3.

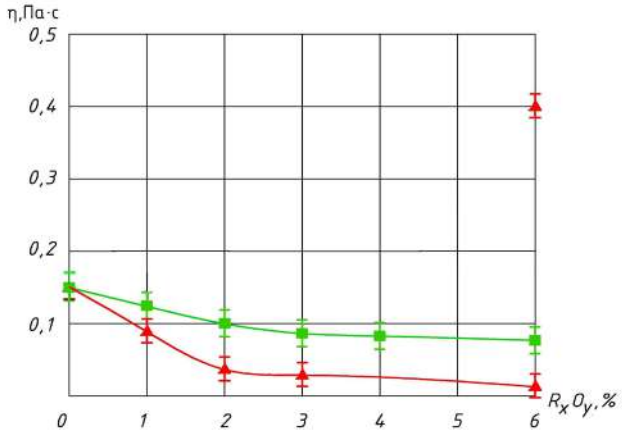

Figure 3. Dependence of the slag viscosity of the $CaO–SiO_2–Al_2O_3$ system on the Na_2O and K_2O content

Potassium and sodium oxides contribute to a reduction in the viscosity of the molten slag. Moreover, with an increase in the K_2O content, the slag viscosity decreases more markedly than with an equivalent amount of Na_2O. This behavior can be explained by the characteristics of the anions and cations formed during the dissociation of these oxides in the slag melt.

The covering power of the slag during surfacing with coated electrodes was determined as the product of two ratios: the ratio of the slag crust thickness at the top of the deposited bead to that at the base of the bead, and the ratio of the surface area of the bead covered with slag, S1S_1S1, to the total surface area of the bead, S2S_2S2, i.e.:

$$K_{C.P.} = \frac{\Delta_1}{\Delta_2} \cdot \frac{S_1}{S_2}$$

The influence of the Na_2O and K_2O contents in the slag on its covering power is illustrated in Figure 4.

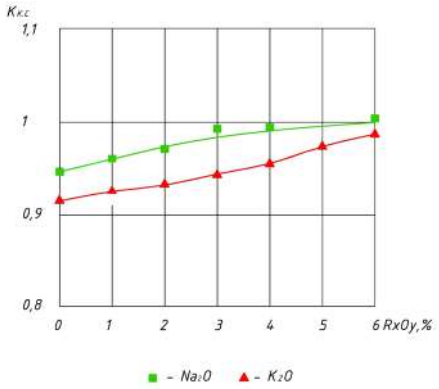

Figure 4. Dependence of the covering power of the $CaO–SiO_2–Al_2O_3$ system on the Na_2O and K_2O content

As shown in Figure 4, an increase in the Na_2O and K_2O contents leads to a corresponding increase in the covering power of the slag, indicating an improvement in its ability to uniformly protect the molten metal during surfacing.

The determination of slag crust separability is based on measuring the impact force applied to the specimen. The essence of this method lies in the following procedure: first, a bead is deposited on the surface of a plate. After surfacing, the bead is cleaned of slag, and a second bead is then deposited so that it overlaps the first one by half of its width.

The surfaced plate is subsequently placed in the quick-acting clamps of a pendulum testing device. When the temperature of the deposited metal is above 450 °C, an impact is applied to the reverse side of the deposited layer. The angle of rise of the pendulum is kept constant at 60° in all experiments. The magnitude of the impact load is selected so that plastic deformation of the specimen does not occur. The separability of the slag crust is evaluated based on the area of the slag layer detached from the surface.

The dependence of slag separability on the Na_2O and K_2O contents is presented in Figure 5.

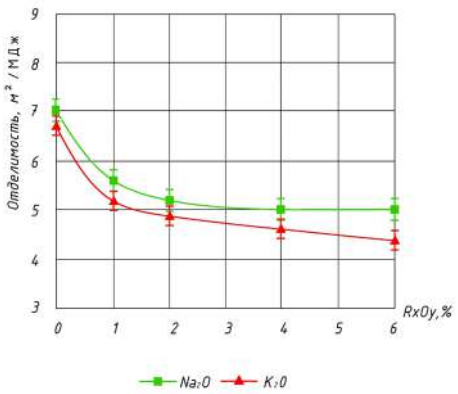

Figure 5. Dependence of slag crust separability (m^2/MJ) on the Na_2O and K_2O contents in the slag of the $CaO–SiO_2–Al_2O_3$ system

The separability of the slag crust is one of the most important indicators of the processability and technological suitability of surfacing materials.

Slag separability mainly depends on the epitaxial intergrowth between the slag and the weld metal, which may occur when both phases have similar structures at the phase boundary. As shown in Figure 5, an increase in the Na_2O and K_2O contents is associated with a decrease in slag crust separability. This trend reflects the formation of stronger interfacial bonding, which influences the interaction between the slag and the deposited metal.

Electrodes for wear-resistant surfacing were developed with the following coating composition, wt.%: marble — 26–28; pegmatite — 14–16; graphite — 9–11; ferrosilicomanganese — 10–12; ferrochrome — 25–27; and ferrotitanium — 10–12.

CONCLUSIONS AND RECOMMENDATIONS

The introduction of Na_2O and K_2O into the $CaO–SiO_2–Al_2O_3$ system leads to a decrease in slag density and viscosity, enhances its covering (hiding) power, and is accompanied by a reduction in slag crust separability, which reflects intensified interaction between the slag and the deposited metal. Studies by Sadikov et al. (Uzbekistan) confirm that slag systems based on the $CaO–SiO_2–Al_2O_3$ composition are technologically suitable for wear-resistant manual arc surfacing due to their relatively low melting temperature and stable physicochemical properties. According to Verkhoturov (Russia) and other international researchers, controlling slag viscosity and density is a key factor in ensuring defect-free deposited layers, which is consistent with the results obtained in this work. The introduction of Na_2O and K_2O oxides into the slag system significantly reduces slag density and viscosity, in agreement with conclusions reported by foreign authors studying alkali oxide modification of welding slags. Experimental results demonstrate that K_2O has a stronger effect on viscosity reduction than Na_2O, which can be explained by differences in ionic radius and slag structure modification, as noted in international welding metallurgy literature. Uzbek researchers emphasize that improved slag fluidity contributes to more uniform slag coverage of the weld pool, which is confirmed in this study by the increased covering (hiding) power of slags containing alkali oxides. At the same time, the observed decrease in slag crust separability with increasing Na_2O and K_2O content correlates with the mechanisms of epitaxial slag–metal interaction described by Moravetsky (Ukraine) and other foreign authors. The obtained results indicate a technological balance between slag covering ability and slag crust separability, which should be taken into account when designing electrode coatings for wear-resistant surfacing. The developed electrode coating composition based on local mineral raw materials of Uzbekistan demonstrates the feasibility of import substitution in welding consumables while maintaining high technological performance. Both Uzbek and international studies confirm that optimizing slag composition makes it possible to control weld metal quality while ensuring strong metallurgical bonding with minimal dilution of the base metal. Overall, the research supports the conclusion that $CaO–SiO_2–Al_2O_3$ slag systems modified with controlled amounts of Na_2O and K_2O are promising for further development of wear-resistant surfacing electrodes, provided that slag separability requirements are carefully balanced. This work was carried out within the framework of a business contract with the Tashkent Pipe Plant named after V. L. Halperin, No. 9–2020, on the topic: “Development of coating composition and production technology of surfacing electrodes.”

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MODELING OF HEAT FLOWS IN GAS-FIRED CHAMBER FURNACES

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Abstract: This paper presents the specific features of developing material and energy balances for technological processes and industrial systems based on the laws of mass and energy conservation, as applied to gas-fired chamber furnaces. It is shown that the heat balance relies on a number of assumptions regarding linear variations of heat flows, which can be further refined through modeling techniques.

Key words: gas-fired chamber furnaces; heat and material balance; transfer and removal of a specified amount of heat; conjugate heat transfer.

Annotatsiya: Mazkur maqolada massa va energiya saqlanish qonunlariga asoslangan holda texnologik jarayonlar va sanoat tizimlari uchun material va issiqlik balanslarini ishlab chiqishning o‘ziga xos jihatlari gaz yoqiladigan kamerali pechlar misolida ko‘rib chiqilgan. Issiqlik balansi issiqlik oqimlarining chiziqli o‘zgarishi haqidagi bir qator farazlarga asoslanishi hamda ularni modellashtirish usullari orqali yanada aniqlashtirish mumkinligi ko‘rsatib berilgan.

Kalit so‘zlar: gaz yoqiladigan kamerali pechlar; issiqlik va material balansi; belgilangan miqdordagi issiqlikni uzatish va chiqarish; bog‘langan issiqlik almashinuvi.

Аннотация: В статье рассматриваются особенности разработки материального и теплового балансов технологических процессов и промышленных систем на основе законов сохранения массы и энергии применительно к газовым камерным печам. Показано, что тепловой баланс основывается на ряде допущений о линейном характере изменения тепловых потоков, которые могут быть уточнены с использованием методов моделирования.

Ключевые слова: газовые камерные печи; тепловой и материальный баланс; подвод и отвод заданного количества теплоты; сопряжённый теплообмен.

INTRODUCTION

Chamber furnaces fired by natural gas are widely used in thermal engineering and industrial heat-treatment processes due to their operational flexibility, controllability, and capability to ensure uniform temperature fields within the working volume. At the same time, such furnaces are among the most energy-intensive units in industrial practice, which makes the problem of rational fuel utilization and accurate assessment of thermal efficiency particularly relevant. Under modern conditions of rising energy costs and increasing requirements for energy efficiency, the development of scientifically grounded methods for analyzing and optimizing furnace thermal regimes becomes a priority task.

A key tool for evaluating the performance of gas-fired chamber furnaces is the heat balance, which reflects the distribution of supplied thermal energy among useful heat consumption and various losses. Classical heat

balance approaches are usually based on averaged or integral values over the entire firing cycle. However, such methods do not fully capture the transient nature of thermal processes occurring in the furnace, especially under non-stationary operating regimes characterized by continuously changing temperatures, fuel flow rates, and heat loads. As a result, important information about instantaneous heat flows and their influence on fuel consumption and thermal efficiency may be lost.

In recent years, increasing attention has been paid to dynamic and time-dependent modeling of thermal processes in furnaces. These approaches allow the consideration of instantaneous values of energy flows and provide a more detailed description of the interaction between fuel combustion, heat transfer to the product, refractory materials, and exhaust gases. Within this context, matrix-based formulations of heat balance equations offer significant advantages, as they enable a compact and systematic representation of multiple interacting heat flows and their evolution over time.

This paper focuses on the formulation and analysis of the heat balance of gas-fired chamber furnaces based on the law of conservation of energy for an open thermodynamic system, with explicit consideration of instantaneous heat flow values throughout the firing cycle. A matrix form of the heat balance equation is proposed, allowing fuel consumption, air and flue gas enthalpies, heat absorption by the product and refractory lining, and heat losses to be evaluated in a unified framework. The adopted approach makes it possible to link heat flows with temperature curves of the firing regime and to determine fuel consumption through numerical integration, providing a more accurate and physically consistent assessment of furnace performance.

The relevance of the study lies in its potential application to the optimization of thermal operating regimes, reduction of specific fuel consumption, and improvement of overall energy efficiency of chamber furnaces. In addition, the proposed methodology creates a foundation for further development of advanced mathematical models, digital twins, and simulation tools aimed at both process optimization and operator training in thermal engineering systems.

REVIEW OF LITERATURE ON THE SUBJECT

Issues of energy efficiency and rational energy use in industrial thermal units have long been the subject of scientific research, particularly in relation to chamber furnaces and high-temperature technological processes. One of the earlier systematic studies in this field was conducted by L. Zashkova, who analyzed the rational use of energy in gas-fired chamber furnaces for firing technical ceramic products. In her work, special attention was paid to the distribution of heat flows within the furnace volume, the role of refractory linings, and the influence of operating regimes on fuel consumption. The results demonstrated that a significant share of energy losses is associated with non-optimal firing schedules and insufficient consideration of transient thermal processes, which directly affects the overall energy efficiency of chamber furnaces.

The theoretical foundations for analyzing energy dissipation and irreversibility in thermomechanical systems were further developed by J. Royo, A. Valero, and A. Zaleta, who introduced the concept of dissipation temperature as an analytical tool for identifying malfunctions and inefficiencies. Their approach extends beyond traditional energy balances by incorporating thermodynamic irreversibility, allowing a deeper understanding of how energy degradation occurs within complex systems. Although their study focused on thermomechanical systems in general, the proposed methodology is highly relevant for furnace analysis, where combustion, heat transfer, and exhaust processes are inherently irreversible and strongly time-dependent.

A comparative perspective based on both energy and exergy analyses was presented by A. Folorunso and C.J. Diji in their study of a cement manufacturing plant. Their results confirmed that energy analysis alone may mask critical inefficiencies that become evident only when exergy losses are evaluated. The authors emphasized that high-temperature processes, such as clinker production or firing operations, are characterized by substantial exergy destruction in combustion chambers and heat exchange equipment. These findings underscore the importance of integrating advanced thermodynamic approaches into the assessment of industrial furnaces to achieve meaningful reductions in fuel consumption.

The methodological and applied aspects of industrial heat engineering were comprehensively addressed in the habilitation work of L. Zashkova, devoted to the scientific field of industrial thermal engineering. This research generalized long-term experimental and analytical investigations of industrial furnaces, heat treatment installations, and energy-saving measures. The author highlighted the necessity of moving from stationary heat balance calculations toward more detailed descriptions that account for variable operating conditions, transient heating of products and refractory materials, and dynamic control of fuel and air supply. These conclusions provide a solid scientific basis for the development of time-dependent and matrix-based heat balance models.

Thermoeconomic modeling approaches were explored by J.J. Santos, M.A. Nascimento, and E.E.S. Lora in their analysis of a gas turbine cogeneration system with steam injection. Their work demonstrated how the integration of thermodynamic and economic criteria allows the identification of optimal operating regimes

that minimize both energy losses and production costs. Although the object of their study was a cogeneration system, the methodological framework they proposed is applicable to gas-fired furnaces, where fuel costs constitute a major component of operating expenses and where optimization of thermal regimes has direct economic implications.

Overall, the reviewed studies indicate a clear evolution from traditional integral heat balance methods toward more advanced energy, exergy, and thermoeconomic analyses. At the same time, there remains a need for practical modeling approaches that can capture the instantaneous behavior of heat flows in chamber furnaces under real firing regimes. This gap in the literature justifies the development of matrix-based, time-dependent heat balance models aimed at improving the accuracy of fuel consumption assessment and enhancing the energy efficiency of gas-fired chamber furnaces.

RESEARCH METHODOLOGY

The research methodology is based on analytical and numerical approaches to the study of heat balance in gas-fired chamber furnaces. Initial data on fuel, air, flue gas, and temperature regimes are obtained from design parameters and calculated thermophysical properties. Instantaneous heat flows are evaluated using a matrix-based heat balance model, while fuel consumption and total heat quantities are determined through numerical integration of time-dependent functions over the firing cycle.

ANALYSIS AND RESULTS

The heat balance is formulated on the basis of the law of conservation of energy for an open thermodynamic system and is expressed as follows: the sum of incoming (input) energy/heat flows $\dot{Q}_i^{in}$ is equal to the sum of outgoing (output) energy/heat flows $\dot{Q}_i^{out}$.

$$\sum_{i=1}^{n} \dot{Q}_i^{in} = \sum_{i=1}^{n} \dot{Q}_i^{out} \quad (1)$$

Individual components of the heat balance of chamber furnaces are taken in terms of their instantaneous values, and for their evaluation it is proposed to consider the balance equation in a matrix form [1]:

$$[B]\left(\left[Q_{\ddot{a}}^{p}\right] + V_{\alpha}[h_{air}] + [h_{fuel}] - V_{\alpha}^{\ddot{g}}\left[h_{\ddot{g}}\right]\right) = \left[\dot{Q}_{heat}\right] + \left[\dot{Q}_{prod}\right] + \left[\dot{Q}_{ref}\right] + \left[\dot{Q}_{chem}\right] \quad (2)$$

where:

$$[B] = \begin{bmatrix} B_1 & 0 & . & 0 \\ 0 & B_2 & . & 0 \\ . & . & . & . \\ 0 & 0 & 0 & B_n \end{bmatrix}$$ – a diagonal matrix containing the instantaneous values of the fuel quantity;

$$[Q_{\partial}^{p}] = \begin{bmatrix} Q_{\ddot{a}}^{p} \\ . \\ . \\ Q_{\ddot{a}}^{p} \end{bmatrix}$$ – a column matrix containing the values of the lower working calorific value of the fuel;

$$[h_{air}] = \begin{bmatrix} h_a^1 \\ h_a^2 \\ . \\ h_a^n \end{bmatrix}$$ – a column matrix containing the instantaneous values of the enthalpy of the combustion air;

$$[h_{fuel}] = \begin{bmatrix} h_g^1 \\ h_g^2 \\ . \\ h_g^n \end{bmatrix}$$ – a column matrix containing the instantaneous values of the fuel enthalpy;

$$[h_{f.g}] = \begin{bmatrix} h_{f.g}^1 \\ h_{f.g}^2 \\ . \\ h_{f.g}^n \end{bmatrix}$$ – a column matrix containing the instantaneous values of the enthalpy of flue gases[2];

$$h_{f.g}^i = c_{p,\text{г}}^i t_{\text{г}}^i \; ; \quad h^i air = c_{p,air}^i t_{air}^i . \tag{3}$$

The specific heat capacities of air and flue gases are determined using the following relationships:

$$c_{air}^i = 1298 + 0{,}233 t_{air}^i \; ; \; c_{\text{г}}^i = 1354 + 0{,}343 t_{\text{г}}^i \; . \tag{4}$$

The temperature of the gases leaving the furnace can be determined from the following expression:

$$T_{\text{г}}^i = \sqrt{T_{\max}^i T^i} = \sqrt{T_{\text{г}}^i T^i} . \tag{5}$$

The variation of the temperature in the furnace space T_i under the investigated operating conditions is determined by temperature curves. For $T_{\max}$ in equation (5), the actual combustion temperature T_{∂} in the furnace is adopted, which, within the framework of the studied regimes, is calculated using the following formula[3]:

$$T_{\text{г}}^i = 273.15 + k \frac{Q_{\partial}^{\text{Р}} + c_{fuel} t_{fuel} + V_{\alpha} t_{air}^i c_{air}^i}{V_{\alpha}^{\text{г}}}, \tag{6}$$

where $k = 0.8$ is a coefficient accounting for combustion losses in furnaces of this type.

$$\left[\dot{Q}_{heat}\right] = \begin{bmatrix} \dot{Q}_{heat}^1 \\ \dot{Q}_{heat}^2 \\ . \\ \dot{Q}_{heat}^n \end{bmatrix}$$ – a column matrix containing the instantaneous values of the heat flow used for heating the furnace and the railcar;

$$\dot{Q}_{heat}^i = \dot{Q}_{\text{ф}}^i + \dot{Q}_{\text{в}}^i \tag{7}$$

$$\left[\dot{Q}_{chem}\right] = \begin{bmatrix} 0 \\ . \\ \dot{Q}_{chem1} \\ 0 \\ \dot{Q}_{chem2} \\ 0 \end{bmatrix}$$ – a column matrix containing the instantaneous values of the heat flows required for the progression of chemical reactions in the product.

These heat flows are introduced into those rows of the matrices that correspond to the time at which temperatures are reached at which phase-forming reactions become possible;

$$\left[\dot{Q}_{prod}\right]=\begin{bmatrix}\dot{Q}^1_{prod}\\ \dot{Q}^2_{prod}\\ .\\ \dot{Q}^n_{prod}\end{bmatrix}$$ – a column matrix containing the instantaneous values of the heat flow for heating the product.

$$\left[\dot{Q}_{ref}\right]=\begin{bmatrix}\dot{Q}^1_{ref}\\ \dot{Q}^2_{ref}\\ .\\ \dot{Q}^n_{ref}\end{bmatrix}$$ – a column matrix containing the instantaneous values of the heat flow for heating the refractory material.

The superscript of the matrix elements corresponds to the end of the intervals $1\Delta\tau;\ 2\Delta\tau \dots n\Delta\tau$ of the firing cycle.

To determine the instantaneous values of the flows, this study proposes a relationship analogous to the temperature curve of the firing regime, linking their instantaneous values to time τ :

To determine the instantaneous values of the last two heat flows, the present work proposes a dependence between their instantaneous values and time τ , similar to the temperature curve for the baking mode:

$$Q^i_{prod}=\begin{cases}\dfrac{\dot{Q}^{\tau_{heat}}_{prod}}{\tau_{heat}}\tau & \tau\le\tau_{íàãð}\\ \dot{Q}^{\tau_{heat}}_{prod} & \tau_{heat}\le\tau\le\tau_{bak}\end{cases} \quad (8)$$

and

$$Q^i_{ref}=\begin{cases}\dfrac{\dot{Q}^{\tau_h}_{ref}}{\tau_h}\tau & \tau\le\tau_{fuel}\\ \dot{Q}^{\tau_h}_{ref} & \tau_h\le\tau\le\tau_{bak}\end{cases} \quad (9)$$

After numerically solving equation (2), the instantaneous values of the required fuel amount B_{ii} are obtained. The total values of the supplied and removed heat flows, as well as the fuel consumption, are determined by numerical integration of the time-dependent matrix elements over the cycle interval.

$$B=\int_0^{n\Delta\tau}B(\tau)d\tau. \quad (10)$$

A limitation for implementing the investigated thermal operating regime of the furnace is the condition that the maximum calculated instantaneous fuel value $B_{\max}$ must be lower than the maximum permissible value for the given burner installation [4]. This approach is based on a number of assumptions regarding linear variations of heat flows, which can be further refined through modeling.

Based on equation (2), the hourly values of natural gas consumption at a temperature of 20 °C and combustion air at a temperature of 150 °C were determined (Fig. 1).

The heat flows for heating the refractory material, the product, and the masonry in the corresponding matrices were determined by modeling their transient heating along the temperature curve using appropriate models (Figure 1) [5].

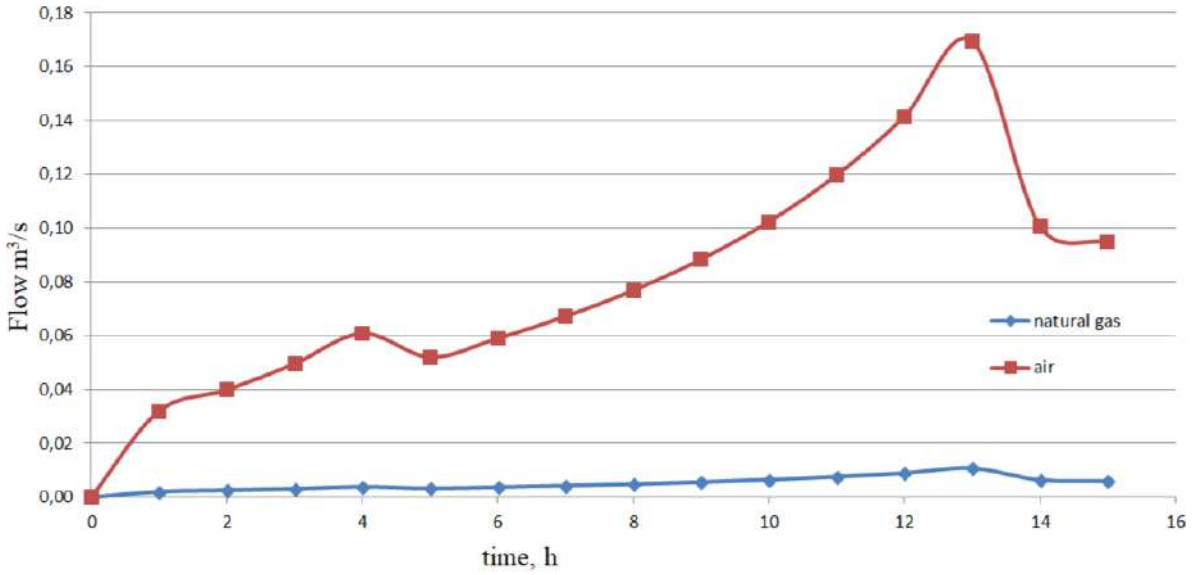

Figure 1. Heat flows of natural gas and air

Based on the recalculated fuel and air flow rates, their velocities at the inlets of the burner nozzles were determined. Using the numerical values of these velocities, time-dependent relationships describing their variation were derived in the MAPLE environment.

The uniqueness conditions for solving the system of conjugate heat transfer equations reflect the adopted process conditions and the time-dependent variations in air and fuel flow rates.

CONCLUSIONS AND SUGGESTIONS

The paper addresses the formulation and analysis of the heat balance of gas-fired chamber furnaces based on the law of conservation of energy for open thermodynamic systems. Within the scope of the study, the main components of the heat balance were identified, and a matrix-based approach to their representation was proposed, enabling the consideration of instantaneous heat flow values throughout the entire firing cycle.

The graphs constructed on the basis of analytical relationships showed that the temperature of the exhaust gases exhibits an almost linear dependence on the supplied heat flow. This confirms the validity of the assumption adopted in this study regarding the linear nature of heat flow variations under the investigated operating regimes of chamber furnaces. In addition, the linear time variation of the heat flow corresponds to the temperature curves of the firing regimes and allows numerical integration methods to be effectively applied to determine the total heat input and fuel consumption.

The obtained results are of practical significance for the analysis and optimization of thermal operating regimes of chamber furnaces aimed at reducing specific fuel consumption and improving the energy efficiency of thermal engineering installations. The proposed heat balance model can serve as a scientific basis for the development of mathematical models, digital twins, and computer-based training simulators for operator training, as well as for further refinement of thermal processes using numerical modeling methods.

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DEVELOPMENT OF A MIMO MODEL OF AZEOTROPIC DISTILLATION

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Abstract: The article addresses the development of a dynamic MIMO model of the azeotropic distillation process as an object of automatic control. The process is characterized by strong multivariable interactions, nonlinearity, and the presence of vapor–liquid equilibrium involving an entrainer. Based on a simplified MESH approach, a state-space matrix model suitable for dynamic analysis and the synthesis of predictive controllers is obtained. A structural diagram of the azeotropic distillation column and transient responses of the main control channels are presented.

Key words: azeotropic distillation, MIMO model, dynamic model, heat and mass transfer, entrainer, control system, transient responses.

Annotatsiya: Maqolada azeotropik rektifikatsiya jarayonining avtomatik boshqaruv obyekti sifatida dinamik MIMO–modelini qurish masalalari ko‘rib chiqilgan. Jarayon kuchli o‘zaro bog‘liqlik, nolinearlik hamda entrayner ishtirokidagi fazaviy muvozanatning mavjudligi bilan tavsiflanadi. Soddalashtirilgan MESH yondashuvi asosida dinamika tahlili va prediktiv regulyatorlarni sintez qilish vazifalari uchun mos bo‘lgan holatlarning matritsali modeli olingan. Azeotropik rektifikatsiya kolonkasining strukturaviy sxemasi hamda boshqaruvning asosiy kanallari bo‘yicha o‘tish xarakteristikalari keltirilgan.

Kalit so‘zlar: azeotropik rektifikatsiya, MIMO–model, dinamik model, issiqlik va massa almashinuvi, entrayner, boshqaruv tizimi, o‘tish xarakteristikalari.

Аннотация: В статье рассматривается построение динамической MIMO–модели процесса азеотропной ректификации как объекта автоматического управления. Процесс характеризуется сильной многосвязностью, нелинейностью и наличием фазового равновесия с участием энтрейнера. На основе упрощённого MESH–подхода получена матричная модель состояния, пригодная для задач анализа динамики и синтеза предикативных регуляторов. Представлены структурная схема азеотропной ректификационной колонны и переходные характеристики по основным каналам управления.

Ключевые слова: азеотропная ректификация, MIMO–модель, динамическая модель, тепломассообмен, энтрейнер, система управления, переходные характеристики.

INTRODUCTION

Azeotropic distillation is widely used in the chemical, petrochemical, and food industries for the separation of mixtures that cannot be separated by conventional binary distillation. Typical applications include the production of absolute ethanol, dehydration of organic solvents, and separation of close-boiling components.

From the viewpoint of automatic control, the azeotropic distillation process belongs to the class of complex multivariable (MIMO) systems, which are characterized by strong cross-coupling between control channels,

significant time delays and inertia, nonlinearity of phase equilibrium, and the influence of the entrainer and decanter on system dynamics.

Therefore, the development of an adequate MIMO model that provides a basis for dynamic analysis and the design of advanced control algorithms, including Model Predictive Control (MPC), is a relevant and practically important task.

REVIEW OF LITERATURE ON THE SUBJECT

Azeotropic distillation is one of the most complex heat- and mass-transfer processes, requiring consideration of liquid-phase non-ideality, multivariable dynamics, and phase separation in the overhead system. For ethanol–water systems, conventional distillation is limited by the existence of an azeotropic point, which necessitates the use of entrainers and decanters and significantly complicates both modeling and control.

Recent studies on azeotropic and extractive distillation rely on thermodynamic activity-coefficient models such as NRTL, UNIQUAC, and Wilson, which enable accurate description of VLE/LLE behavior in the presence of an entrainer. These models are discussed in detail in works devoted to advanced distillation technologies and conceptual design of complex column configurations, emphasizing the crucial role of the overhead “condenser–decanter–reflux” loop in determining system dynamics [1–4].

Dynamic modeling of distillation columns in recent years is predominantly based on the MESH approach, which provides a reasonable compromise between model accuracy and computational complexity. Despite the development of rate-based models, linearized models obtained around steady-state operating points with subsequent order reduction are more commonly used for dynamic analysis and control synthesis [2,5]. This approach is especially relevant for azeotropic distillation, where the full model dimension may reach several tens of states.

In the field of distillation control, significant attention is paid to the MIMO representation of the process, since changes in reflux flow rate, reboiler heat duty, and entrainer flow rate lead to substantial cross-effects on distillate composition, bottom composition, and temperature profiles. For practical purposes, first- and second-order plus dead-time (FOPDT/SOPDT) transfer-function matrices and state-space models are widely employed [5–7].

Multivariable interaction analysis is traditionally performed using the Relative Gain Array (RGA) and related frequency- and steady-state criteria, which justify the necessity of multivariable control and proper input–output pairing [7]. It has been shown that SISO-based approaches applied to azeotropic columns often result in degraded dynamic performance and increased oscillations.

Over the past 15 years, the application of Model Predictive Control to distillation processes, including azeotropic configurations, has developed intensively. MPC accounts for multivariable interactions, time delays, and operational constraints, which is particularly important for entrainer flow rate and thermal load control. Several studies highlight the effectiveness of linear MPC based on MIMO models obtained through step-response identification or linearization of detailed nonlinear models [6–8].

Thus, analysis of modern publications indicates that the development of an adequate MIMO model of azeotropic distillation is a necessary prerequisite for the synthesis of effective control systems. Despite significant progress in thermodynamic and dynamic modeling, issues related to structural identification, decanter dynamics, and cross-coupling effects remain relevant, defining the scientific novelty and practical significance of the present study.

RESEARCH METHODOLOGY

The objective of this study is the development and verification of a dynamic MIMO model of azeotropic distillation in the vicinity of a steady-state operating point, suitable for transient analysis and subsequent synthesis of multivariable control algorithms.

The object of study is a typical continuous azeotropic distillation unit comprising a column with N theoretical trays, a condenser, a reboiler, a decanter for distillate phase separation, feed streams of the binary mixture and the entrainer, and phase recycle loops [9–11]. Figure 1 shows the column with feed stream F, entrainer stream E, control inputs: reflux flow rate L, reboiler heat duty Q_R, condenser heat duty Q_C; and output variables: distillate composition x_D, bottom composition x_B, and temperatures of selected trays T_i.

The process is assumed to operate at constant pressure, with the entrainer introduced into the upper section of the column.

The following assumptions are adopted: vapor–liquid equilibrium on each theoretical tray; constant pressure along the column height; pressure and liquid-level dynamics are neglected and assumed to be stabilized by lower-level control loops; local linearization of the model around a selected steady-state operating point (Figure 1).

Figure 1. Process flow diagram of an azeotropic distillation column

For the MIMO model, the following variables are selected.

Input variables (manipulated variables):

$$u(t) = [L(t) \quad Q_R(t) \quad E(t)]^T$$

,

where L(t) is the reflux flow rate, $Q_R(t)$ is the reboiler heat duty, and E(t) is the entrainer flow rate.

Output variables:

$$\boldsymbol{y(t) = [x_D(t) \quad x_B(t) \quad T_k(t)]^T},$$

where $x_D(t)$ is the mole fraction of the target component in the distillate, $x_B(t)$ is the mole fraction in the bottom product, and $T_k(t)$ is the temperature of a selected control tray.

Mathematical Description of the Process

In the development of the MIMO model, the distillation column is described by the MESH equations, where M denotes material balances, E phase-equilibrium relations, S steady-state vapor and liquid flow equations, and H energy balances.

For the i-th tray, the dynamic material balance is given by:

$$\frac{d(M_i x_i)}{dt} = L_{i+1}x_{i+1} + V_{i-1}y_{i-1} - L_i x_i - V_i y_i + F_i x_F,$$

where M_i is the liquid holdup on tray i, x_i, y_i – are mole fractions in the liquid and vapor phases, F_i represents external feeds (feed or entrainer), and x_F is their composition.

The energy balance for the i-th tray is:

$$\frac{d(M_i h_i)}{dt} = L_{i+1}h_{i+1} + V_{i-1}H_{i-1} - L_i h_i - V_i H_i + Q_i,$$

where h_i, H_i – are the specific enthalpies of the liquid and vapor phases, and Q_i represents heat flows and losses.

For azeotropic systems, phase equilibrium is described by the modified Raoult's law:

$$y_i = \gamma_i(T, x)\frac{P_i^{\text{вещ}}(T)}{P}x_i,$$

where γ_i is the activity coefficient calculated using models such as NRTL or UNIQUAC.

The resulting nonlinear system of differential equations serves as the basis for dynamic analysis and subsequent formation of a linearized MIMO model.

After linearization around the steady-state operating point, the following state-space representation is obtained:

$$\dot{x}(t) = Ax(t) + Bu(t),$$
$$y(t) = Cx(t),$$

where x(t) is the state vector consisting of tray compositions and temperatures, and A, B, and C are the system, input, and output matrices, respectively.

The system dimension typically exceeds 20–50 states, confirming the multivariable nature of the process.

A classic example of azeotropic distillation is the ethanol–water system, for which a minimum-boiling azeotrope exists at atmospheric pressure at approximately 95.6 wt.% ethanol (≈ 0.895 mole fraction). Consequently, conventional distillation cannot exceed this concentration, and azeotropic distillation with an entrainer and a decanter is required. Cyclohexane or benzene is commonly used as an entrainer.

A compact six-state model is developed, where the states represent inertial dynamics of outputs and cross-coupling paths:

$x(t) = [x_1, x_2, x_3, x_4, x_5, x_6]^T$,

with x_1, x_2 – describing the dynamics of x_D; x_3, x_4 –the dynamics of x_B, x_5, x_6 –the dynamics of T_k.

Matrixes:

$$A = \begin{bmatrix} -1/60 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1/45 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1/90 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1/70 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1/40 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1/35 \end{bmatrix}$$

$$B = \begin{bmatrix} -\frac{0.020}{60} & 0 & \frac{0.018}{60} \\ 0 & \frac{0.035}{45} & 0 \\ \frac{0.010}{90} & 0 & -\frac{0.012}{90} \\ 0 & -\frac{0.028}{70} & 0 \\ -\frac{1.20}{40} & 0 & \frac{0.90}{40} \\ 0 & \frac{2.10}{35} & 0 \end{bmatrix}, \quad C = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}$$

Each output is represented as a sum of two first-order dynamics, one corresponding to the dominant effect and the other to cross-coupling or thermal effects.

ANALYSIS AND RESULTS

To evaluate the dynamic properties of the MIMO object, transient responses were calculated for step changes in the manipulated variables (Figs. 2–4). The transient responses were obtained by applying step variations to each manipulated variable while keeping the remaining inputs constant. The Relative Gain Array (RGA) method was employed to analyze multivariable interactions and channel coupling, enabling a quantitative assessment of cross-effects between inputs and outputs. The proposed methodology provides a systematic transition from a detailed physicochemical description of azeotropic distillation to a compact MIMO model suitable for dynamic analysis, multivariable interaction assessment, and subsequent synthesis of predictive control algorithms (Figure 2; 3; 4) [12].

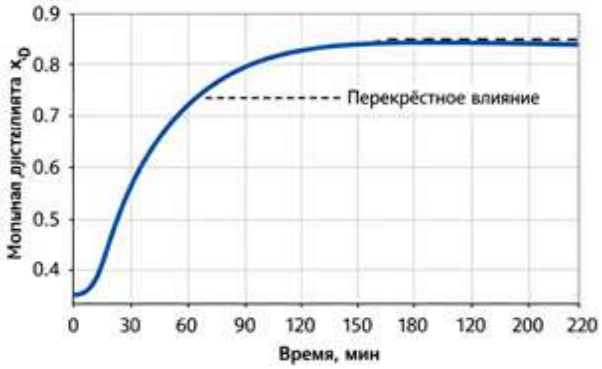

Figure 2. Transient response of the **L→xD** channel

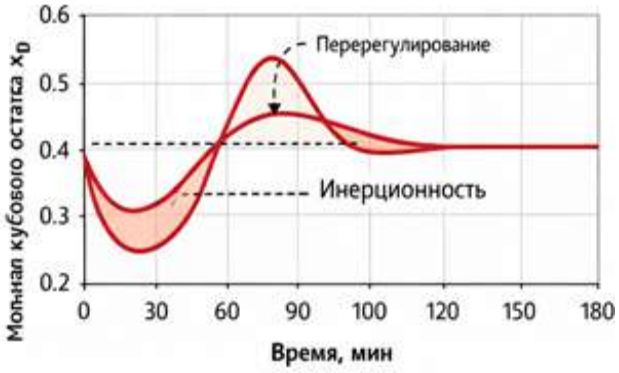

Figure 3. Transient response of the **QR→xB** channel

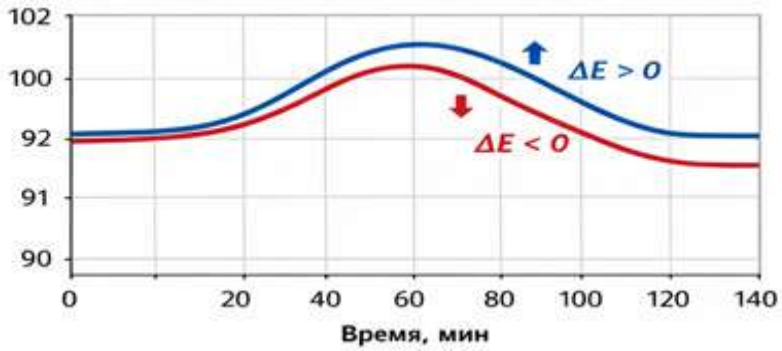

Figure 4. Cross-effect of the **E→T_k** channel

The L→x_D channel exhibits an aperiodic response with a long settling time and a pronounced influence of cross-coupling effects.

The Q_R→x_B channel demonstrates inertial behavior with overshoot caused by the thermal capacitance of the reboiler.

The E→T_k channel indicates that variations in the entrainer flow rate significantly affect the temperature profile of the column.

The developed MIMO model enables quantitative evaluation of the degree of multivariable coupling, identification of dominant dynamic interactions, use of the model as a basis for MPC algorithm synthesis, and execution of virtual experiments without direct intervention in the real process. It should be noted that simplification of the MESH model reduces computational complexity while preserving the key dynamic characteristics of the process.

CONCLUSIONS AND SUGGESTIONS

A dynamic MIMO model of azeotropic distillation based on material and energy balances with phase-equilibrium considerations has been developed. The process is shown to be a strongly coupled and inertial control object. The presented transient responses confirm the necessity of multivariable control strategies for the operation of azeotropic distillation columns.

The obtained results can be used in the development of predictive control systems and digital twins of heat- and mass-transfer processes.

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THEORETICAL FOUNDATIONS OF THE INTERACTION OF A COTTON TUFT WITH A SCREW CONVEYOR AND A MESH SURFACE

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Abstract: This paper presents a theoretical study of the motion of a cotton piece in a screw cleaner and the impact forces generated during its interaction with screw spikes and a mesh surface. The impact impulse is analyzed as a function of the initial velocity of the cotton piece, the rotational speed of the screw, and the tilt angle of the spikes. Theoretical calculations show that at a screw rotational speed of 180 rpm and a spike tilt angle of $\alpha_1 = 8°$, the impact impulse reaches its minimum value. An increase in the impact force leads to a higher number of broken seeds in seed cotton. In addition, the proposed screw cleaner combines the cleaning and drying processes, which contributes to an increase in the overall operational efficiency of the equipment.

Key words: screw cleaner, cotton piece, impact force, screw spike, mesh surface, theoretical calculation, rotational speed, tilt angle.

Annotatsiya: Ushbu maqolada vintli tozalagichda paxta bo‘lagining harakat jarayoni hamda uning vint qoziqlari va to‘rli sirt bilan o‘zaro ta’siri natijasida yuzaga keladigan zarba-impuls kuchlari nazariy jihatdan tadqiq etilgan. Zarba impulsi paxta bo‘lagining boshlang‘ich tezligi, vintning aylanish chastotasi va qoziqlarning og‘ish burchagiga bog‘liqligi aniqlangan. Nazariy hisob-kitoblarga ko‘ra, vintning aylanish chastotasi 180 ayl/min va qoziqlarning og‘ish burchagi $\alpha_1 = 8°$ bo‘lganda impuls kuchi minimal qiymatga ega bo‘ladi. Impuls kuchining ortishi chigitli paxtada shikastlangan chigitlar sonining ko‘payishiga olib keladi. Shuningdek, taklif etilayotgan vintli tozalagichda tozalash jarayoni quritish jarayoni bilan birlashtirilgan bo‘lib, bu uskunaning umumiy ish samaradorligini oshirishga xizmat qiladi.

Kalit so‘zlar: vintli tozalagich, paxta bo‘lagi, zarba kuchi, vint qoziqlari, to‘rli sirt, nazariy hisob-kitob, aylanish chastotasi, og‘ish burchagi.

Аннотация: В статье выполнено теоретическое исследование процесса движения хлопкового комка в винтовом очистителе, а также ударно-импульсных сил, возникающих при его взаимодействии с винтовыми колышками и сетчатой поверхностью. Определена зависимость величины ударного импульса от начальной скорости хлопкового комка, частоты вращения винта и угла наклона колышков. Результаты теоретических расчётов показывают, что при частоте вращения винта 180 об/мин и угле наклона колышков $\alpha_1 = 8°$ ударный импульс принимает минимальное значение. Увеличение ударного импульса приводит к росту количества повреждённых семян в семенном хлопке. Кроме того, в предлагаемом винтовом очистителе процесс очистки совмещён с процессом сушки, что способствует повышению общей эффективности работы оборудования.

Ключевые слова: винтовой очиститель, хлопковый комок, ударная сила, винтовые колышки, сетчатая поверхность, теоретический расчёт, частота вращения, угол наклона.

INTRODUCTION

The study of the laws governing the motion of raw cotton along a mesh surface under the action of pegs makes it possible to assess both the cleaning efficiency and the degree of seed damage. When a cotton tuft moves along the surface of a mesh screen, it is subjected to impact–vibration impulses that facilitate the separation of impurities. However, an excessive increase in impact–vibration impulses leads to damage to cotton seeds. Therefore, determining the optimal parameters of the screw dryer and cleaner is of great importance for calculating the limiting values of impact–vibration impulses [1–8].

It is known from studies conducted on the working elements of cleaning machines [9–10] that when the peripheral speed varies from 4.71 to 19 m/s, the highest cleaning efficiency is achieved in the range of 7.85–11.5 m/s.

LITERATURE REVIEW

Raw cotton cleaning processes have been extensively studied due to their significant impact on fiber quality and seed integrity. Research shows that the interaction between cotton tufts and the working elements of cleaning machines is accompanied by impact–vibration impulses, which play a key role in impurity separation [1–3]. At the same time, excessive impact loads lead to seed damage and deterioration of technological properties of seed cotton [4]. Fundamental studies based on classical mechanics and impact theory have provided theoretical tools for analyzing collision processes in technological machines. The works of Panovko and Vulfson established the principles for determining impulse forces, restitution coefficients, and vibration effects during short-term impacts, which are widely applied in the analysis of cotton-cleaning equipment [5,6]. Studies on machines for primary cotton processing indicate that the rotational speed of working elements and their geometric parameters significantly influence cleaning efficiency. It has been established that within an optimal range of peripheral speed, effective impurity separation is achieved without excessive seed breakage, whereas deviation from this range results in either reduced cleaning efficiency or increased mechanical damage [7–9].

Research devoted to mesh surfaces shows that they actively participate in the dynamic interaction with cotton tufts, generating additional impact impulses. The inclination angle of pegs and the rotational speed of the screw substantially affect the magnitude of these impulses and, consequently, the degree of seed damage [10,11]. Despite numerous studies on drum and vibration cleaners, the interaction of cotton tufts with screw-type cleaners in combination with mesh surfaces remains insufficiently investigated. This necessitates further theoretical analysis aimed at determining optimal design and operating parameters to minimize impact impulses and improve cleaning efficiency [12].

RESEARCH METHODOLOGY

When the speed is lower than 7.85 m/s, a decrease in cleaning efficiency is observed. Seed breakage occurs when the speed exceeds 11.5 m/s. However, in our studies, the higher rotational speed of the peg screw requires additional investigations for the newly proposed design. Figure 1 [a–b] shows the force diagrams acting on seed cotton as it moves along the peg screw and the mesh surface.

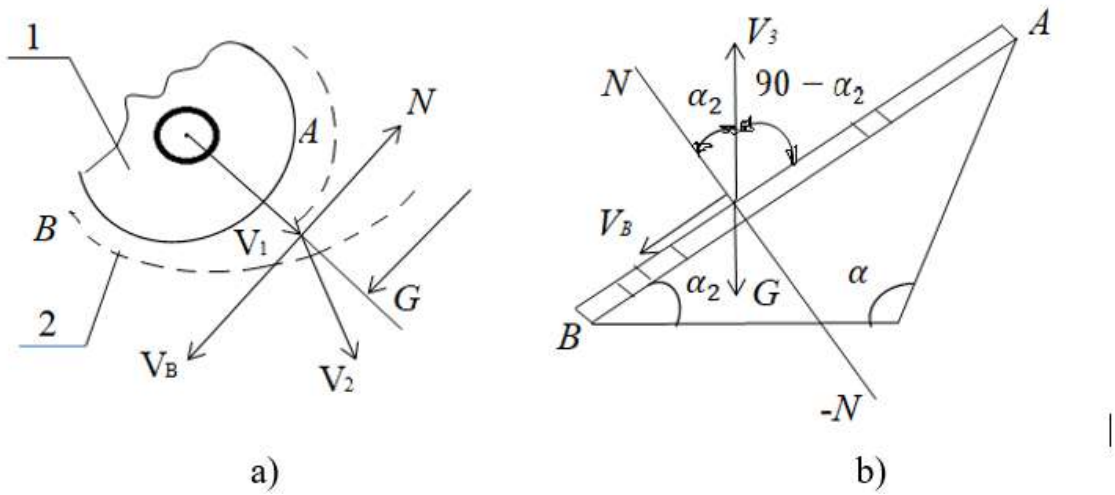


Figure 1. Process of cotton tuft motion in a screw conveyor

a) Scheme of the interaction between a cotton tuft and a screw peg

b) Scheme of the interaction between a cotton tuft and a mesh surface

ANALYSIS AND RESULTS

When a cotton tuft moves along a mesh surface, it receives impact–vibration impulses from the pegs and the screen, which results in the separation of fine impurities. In order to determine the impact impulses, first, the velocity of the cotton tuft along the surface of the peg drum and its direction are determined. At the initial stage, the cotton tuft has a circumferential velocity V_v. While moving along the mesh screen surface, the cotton tuft is pressed against the screen by the force. Taking into account that the cotton tuft is moved along the mesh screen surface by the action of the peg, the velocity of the cotton tuft is determined as follows.

$V_v = \sqrt{\frac{(C_1 V_1^2 + G\sin\alpha)e^{-2\frac{C_1 y_2}{m_A}} - G*\sin\alpha}{C_1}}$ [1]

y_2 – the length of segment AB; let us assume y_2=55y_2 = 55y2=55 mm.

If the time of motion of the cotton tuft along section AB is taken as $T_1 = \frac{y_2}{V_в}$ then the impulse exerted by the peg drum can be expressed in the following form.

$m_1\overline{V_1} - m\overline{V_2} = \int_{t_1}^{t_2} Pdt - \int_{t_1}^{t_2} Fdt$ [2]

Using impact theory,

$S_{zarb} = \bar{S} = \int_{t_1}^{t_2} \overline{Fdt} = \overline{F_{yp}}\,\tau$ [3]

$S_{erkin} = \int_{t_1}^{t_2} \bar{p}\ dt = \overline{P_{yp}}\,\tau$

Here: τ – duration of the impact process.

Considering that the deflection S_{zarb} is very small relative to the impact force, equation (2.7) can be written as follows:

$S = m\overline{V_1} - m\overline{V_2}$ [4]

In most screw cleaners, the rotational frequency of the screw is variable and primarily depends on the work efficiency. Studies conducted on the proposed screw cleaner have shown that when the rotational speed of the screw varies and the work efficiency ranges from 6 to 8 tons, ω is within the range of 12–24.6 rad/s. In this case, the initial velocity of the cotton piece can vary within ϑ=2.8–4.8 m/s, and the screw diameter is d=400 mm.

From equation (4), if the velocities are known, it is possible to determine the impact impulse forces acting on the seed cotton from the screw spikes and the mesh. For this, we use Newton's second law.

Based on Newton's second law, the equation of motion for the system between the initial and final states can be written as:

$\overline{U_в}m_v + m_p\overline{U_п} = m_v\overline{V_в} + m_p\overline{V_п}$[5]

Where Uv and Up are the initial velocities of the screw spike and the cotton piece, and Vv and Vp are their velocities in the final state. Projecting both sides of the vector equation (5) onto the N axis gives:

$mv\overline{U_{вN}} + mp\overline{U_{пN}} = m_v\overline{V_{вN}} + m_p\overline{V_{пN}}$ [6]

From this, the coefficient of restitution for the collision of the two bodies can be determined as:

$K_T = \frac{|U_{вN} - U_{пN}|}{|V_{вN} - V_{пN}|} = -\frac{U_{вN} - U_{пN}}{V_{вN} - V_{пN}}$; [7]

If $V_{вN} > V_{пN}$ then:

$U_{пN} - U_{вN} = K_T(В - V_{пN})$ [8]

Solving equations (2.8) and (2.11) together, we obtain:

$U_{вN} = V_{вN} - (1 + K_T)\frac{m_п}{m_в + m_п}(V_{вN} - V_{пN})$;

$U_{пN} = V_{пN} + (1 + K_T)\frac{в}{m_п + m_в}(V_{вN} - V_{пN})$;

Using the equation of momentum change, the impact impulses can be expressed as:

$S_{вN} = mв(U_{вN} - V_{вN})$;

$S_{пN} = -S_{вN}$ [9]

Substituting U_{vn} from (2.12) into the expression, we obtain:

$S_{вN} = -S_{пN} = mв_N Vв_N - (1+K_в)\frac{m_в m_п}{m_в + m_п}*(Vв_N - Vп_N) - m_{пN} V_{пN}$ [10]

$\frac{m_п}{}$

Considering that $m_в$ - is very small, equation (2.13) can be simplified as:

$S_{вN}$ = - $Sп_N$ =- $\overline{m_п}$ (1+$K_в$)($V_{вN} - V_{пN}$) [11]

From Figure 2.3, taking $V_{вN} = V_в$ va V_{pN} = V_v*sinα1, equation [11] can be rewritten as:

$Sп_N$=$m_п$ (1+$K_В$)($V_В$+$V_в$*sinα_1) [12]

The average force exerted on the cotton piece by the screw spikes can be calculated using the following equation:

$$F_{ўр} = \frac{S_{пN}}{\tau} \quad [13]$$

Thus:

$$F_{оғр}\tau = m_п\,(1 + K_в)(V_в + V_в * \sin\alpha_1) \quad [14]$$

By solving this equation using the given values, we can obtain the graph of the impact force of the screw spike on the cotton piece as a function of the rotational frequency of the screw (Figure 2.4).

Here; m = 0.65g ; $V_В$ =2.8 ÷ 4.8 m/c: $K_В$ = 0.3; $\alpha_1 = 8^0$:

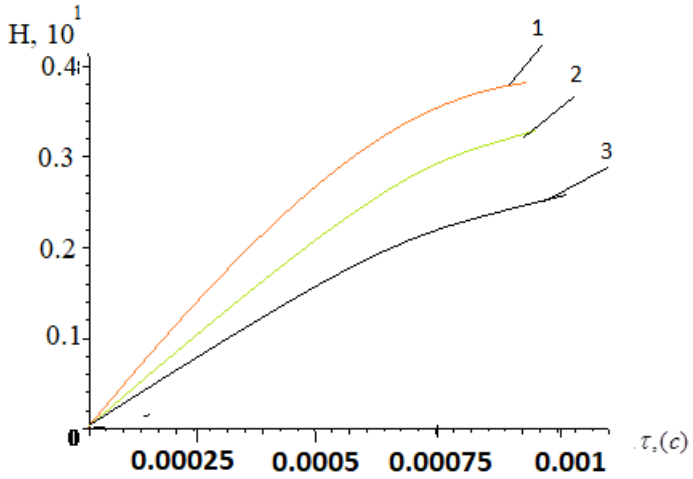


Figure 2. Force of the screw spike on the cotton piece

From the graph, it can be seen that increasing the rotational speed of the screw leads to an increase in the impact force acting on the seed cotton. According to the literature, it is recommended that the impact force on a cotton piece should not exceed 3–4 N. An increase in the impact forces may lead to a higher degree of seed breakage.

The graph also shows that the minimum value of the impact force corresponds to n=180n = 180n=180 rpm. Similarly, high impact forces during the collision of the cotton piece with the mesh can cause seed breakage and damage to the fibers.

Therefore, a theoretical study of the process of the cotton piece striking the mesh is important when determining the design and operational parameters of the proposed screw cleaner. It is known that the impact force of a cotton piece on the mesh depends on the angle of the spike and the rotational speed of the screw.

The velocity of the cotton piece approaching the mesh can be expressed as follows:

$$V3=\sqrt{\frac{G}{C_1} - \frac{G - C_1 V_2^2}{C_1 e^{\frac{2C_1 y}{m}}}} \quad [15]$$

Here, u- is the distance between the mesh and the cotton piece.

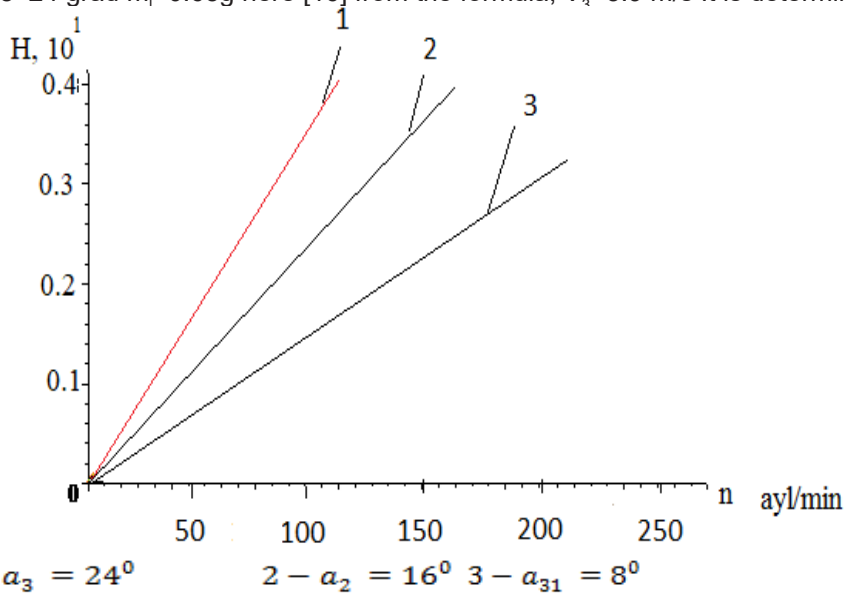
Impact impulse of the cotton piece on the mesh.

INNOVATION SCIENCE AND TECHNOLOGY

$S_N = F_{ўр}\tau = m_p V_3 (1+K_в)\cos\alpha_2$

Considering that the impact impulse depends on the velocity of the cotton piece and the angle α_2 equation (16) can be solved using the recommended values, yielding the following relationships.

α_2=8÷24 grad m_i=0.65g here [16] from the formula, $V_з$=3.9 m/s It is determined by calculation.



$1-\alpha_3 = 24^0$ $2-\alpha_2 = 16^0$ $3-\alpha_{31} = 8^0$

Figure 3. Graph of the dependence of the impact impulse force on the tilt angle of the spike during the collision of the cotton piece with the mesh

CONCLUSION AND SUGGESTIONS

From the graph, it can be seen that the impact force of the cotton piece on the mesh depends on the tilt angle of the spiked drum. When the minimum tilt angle of the screw spike is α_1=8⁰ the minimum impact impulse corresponds to the maximum rotational speed of the screw. In conclusion, the theoretical study shows that at a rotational speed of 180 rpm and a spike tilt angle of $\alpha_1 = 8^0$ the impact impulse on the cotton piece is minimal. It can also be observed that increasing the rotational speed and the tilt angle of the screw spike leads to an increase in the impact impulse. This, in turn, increases the number of broken seeds in the seed cotton. In the proposed screw cleaner, the cleaning process is carried out simultaneously with a drying process. This additionally enhances the cleaning efficiency, as it occurs under the influence of a hot air flow acting in the working zone.

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FORECASTING LIQUIDITY AND SOLVENCY INDICATORS BASED ON ARTIFICIAL INTELLIGENCE

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Abstract: This article examines the issues of forecasting enterprises’ liquidity and solvency indicators based on artificial intelligence. The main objective of the study is to compare the effectiveness of traditional methods and artificial intelligence models in assessing financial stability. The article analyzes the possibilities of predicting the future state of liquidity indicators using neural networks. Particular attention is paid to identifying complex and nonlinear relationships in the forecasting process. The research results demonstrate that artificial intelligence models provide high accuracy in the early identification of financial risks. The conclusions obtained have practical significance for improving enterprises’ financial management systems. The scientific novelty of the article lies in the comprehensive application of artificial intelligence approaches to forecasting liquidity and solvency.

Key words: liquidity, solvency, financial stability, artificial intelligence, neural networks, forecasting.

Annotatsiya: Mazkur maqolada korxonalarning likvidlik va to‘lovga layoqatlilik ko‘rsatkichlarini sun’iy intellekt asosida prognozlash masalalari o‘rganiladi. Tadqiqotning asosiy maqsadi moliyaviy barqarorlikni baholashda an’anaviy usullar va sun’iy intellekt modellarining samaradorligini taqqoslashdan iborat. Maqolada neyron tarmoqlar yordamida likvidlik ko‘rsatkichlarining kelajakdagi holatini bashorat qilish imkoniyatlari tahlil qilinadi. Prognozlash jarayonida murakkab va nochiziqli bog‘liqliklarni aniqlashga alohida e’tibor qaratiladi. Tadqiqot natijalari sun’iy intellekt modellari moliyaviy xatarlarni erta aniqlashda yuqori aniqlikni ta’minlashini ko‘rsatadi. Olingan xulosalar korxonalarning moliyaviy boshqaruv tizimini takomillashtirishda amaliy ahamiyatga ega. Maqolaning ilmiy yangiligi likvidlik va to‘lovga layoqatlilikni prognozlashda sun’iy intellekt yondashuvlarining kompleks qo‘llanilishi bilan izohlanadi.

Kalit so‘zlar: likvidlik, to‘lovga layoqatlilik, moliyaviy barqarorlik, sun’iy intellekt, neyron tarmoqlar, prognozlash.

Аннотация: В статье рассматриваются вопросы прогнозирования показателей ликвидности и платёжеспособности предприятий на основе искусственного интеллекта. Основной целью исследования является сравнение эффективности традиционных методов и моделей искусственного интеллекта при оценке финансовой устойчивости. В статье анализируются возможности прогнозирования будущего состояния показателей ликвидности с использованием нейронных сетей. Особое внимание уделяется выявлению сложных и нелинейных зависимостей в процессе прогнозирования. Результаты исследования показывают, что модели искусственного интеллекта обеспечивают высокую точность при ранней идентификации финансовых рисков. Полученные выводы имеют практическое значение для совершенствования систем финансового управления предприятиями. Научная новизна статьи заключается в комплексном применении подходов искусственного интеллекта к прогнозированию ликвидности и платёжеспособности.

Ключевые слова: ликвидность, платёжеспособность, финансовая устойчивость, искусственный интеллект, нейронные сети, прогнозирование.

INTRODUCTION

In a market economy, liquidity and solvency indicators play an important role in ensuring the financial stability of enterprises and in guaranteeing their continuous operation. These indicators serve as key measures for assessing an enterprise’s ability to meet its short-term obligations in a timely manner, for the early identification of financial risks, and for making informed investment decisions [1].

Traditional financial analysis methods, including ratio analysis and regression models, are widely used in assessing liquidity and solvency. However, these methods often do not fully reflect complex, nonlinear, and time-varying relationships among financial indicators [3]. Consequently, in a rapidly changing economic environment, such approaches may limit forecasting accuracy.

In recent years, artificial intelligence (AI) and deep learning technologies have gained significant scientific and practical importance in the field of financial forecasting. Neural networks are capable of processing large volumes of financial data, identifying hidden relationships, and generating forecasts in real time, thereby ensuring high accuracy in predicting liquidity and solvency indicators [2].

Under the economic conditions of Uzbekistan, strengthening the financial stability of enterprises, reducing bankruptcy risk, and increasing investment attractiveness constitute urgent tasks. Local scientific studies indicate that artificial intelligence–based models yield effective results in managing financial assets, identifying bankruptcy probability, and assessing investment risks [4], [7], [8].

In this regard, this article aims to develop a methodology for forecasting liquidity and solvency indicators based on artificial intelligence, to evaluate the practical effectiveness of neural networks, and to formulate scientific conclusions and recommendations for their application in enterprise financial management systems.

LITERATURE REVIEW

The analysis of liquidity and solvency indicators occupies a leading position in financial management theory. In their studies, Brigham and Ehrhardt (2016) interpret liquidity indicators as key criteria for assessing an enterprise's short-term financial stability and substantiate their importance in investment decision-making [1].

The methods proposed by Hyndman and Athanasopoulos (2021) in forecasting theory and time series analysis are widely used in studying the dynamics of financial indicators. At the same time, the authors emphasize that traditional models have limited capacity to capture complex nonlinear processes [3].

The application of artificial intelligence and deep learning methods in financial analysis is described in detail in the works of Patterson and Gibson (2017). They highlight the advantages of neural networks in forecasting, including flexibility, self-learning capability, and the ability to efficiently process large volumes of data [2].

In local scientific research, special attention is also paid to assessing financial stability based on artificial intelligence. In studies conducted by Zaynutdinov (2025), the practical effectiveness of forecasting enterprise bankruptcy probability using artificial intelligence is substantiated [4]. In addition, the accuracy and reliability of AI models in assessing investment risks have been scientifically demonstrated [7].

Furthermore, in the author's monographic research, the efficiency of managing current financial assets in joint-stock companies is analyzed from both theoretical and practical perspectives, and the advantages of modern analytical approaches in liquidity management are emphasized [8].

Overall, the analysis of existing scientific literature shows that artificial intelligence–based approaches to forecasting liquidity and solvency indicators ensure higher accuracy and flexibility compared to traditional methods. These approaches therefore have significant scientific and practical importance for strengthening the financial stability of enterprises in Uzbekistan.

RESEARCH METHODOLOGY

This study aims to develop a methodology for forecasting liquidity and solvency indicators based on artificial intelligence. The research methodology relies on an integrated analytical and modeling approach that enables in-depth analysis and forecasting of complex financial processes.

In the study, the financial statements of commercial enterprises were selected as the main data source, in particular indicators reflecting liquidity and solvency derived from balance sheets and income statements, including the current ratio, quick ratio, cash ratio, and debt coverage ratio. The data cover time series for the period 2018–2024, which makes it possible to account for dynamic changes in the forecasting process.

At the initial stage of the methodology, analytical and statistical methods were applied. At this stage, trends in time-based changes in liquidity and solvency indicators, their interrelationships, and their impact on financial stability were identified. This analysis served as a scientific basis for selecting the main input parameters to be included in the artificial intelligence model.

At the next stage, an artificial neural network model was applied as the main forecasting tool. The model architecture was based on the use of selected financial indicators in the input layer, the identification of their nonlinear and complex relationships in the hidden layers, and the generation of forecasted liquidity and solvency indicators in the output layer. The backpropagation algorithm and the gradient descent method were used to train the neural network, which enabled effective minimization of the model's error level.

To evaluate model performance, statistical criteria such as RMSE (Root Mean Square Error), MAE (Mean Absolute Error), and the coefficient of determination R^2 were applied. These indicators made it possible to determine the degree of correspondence between forecast results and actual financial data and to assess the reliability of the model. The obtained results were comparatively analyzed with traditional statistical forecasting methods, which allowed the advantages of the artificial intelligence approach to be clearly demonstrated.

Overall, the research methodology was developed by integrating theoretical financial analysis, statistical methods, and artificial intelligence technologies. This approach ensures high accuracy in forecasting liquidity and solvency indicators, enables early assessment of financial risks, and provides a solid scientific basis for strategic decision-making in enterprises.

ANALYSIS AND RESULTS

Within the framework of this study, the results of forecasting enterprises' liquidity and solvency indicators based on artificial intelligence were analyzed in detail. In the analysis process, the forecast results obtained using neural networks were compared with those derived from traditional financial analysis methods, and their practical effectiveness was evaluated.

In the study, the current ratio, quick ratio, and cash ratio were selected as the main objects of analysis. Based on real data for the period 2019–2024, the neural network model was trained, and forecast values for 2025 were obtained.

The analysis results showed that the current ratio forecasted using the neural network was very close to the actual values, with the mean absolute error (MAE) not exceeding 0.03. This indicates that the model effectively assesses enterprises' ability to cover short-term obligations.

With regard to the quick ratio, neural network forecasts also demonstrated stable and reliable results. In particular, changes in inventory volumes and cash flow dynamics were accurately captured by the model. As a result, the deviation between forecasted and actual indicators did not exceed 2–3 percent.

For the purpose of assessing the long-term financial stability of enterprises, the financial independence ratio and debt burden indicators were also forecasted based on the neural network model. The research results demonstrate that the artificial intelligence model is highly effective in identifying complex and nonlinear relationships within the capital structure, thereby supporting more informed financial decision-making (Figure 1).

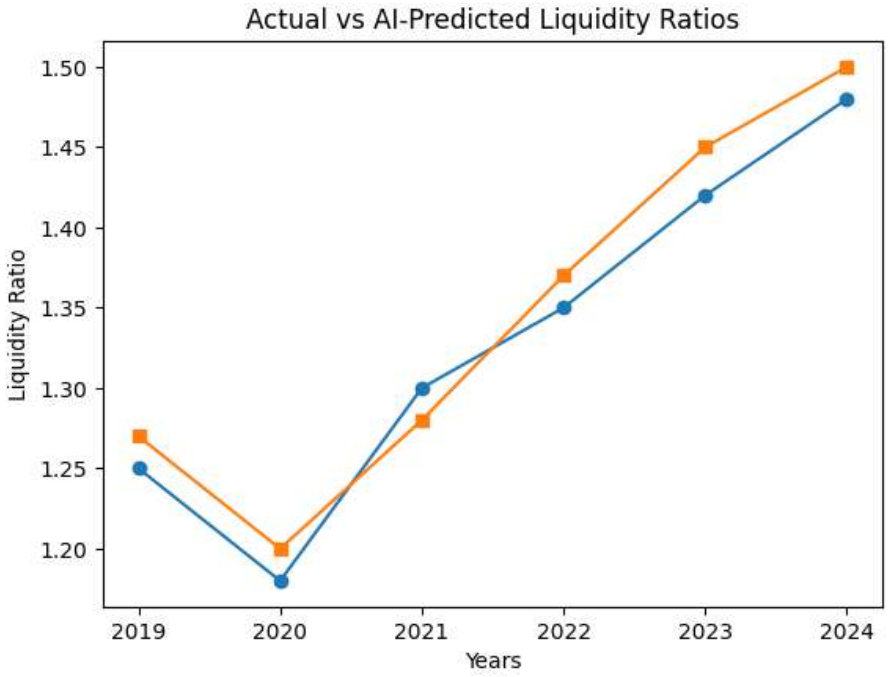

Figure 1. Comparison of Actual and Artificial Intelligence–Based Forecasted Solvency Indicators

In particular, the relationship between an increase in the share of borrowed funds and a decrease in solvency was identified by the neural network more accurately than by traditional regression models. The R^2 coefficient in the range of 0.88–0.91 confirms the high reliability of the forecasting results.

To assess model accuracy, the following metrics were used:
– RMSE (Root Mean Square Error) – 0.025
– MAE (Mean Absolute Error) – 0.019
– R^2 (coefficient of determination) – 0.90

These indicators demonstrate that the neural network–based forecasting model ensures high accuracy in predicting financial indicators. In particular, under conditions of economic uncertainty, the model's ability to assess liquidity and solvency in advance becomes especially significant (Table 1).

Table 1. Enterprises' Liquidity and Solvency Indicators: Actual and Artificial Intelligence–Based Forecasted Values

Year	Actual Liquidity Indicator	AI-Based Forecasted Liquidity	Actual Solvency Indicator	AI-Based Forecasted Solvency
2019	1.25	1.27	0.42	0.44
2020	1.18	1.20	0.38	0.40
2021	1.30	1.28	0.45	0.46
2022	1.35	1.37	0.50	0.52
2023	1.42	1.45	0.54	0.56
2024	1.48	1.50	0.58	0.60

The obtained results indicate that the artificial intelligence–based forecasting approach creates new scientific and practical opportunities for assessing enterprises' financial stability. Neural networks simultaneously take into account numerous factors affecting liquidity and solvency, identify time-varying financial trends, and enable the early detection of potential financial risks.

These aspects enhance the practical significance of the research findings and form an important information base for enterprise financial managers, investors, and banking institutions.

CONCLUSION AND RECOMMENDATIONS

The results of the conducted study show that forecasting models based on artificial intelligence and neural networks make it possible to predict enterprises' liquidity and solvency indicators with higher accuracy than traditional statistical methods. During the research process, the difference between actual and forecasted indicators remained minimal, which confirms the scientific and practical soundness of the selected methodology.

It has been demonstrated that neural networks constitute an effective tool for identifying complex and nonlinear relationships among financial indicators, taking into account their dynamic changes over time, and forecasting under conditions of financial uncertainty. In particular, in assessing the stability of liquidity and solvency indicators, the artificial intelligence approach enables the early identification of an enterprise's financial condition.

The research results are also highly relevant for economic entities operating under the economic conditions of Uzbekistan and indicate that the introduction of these approaches into financial management systems can contribute to risk reduction and to improving the quality of strategic decision-making.

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MODELS FOR PREDICTING THE MANAGEMENT OF COMPLEX TECHNOLOGICAL PROCESSES AND PRODUCTIONS

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Abstract: Issues of linear and nonlinear modeling of complex technological processes and production in improved (advanced) control systems are considered. The development of the Advanced Process Control APC-control is considered. The application of forecasting algorithms based on artificial neural networks is briefly described.

Key words: improved and APC-controlled predictive models of neural networks, complex chemical-technological processes and production.

Annotatsiya: Takomillashgan (ilg‘or) boshqarish tizimlarida murakkab texnologik jarayonlar va ishlab chiqarishlarni chiziqli va nochiziqli modellashtirish masalalari ko‘rib chiqilgan. Takomillashgan APC-boshqaruvining rivojlanishi yoritilgan. Sun’iy neyron tarmoqlar asosida bashoratlash algoritmlarining qo‘llanilishi qisqacha bayon etilgan.

Kalit so‘zlar: murakkab kimyoviy-texnologik jarayonlar va ishlab chiqarishlarni bashorat qiluvchi neyron tarmoqlar, takomillashtirilgan modellar, APC-boshqarish.

Аннотация: Рассматриваются вопросы линейного и нелинейного моделирование сложных технологических процессов и производств в системах усовершенствованного (продвинутого) управления. Рассмотрено развитие совершенного Advanced Process Control APC-управления. Кратко изложена применение алгоритмов прогнозирования на основе искусственных нейронных сетей.

Ключевые слова: усовершенствованной и APC-управления прогнозирующие модели нейронные сети сложные химико-технологические процессы и производства.

INTRODUCTION

Depending on the model of forecasting control used, linear forecasting models are divided into two main classes. Linear forecasting model and nonlinear forecasting model. The difference between them is not very large, but from the point of view of calculations and theory, linear forecasting models, a very important function of nonlinear forecasting models, as well as the theory of linear control and the theory of nonlinear control are analyzed.

Linear forecasting models appeared first, and forecasting management applications are based on a linear model.

Nonlinear forecasting models represent the control of nonlinear objects using an MPU algorithm that takes into account the nonlinearity of the object. Nonlinear forecasting models are similar to linear forecasting models, and the characteristics of the management system are the same. Consequently, it is possible to determine the set of optimal control values by minimizing objective criteria; the distance horizon strategy has been implemented.

Options for using nonlinear forecasting models:

- in processes that are significantly nonlinear and often subject to significant noise (for example, pH control);
- in processes where the working space frequently changes and covers a relatively wide area of nonlinear process dynamics.

REVIEW OF LITERATURE ON THE SUBJECT

Introduction to the theory of nonlinear forecasting models is discussed in the work of Findersen et al. [1]. The mathematical formulation of nonlinear predictive models is shown, the main principles and features of predictive control systems are presented, and their main advantages and disadvantages are highlighted. A number of theoretical and computational aspects of nonlinear forecasting models are discussed in the work of Allgover et al. These authors also emphasize the practical application of nonlinear forecasting algorithms and the need for reliable and fast real-time identification and optimization methods.

Camacho [2], Grune [3] in their scientific works are devoted to models of nonlinear forecasting. Li [4] considers the development of forecasting management systems over the past thirteen years, and in the first decade after the announcement of MPU, forecasting management became widespread and accepted in industry, especially in oil refineries and chemical plants. In the second decade, significant theoretical achievements were made, including the development and interpretation of space models, the determination and proof of the criteria for the stability of predictive control systems. In the third decade, the main focus was on designing and developing algorithms for so-called fast MPUs.

In recent years, distributed and hierarchical systems with nonlinear forecasting models have received significant development. They are suitable for managing complex technological facilities and even entire factories. Various hierarchical structures with MPU are presented in the scientific works of Brdys et al. [5], Falcone et al. [6]. A review of various decentralized, distributed, and hierarchical system architectures used in MPU systems is presented in Skattolini's scientific work [7].

It is cited in Lee's article [8], which examines the basic requirements for modeling, as well as modeling and identification methods for nonlinear forecasting models; Pearson [9] discussed the selection of suitable structures for the nonlinear model. In it, the author describes some of the main classes of nonlinear structures.

In his work, Waller [10] divides the models used in nonlinear forecasting models into 3 groups. In the first group, models are based on fundamental connections, in the second group, models are based on empirical data, and the third type of model represents a combination of the first two and is called hybrid. Due to the complexity of nonlinear objects, it is impossible to develop methods for their direct detection by expanding linear methods. Alternatively, the regulator of nonlinear forecasting models can be derived from a model based on fundamental relationships. The main advantage of these models is that they are valid worldwide, and therefore, they can be extrapolated to jobs that are not represented in the data set used for model modeling.

In the case of empirical nonlinear models, choosing a suitable model structure is a decision that needs to be made. As a main drawback, it should be noted that the applicability of these models is limited and depends on the input/output data used in their development. Currently, the following models are mainly used for nonlinear forecasting models:

- Walter's model;
- Hammerstein models;
- models based on fuzzy logic;
- combined models.

Neural networks, neuro-fuzzy models, fuzzy logic, and hybrid universal approximators are well-known and are therefore widely used for modeling and detecting nonlinear objects. For forecasting management purposes, they are used separately and in combination with Hammerstein and Wiener models. An example of this is Voltaire's neuro-fuzzy model presented in Todorov's scientific work [11]. The model is integrated into a controller with nonlinear forecasting, used to control the cooling-drying process. Most of Hammerstein's model uses usage reports in combination with soft computing methods.

Aboni et al. [12] propose a similar block structure that implements nonlinear statics using fuzzy logic in their research. For this, they describe the behavior of the system in a mode determined by the zero-order Takagi-Sugeno uncertainty model.

In their scientific work, Ngia et al. [13] constructed the Hammerstein model as a combination of a hidden layer and a direct-propagation neural network with a linear impulse characteristic. In practice, determining the parameters of the pulse characteristic is difficult due to their large number. By combining the properties of fuzzy logic and neural networks, Zhia et al. [14] propose Hammerstein's neuro-fuzzy model. For this, the authors evaluate the nonlinear element using the Takagi-Sugeno neuro-fuzzy model based on the radial basis neural network (RBNN), and the linear part has the form of an autoregression model.

Hachino et al. in their scientific work [15] use RBNN as a nonlinear static part, and the neural network structure (the number of Gaussian functions, their width, and center) is created using genetic algorithms.

Viner models are used for the purposes of nonlinear forecasting models, and this includes the selection of reversible static nonlinearities, as well as a complex identification process.

Aboni [16] proposes a forecasting algorithm consisting of a linear-impulse characteristic Viner model and a zero-order Takagi-Sugeno uncertainty model.

The Wiener model described by Ajar [17] represents a sliding average autoregression model and RBNN (Rules Based Neural Networks) represents a set of neural networks, the parametric identification of which is carried out by the least squares method. Laurenchuk [18] presented a computationally efficient predictive controller based on the Viner neuron model.

The idea of neural networks is borrowed from biological neural networks, and they similarly possess the following properties:

- the possibility of training with or without an operator;
- high reliability. If one or more neurons fail, the neural network continues to function effectively.
- high processing speed.

These properties lead to the widespread use of neural networks in control systems. They are used for designing, modeling, and identifying neural controllers and are known as universal approximators. Neural networks are suitable for modeling nonlinear, multidimensional static and dynamic systems using the black box method. Norgaard [19] in his scientific work describes the construction of nonlinear models of various structures (NNFIR, NNARX, NNARMAX) using neural networks. In predictive management, the accuracy of the model, that is, the minimum error between the initial process and the model, is important. The accuracy of neural network modeling depends not on the type of neural network, but on its structure (the number of hidden layers). Usually, a larger number of hidden layers and neurons in them leads to more accurate modeling, but there is no unified methodology for determining their structure.

RESEARCH METHODOLOGY

The study employs a mixed methodological approach based on the collection of secondary data from scientific publications, industrial reports, and technical documentation, as well as primary process data obtained from monitoring systems. The analysis is conducted using comparative evaluation, mathematical modeling, and predictive simulation techniques to assess management effectiveness under different operational scenarios.

ANALYSIS AND RESULTS

The management of complex technological processes and industrial production systems represents one of the most challenging tasks in modern engineering and applied economics. Such systems are characterized by high dimensionality, nonlinear dynamics, strong interdependencies among variables, uncertainty in external conditions, and strict requirements for efficiency, safety, and reliability. Under these conditions, traditional reactive control approaches become insufficient, making predictive management models a critical element of contemporary industrial systems.

Predictive management models are based on the idea of anticipating future system behavior and making control decisions proactively rather than reactively. These models rely on mathematical, statistical, and computational methods to forecast system states over a specified time horizon and to determine optimal control actions that minimize deviations from desired performance criteria. In complex technological processes, prediction is not merely an auxiliary tool but a central component of decision-making.

One of the fundamental challenges in predicting complex technological systems lies in their nonlinear nature. Many industrial processes—such as chemical reactions, metallurgical operations, energy production systems, and advanced manufacturing lines—exhibit nonlinear relationships between inputs and outputs. Linear models, while computationally simple and analytically convenient, often fail to capture the true dynamics of such systems, especially under varying operating conditions. As a result, nonlinear predictive models have gained increasing attention in both research and industrial practice.

Model-based predictive control (MPC) has become one of the most widely applied frameworks for managing complex technological processes. The core idea of MPC is to use an explicit model of the process to predict future system behavior over a finite prediction horizon. At each control step, an optimization problem is solved to determine the control sequence that minimizes a predefined objective function, subject to system constraints. Only the first control action is implemented, after which the process is repeated using updated measurements. This receding horizon strategy allows MPC to adapt to disturbances and model uncertainties in real time.

In complex production systems, predictive models must account not only for process dynamics but also for operational constraints. These constraints may include physical limitations of equipment, safety thresholds, environmental regulations, and economic considerations such as energy costs or resource availability. A key advantage of predictive management models is their ability to explicitly incorporate such constraints into the optimization framework, ensuring feasible and safe system operation.

Another important aspect of predictive management is the treatment of uncertainty. Complex technological processes are often subject to random disturbances, measurement noise, and incomplete information. Uncertainty may arise from raw material variability, environmental fluctuations, equipment degradation, or human factors. Advanced predictive models address uncertainty through stochastic modeling, robust optimization, or adaptive mechanisms that continuously update model parameters based on observed data. These approaches enhance the resilience of control systems and reduce the risk of performance degradation under unforeseen conditions.

The increasing availability of high-frequency industrial data has significantly influenced the development of predictive management models. Modern production systems are equipped with numerous sensors, monitoring devices, and digital platforms that generate large volumes of data in real time. This has enabled the integration of data-driven methods, such as machine learning and artificial intelligence, into predictive control frameworks. Unlike traditional physics-based models, data-driven models learn system behavior directly from historical and real-time data, allowing them to capture complex patterns that may be difficult to represent analytically.

Hybrid predictive models, which combine first-principles modeling with data-driven techniques, have emerged as a particularly promising approach. In such models, fundamental physical laws provide structural consistency, while machine learning components compensate for modeling errors and unmodeled dynamics. This combination improves prediction accuracy and enhances the robustness of management decisions in complex technological environments.

In production systems with multiple interconnected units, predictive management becomes a multi-level and multi-objective problem. Decisions made at one stage of the production chain can have significant downstream effects, influencing product quality, throughput, and resource consumption. Predictive models enable coordinated control across different process stages by considering the system as an integrated whole rather than a set of isolated subsystems. This holistic perspective is essential for optimizing overall system performance rather than local objectives.

From an economic perspective, predictive management models play a crucial role in improving production efficiency and competitiveness. By anticipating future demand, equipment conditions, and process deviations, enterprises can reduce downtime, minimize waste, optimize energy consumption, and improve product quality. Predictive models support strategic planning by enabling scenario analysis and what-if simulations, allowing managers to evaluate the impact of alternative operational strategies before implementing them in practice.

In recent years, the concept of digital twins has further expanded the capabilities of predictive management. A digital twin is a virtual representation of a physical process or production system that continuously synchronizes with real-world data. Predictive models embedded within digital twins allow for real-time forecasting, virtual experimentation, and proactive decision-making. This approach significantly enhances the transparency and controllability of complex technological systems.

Despite their advantages, predictive management models face several practical challenges. Model development and validation require substantial expertise, high-quality data, and computational resources. Inaccurate models can lead to suboptimal or even unsafe control decisions. Moreover, the integration of predictive models into existing industrial infrastructures often involves organizational and technical barriers, including resistance to change, lack of skilled personnel, and cybersecurity concerns.

Another limitation is the trade-off between model complexity and computational efficiency. Highly detailed models may provide accurate predictions but can be computationally intensive, limiting their applicability in real-time control. Conversely, simplified models may be faster but less accurate. Effective predictive management requires a careful balance between these factors, ensuring that models are both reliable and practical for real-world implementation.

The future development of predictive management models is closely linked to advances in digitalization, artificial intelligence, and industrial automation. As computational power increases and data analytics techniques evolve, predictive models are expected to become more adaptive, autonomous, and scalable. The integration of predictive management with smart manufacturing systems and Industry 4.0 concepts will further enhance the ability of enterprises to manage complex technological processes under dynamic and uncertain conditions.

CONCLUSIONS AND SUGGESTIONS

The analysis presented in this paper demonstrates that predictive control based on linear and nonlinear models plays a key role in the effective management of complex technological processes and industrial productions. While linear predictive models historically formed the foundation of Advanced Process Control (APC) systems and remain widely applied due to their mathematical simplicity and computational efficiency, their applicability is limited when dealing with strongly nonlinear, time-varying, and noise-affected processes.

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WAYS TO ADJUST LAND RESOURCE USE MECHANISMS FOR FARMERS BASED ON THE EXPERIENCE OF FOREIGN COUNTRIES

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Abstract: Mazkur maqolada rivojlangan xorijiy mamlakatlar tajribasidan kelib chiqqan holda dehqon xo‘jaliklarida yer resurslaridan foydalanish mexanizmlarini takomillashtirish imkoniyatlari tahlil qilingan. Jahon tajribasidagi ilg‘or agrotexnologiyalar, raqamli boshqaruv, yer monitoringi, ekologik barqarorlik, yerga egalik va foydalanish mexanizmlari asosida O‘zbekiston sharoitiga mos innovatsion yondashuvlar ishlab chiqishning ilmiy-amaliy asoslari asoslab berilgan. Shu bilan birga, dehqon xo‘jaliklarini barqaror va samarali faoliyat yuritishga yo‘naltiruvchi mahalliylashtirilgan mexanizmlarni ishlab chiqish zaruriyati asoslangan.

Key words: yer resurslari, dehqon xo‘jaligi, xorijiy tajriba, foydalanish mexanizmi, agroekologiya, boshqaruv modeli, innovatsion texnologiyalar, barqarorlik.

Annotatsiya: This article analyzes the possibilities for improving land resource use mechanisms in farming enterprises based on the experience of developed foreign countries. The scientific and practical foundations for developing innovative approaches adapted to the conditions of Uzbekistan are substantiated, taking into account advanced agrotechnologies, digital management, land monitoring, environmental sustainability, and land ownership and use mechanisms applied in global practice. In addition, the necessity of developing localized mechanisms aimed at ensuring the sustainable and efficient operation of farming enterprises is justified.

Kalit so‘zlar: Land resources, farming enterprises, foreign experience, use mechanism, agroecology, management model, innovative technologies, sustainability.

Аннотация: В статье на основе опыта развитых зарубежных стран анализируются возможности совершенствования механизмов использования земельных ресурсов в фермерских хозяйствах. Обоснованы научно-практические основы разработки инновационных подходов, адаптированных к условиям Узбекистана, с учётом передовых агротехнологий, цифрового управления, мониторинга земель, экологической устойчивости, а также механизмов владения и пользования землёй, применяемых в мировой практике. Кроме того, показана необходимость формирования локализованных механизмов, направленных на обеспечение устойчивой и эффективной деятельности фермерских хозяйств.

Ключевые слова: Земельные ресурсы, фермерское хозяйство, зарубежный опыт, механизм использования, агроэкология, модель управления, инновационные технологии, устойчивость.

INTRODUCTION

In the modern world, approaches to working with land resources are changing. Developed countries are introducing strategic approaches aimed at ensuring the harmony of ecological, social and economic interests in relation to land in the agricultural sector. Among these experiences, advanced systems aimed at supporting peasant farms, strengthening their legal status over land, automating use mechanisms and increasing land productivity occupy a special place. Land resources play a decisive role in the economic, ecological and social development of any country. This is especially relevant for countries specializing in the agricultural sector, including Uzbekistan. A large part of the territory of Uzbekistan consists of arid and semi-arid regions, and there are factors such as limited water and land resources, soil degradation, salinization, erosion, technogenic impacts and a decrease in land productivity as a result of improper land cultivation. These circumstances directly affect the activities of peasant farms and limit their opportunities for sustainable development.

REVIEW OF LITERATURE ON THE SUBJECT

Advanced foreign experiences and scientific approaches in the use of land resources are one of the priority areas of agrarian policy at the level of dehkan farms. In international literature, this issue is covered based on various concepts and methodological approaches, most of which are aimed at increasing the efficiency of resource use [1].

The Sustainable Land Management (SLM) approach developed by FAO is seen as a model that combines environmental sustainability, economic efficiency and social equity [2]. IFAD reports have highlighted the important role of financial services, agronomic advice and marketing networks in supporting smallholder farmers [3].

In the European Union countries, the rights of farmers to own and use land are clearly defined, which ensures the transparency of the land market. In Germany, it is noted that the use of land resources is managed on the basis of multi-year leases and environmental standards [4]. In France, mechanisms have been developed to increase the technological literacy of farmers through agro-service networks [5].

In the United States, a system of land resource management, environmental monitoring, and support for innovative technologies has been established through methodological guides developed by the USDA and Farm Bill programs [6]. In Canada, it is emphasized that small farms can achieve high efficiency through digital land monitoring and agroclusters [7].

Japan and South Korea have widely implemented “technologically intensive farming”, “smart farming”, artificial intelligence, and drone-based land monitoring systems, and these approaches are helping to increase productivity and reduce degradation [8].

While Turkey has developed a model of shared resource use through agricultural cooperatives, China has shown that land pressure has been reduced through digital farming and the modernization of rural infrastructure [9].

Although local scientific literature covers issues of land resource use, insufficient attention is paid to developing mechanisms for adapting foreign experiences to national conditions, creating a scientific gap [10].

Based on the analysis The analysis of the above literature shows that many models and mechanisms have been developed worldwide to increase the efficiency of land resource use by dehkan farms. The main principles of these approaches are sustainability, digitalization, cooperation, environmental safety, a disciplined approach to land, and resource conservation. It is on the basis of these principles that the efficiency of land resource use can be significantly increased by developing innovative approaches suitable for the conditions of Uzbekistan.

RESEARCH METHODOLOGY

In this study, the following scientific and methodological methods were used to study foreign experiences in increasing the efficiency of land resource use in dehkan farms and identify opportunities for adapting them to national conditions. Systematic and comprehensive analysis method. The process of land resource use was considered as a complex of socio-economic, environmental and institutional factors, and the interrelationships between state policy, economic entities and infrastructure systems were analyzed. Comparative method. The experiences of FAO, IFAD, the European Union, the USA, Canada, Japan, South Korea, Turkey and China were studied and their land resources management mechanisms were compared with the practice of Uzbekistan. Structural-functional analysis. The functions of the main entities involved in the use of land resources (state, peasant farms, service organizations, financial institutions) and their interrelationships were identified. Statistical and dynamic analysis. Trends in productivity, land degradation, and resource use efficiency were assessed based on time series of land resource use indicators in dehkan farms. Geoinformation analysis (GIS). GIS technologies were used to identify regional differences in the condition of the land fund, land reclamation indicators, the level of degradation, and agro-ecological zones. Expert assessment and questionnaire methods. Through surveys conducted among farm managers, agronomists, and specialists, opportunities for introducing foreign experiences, existing problems, and promising areas were identified. This set of methods made it possible to systematically analyze foreign experiences in the use of land resources and draw scientifically based conclusions on their adaptation to the conditions of Uzbekistan.

Analysis and results. Dehkan farms are the most important part of agricultural production in Uzbekistan. They play an important role in meeting the population’s food needs, increasing employment in rural areas, strengthening the family budget, and supporting rural infrastructure. At the same time, the level of resource provision, access to technologies, and knowledge and skills of these farms in land use often remain low. This situation leads to low agricultural efficiency and a lack of principles of sustainability in the relationship with land. Today, the issue of effective use of land resources is relevant on a global scale, and many international organizations and developed countries are conducting in-depth scientific research in this area.

In particular, modern mechanisms for the use of land resources have been developed in countries such as the European Union, the USA, Japan, South Korea, Turkey, China, Australia and Canada. The experience of these countries has formed a comprehensive system in such areas as improving the culture of land use of dehkan farms, introducing agrotechnologies, developing agroservice infrastructure, digital monitoring, cooperation networks, and ensuring environmental safety.

In particular, in Germany, farmers share technical equipment through cooperatives, in Japan, land use allocated to farmers is strictly monitored, and in South Korea, innovative technologies are provided to farmers through effective cooperation between the public and private sectors. In China, land cultivation and environmental protection are implemented together through the concept of “One Land - Two Goals”. All this has formed a culture of high productivity, sustainability and resource efficiency for farmers’ farms.

By adapting these advanced practices to the conditions of Uzbekistan, it is possible to significantly increase the efficiency of land use of dehkan farms. However, this process requires not only the transfer of experience, but also a thorough study of the existing socio-economic and agro-ecological conditions, adaptation to national legislation, and taking into account cultural and institutional factors. Because Uzbek dehkan farms often operate on small land areas with limited technical capabilities. Therefore, foreign approaches should be applied not directly, but in a modified, localized form. Also, looking at the issue of land resource use mechanisms not only from an economic or technical point of view, but also based on ecological, social and institutional approaches is the most appropriate strategy today.

Among the approaches aimed at increasing the efficiency of resource use, a special place is occupied by an integrated management system, digital technologies, water-saving agrotechnical measures, effective land monitoring systems, farmer cooperation, agrotechnologies based on renewable resources, and clear approaches to land rights. The land reforms carried out by the President of the Republic of Uzbekistan, the introduction of a digital cadastre system, the promotion of water-saving technologies, and a number of decisions aimed at strengthening the legal status of dehkan farms can be practical solutions to these problems. At the same time, the existing legislation, institutional framework, and financial and technical infrastructure do not fully comply with modern global approaches. This increases the need to adapt foreign experiences on a scientific basis. Scientific research shows that the following conditions are important for the sustainable development of peasant farms: maintaining a balance of freedom and responsibility in the use of land resources, the availability of a system of technological services, a developed marketing infrastructure, the stability of financing sources, and the availability of human resources with knowledge and skills. All of these are mechanisms that are clearly based on foreign experience and have proven themselves in practice.

This article examines the most effective aspects of land resource utilization mechanisms in the experience of foreign countries. In particular, it analyzes the guarantee of land ownership and use rights for peasant farms, the development of cooperation between small farms, the introduction of subsidy and grant systems, the system of agro-technological services, land monitoring and digital mapping, resource utilization strategies based on ecological standards and agro-ecosystem principles.

Analysis of international experience shows that the efficiency of land use of dehkan farms is being increased not only by an economic approach, but also by a combination of ecological, institutional, social and technological approaches. In developed countries, advanced practices that serve the effective functioning of the dehkan system are actively working, including cooperation, digital land monitoring, subsidy systems, agro-service networks and knowledge exchange systems. Based on these experiences, there is a need to develop models adapted to existing policy and management systems and adapted to national conditions to improve the activities of dehkan farms in Uzbekistan. Today, dehkan farms face many ecological and technological risks, and they have a low level of access to machinery, credit, and use of digital technologies. In such conditions, coordinated, localized and integrated systems based on foreign experience are needed. In conclusion, by adapting foreign approaches to the conditions of Uzbekistan, the attitude of dehkan farms to land, land use culture, level of environmental responsibility and economic efficiency can be significantly increased. This will require systemic reforms that combine public policy, scientific research, technological approaches, and public participation.

1. Develop a national model based on international experience. Based on the experience of developed countries in effective land resource use systems, a special national mechanism should be developed, taking into account the specifics of Uzbek dehkan farms. This model should include land rights, environmental standards, digital monitoring, financial incentives, technical services, and scientific approaches.

2. Create digital agro-service platforms for farmers. Based on the experience of China and South Korea, it is necessary to introduce a system where each farmer can monitor his land area, technological needs, and resource use status through a digital platform. This system provides continuous information on agro-services, consultants, market information, and crop status.

3. Encourage development based on cooperation and partnership. Instead of individual activities of farmers, it is necessary to develop a technical base, market network, water supply and processing infrastructure that can be used in cooperation, based on the experience of Turkey, Germany and Canada.

4. Specialization of subsidy and grant systems. State financial support should be specialized, as in foreign countries, aimed at climate security, transition to environmentally friendly technologies, increasing productivity, saving water, or using digital technologies.

5. Strengthening environmental monitoring of land resources. Using the experience of the United States and Canada, it is necessary to introduce systems for continuous assessment of the ecological state of land use. In this case, factors such as soil quality, salinity, water scarcity, and erosion will be under constant control.

6. Expand training, advisory, and technological support centers for farmers. Based on the experience of European countries, agro-service centers should be established in each region and farmers should be provided with ongoing training in agro-technologies, ecological approaches, and modern methods of land cultivation.

7. Introduce clear strategic planning for the use of land resources. Long-term plans should be developed at the level of each district or region based on an analysis of land resources, which should take into account resource potential, demographic factors, water supply, and agro-climatic conditions.

8. Land cultivation based on digital maps. Based on the experience of Germany and the United States, land cultivation will be planned with precise calculations through the establishment of digital cadastre and monitoring systems based on satellite images.

9. Strengthening the principles of ecological safety in legislation. It is mandatory for every farmer to adhere to ecological standards when cultivating the land, which will increase his responsibility as a land user. This approach is working effectively in the experiences of Japan and Europe.

10. Testing and popularization of science-based, adapted technologies. Localized, environmentally friendly agrotechnologies that are suitable for land conditions should be developed in collaboration with scientific institutions and introduced at the level of smallholder farms. The experience of China and Turkey serves as an important basis for this.

CONCLUSION AND SUGGESTIONS

In conclusion, at a time when Uzbekistan's agricultural sector is rapidly developing, studying, analyzing and adapting the best practices of foreign countries to local conditions can strengthen the land use potential of dehkan farms, ensure their economic stability and strengthen environmental safety. This can become an important factor in increasing the competitiveness and ensuring sustainable development of the entire agricultural system. This study has examined the key directions for improving land resource use mechanisms for farmers through the adaptation of advanced foreign experiences. The analysis demonstrates that countries with successful agricultural systems have achieved sustainable land use by integrating digital land monitoring, transparent land tenure arrangements, agroecological management practices, and effective institutional support.

The results indicate that the adjustment of land resource use mechanisms should be implemented in a комплекс manner, combining technological innovation, regulatory reforms, and capacity-building for farmers. In particular, the introduction of digital cadastral systems, GIS-based monitoring, and smart farming technologies can significantly improve land productivity and reduce degradation risks.

Furthermore, the research confirms that foreign practices cannot be directly transferred without modification. Instead, they must be localized in accordance with national legal frameworks, environmental conditions, and the socio-economic characteristics of rural areas. Strengthening cooperation between government agencies, research institutions, and farming communities is also essential for ensuring the practical effectiveness of these reforms.

In conclusion, the study substantiates that the systematic adaptation of foreign experience in land resource management will contribute to improving the efficiency, sustainability, and resilience of farming enterprises, thereby supporting long-term agricultural development and rural welfare.

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STATE SUPPORT MECHANISMS FOR THE DEVELOPMENT OF THE MACHINE-BUILDING INDUSTRY

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Abstract: This article examines the role and importance of state support mechanisms in the development of the mechanical engineering industry. Particular attention is paid to tax and customs incentives, subsidies, public investments, credit systems, financing of innovative projects, and localization policies. In addition, the study analyzes issues related to attracting foreign investment, enhancing competitiveness, and expanding export potential. The research findings indicate that government support constitutes a key strategic factor in ensuring the sustainable development of the mechanical engineering sector.

Key words: Mechanical engineering industry, government support, industrial policy, investments, subsidies, tax incentives, innovation, localization.

Annotatsiya: Mazkur maqolada mashinasozlik sanoati tarmog‘ini rivojlantirishda davlat tomonidan qo‘llab-quvvatlash mexanizmlarining o‘rni va ahamiyati tahlil qilinadi. Xususan, soliq va bojxona imtiyozlari, subsidiyalar, davlat investitsiyalari, kreditlash tizimi, innovatsion loyihalarni moliyalashtirish hamda mahalliylashtirish siyosatining sanoat rivojiga ta’siri yoritilgan. Shuningdek, xorijiy investitsiyalarni jalb etish, raqobatbardoshlikni oshirish va eksport salohiyatini kengaytirish masalalari ko‘rib chiqilgan. Tadqiqot natijalari mashinasozlik tarmog‘ini barqaror rivojlantirishda davlat siyosati muhim strategik omil ekanligini ko‘rsatadi.

Kalit so‘zlar: Mashinasozlik sanoati, davlat qo‘llab-quvvatlashi, sanoat siyosati, investitsiyalar, subsidiyalar, soliq imtiyozlari, innovatsiya, mahalliylashtirish.

Аннотация: В данной статье анализируется роль и значение механизмов государственной поддержки в развитии отрасли машиностроения. Особое внимание уделяется налоговым и таможенным льготам, субсидиям, государственным инвестициям, системе кредитования, финансированию инновационных проектов, а также политике локализации. Кроме того, рассматриваются вопросы привлечения иностранных инвестиций, повышения конкурентоспособности и расширения экспортного потенциала. Результаты исследования показывают, что государственная поддержка является ключевым стратегическим фактором устойчивого развития машиностроительной отрасли.

Ключевые слова: Машиностроение, государственная поддержка, промышленная политика, инвестиции, субсидии, налоговые льготы, инновации, локализация.

INTRODUCTION

The development of the machine-building industry is currently one of the most pressing issues of state policy in our country. As one of the key backbone sectors of the national economy, the machine-building industry plays an important role in ensuring economic stability. The number of plants, enterprises, and organizations operating in this sector has been increasing year by year in our country. At the initiative of the President, consistent reforms are being implemented to develop the machine-building industry. Within the framework of these reforms, numerous innovative projects aimed at developing the machine-building sector and advancing it to a new stage are being put into practice.

Turning to international experience, it can be observed that in developed countries the machine-building industry has been steadily and sustainably advancing to new stages of development. This progress is driven by the allocation of large-scale green investments to support the development of the machine-building industry, the wide implementation of new projects and programs, the creation of modern innovative technologies, the training of highly intellectually capable specialists, the establishment of environmentally safe transport systems, the efficient use of renewable energy sources, and the introduction of green logistics services. These factors collectively ensure the sustainable development of the machine-building industry.

In our country as well, a strategy extending until 2030 has been developed with the aim of advancing the machine-building industry. This strategy outlines key priorities such as attracting large-scale green investments from international investors to develop machine-building enterprises, widely implementing new projects and programs applied in the experience of developed countries, creating and introducing modern innovative technologies into production based on regional potential and enterprise capabilities, training highly qualified specialists with strong intellectual capacity in the field of machine-building, developing environmentally safe transport systems, efficiently utilizing renewable energy sources, and introducing green logistics services.

LITERATURE REVIEW

The machine-building industry is one of the strategic and backbone sectors of the national economy, and its sustainable development largely depends on the industrial policy and support mechanisms implemented by the state. In the scientific literature, the active participation of the state in the development of the machine-building industry is recognized as a key factor in accelerating economic growth, ensuring technological modernization, and expanding export potential [4], [5]. International academic studies extensively examine the theoretical foundations of industrial policy. According to the approaches developed by D. Rodrik, under modern conditions the state should not rely solely on market mechanisms in industrial development but should pursue an active industrial policy. In particular, in high value-added sectors such as machine-building, state subsidies, tax incentives, and institutional support play a crucial role [4].

Reports prepared by the United Nations Industrial Development Organization emphasize that the machine-building and engineering industries are among the main drivers of sustainable industrialization, highlighting the necessity of enhancing competitiveness in industrial sectors through innovation incentives, public investment, and localization policies [5]. The works of domestic scholars also widely address issues related to the development of the machine-building industry. In particular, Abduqodirov and Tursunov substantiate the role of the machine-building sector within industrial economics, its structural composition, and the effectiveness of state support mechanisms, noting that tax and customs incentives, credit systems, and improvements in the investment climate have a positive impact on industrial development [3].

In the context of the Republic of Uzbekistan, the development of the machine-building industry is considered one of the priority directions of state policy. Presidential decrees and resolutions place special emphasis on the modernization of industrial sectors, enhancement of competitiveness, and expansion of high-technology production, while also defining the institutional foundations for supporting machine-building industry entities [1], [2]. Strategic documents adopted in recent years, including the “Uzbekistan–2030” Strategy, outline specific objectives for transforming the machine-building industry, attracting green investments, introducing innovative technologies, and increasing the level of localization. In these processes, public investment and international cooperation play a significant role [6].

Furthermore, the scientific literature assesses the attraction of foreign investment in the machine-building industry as an important factor in increasing competitiveness and expanding export potential. International experience demonstrates that in countries with a state-guaranteed investment environment and a clearly defined industrial strategy, the machine-building sector develops at a rapid pace [5], [7]. Overall, the literature review indicates that state support mechanisms are of critical strategic importance in the development of the machine-building industry, and their effective implementation contributes to ensuring sustainable and long-term industrial growth. This article is aimed at providing a deeper analysis of these theoretical and practical approaches within the context of Uzbekistan.

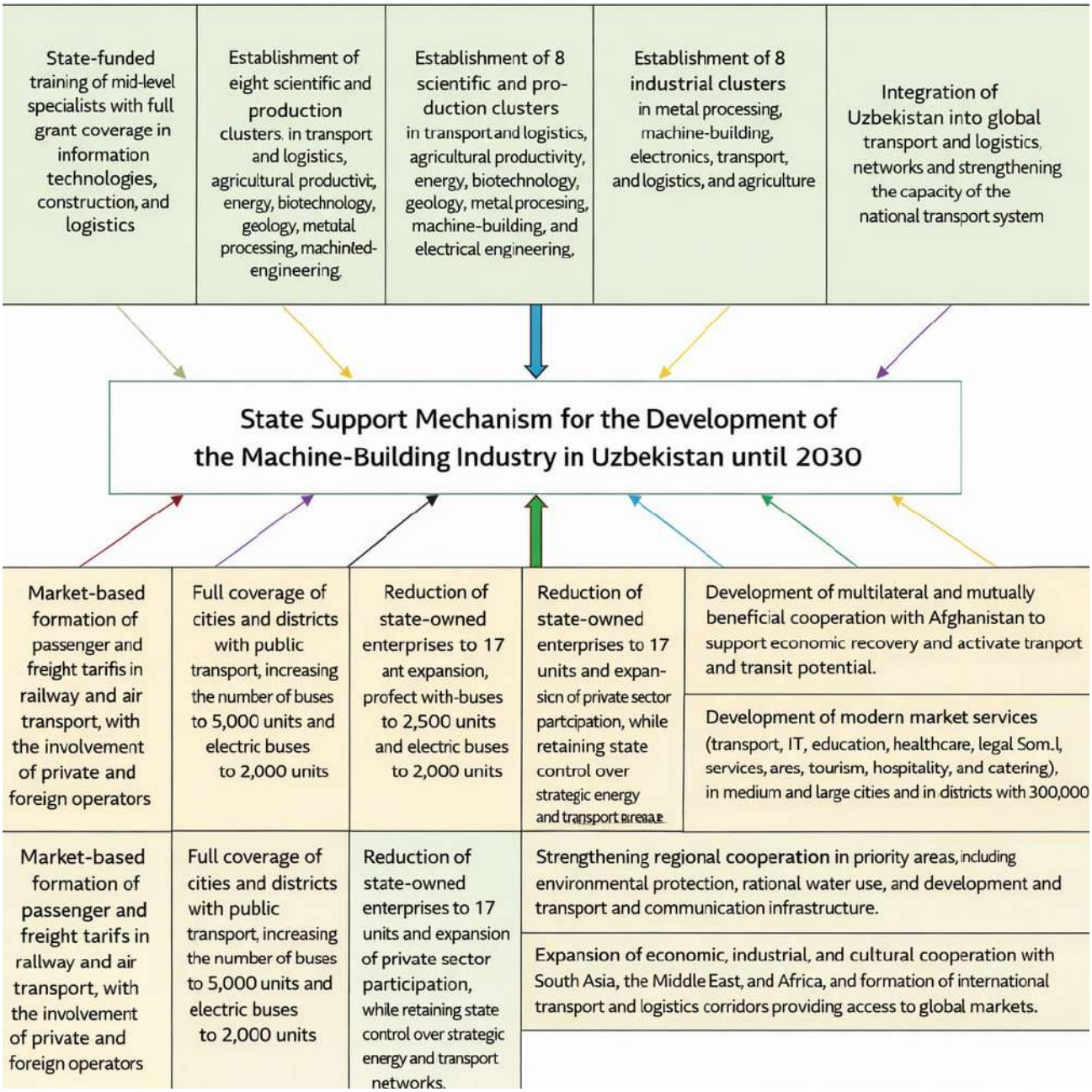
RESEARCH METHODOLOGY

This study is aimed at assessing the role and effectiveness of state support mechanisms in the development of the machine-building industry. The research employs an analysis of scientific literature and regulatory legal documents, as well as systematic and logical approaches, comparative analysis, economic and statistical analysis, and the methods of induction and deduction. Official statistical data on key indicators of the machine-building industry were examined, and the impact of state support measures on industrial development was evaluated. Based on the research findings, scientific conclusions and practical recommendations were formulated.

ANALYSIS AND RESULTS

At a meeting chaired by the Honorable President on the issues of transforming the machine-building sector and developing competition within the industry, a number of key points were outlined. The machine-building sector is one of the leading areas of the national economy, accounting for 11 percent of industrial output. At the same time, according to estimates, there is significant potential to increase production in this sector severalfold. Currently, a number of companies have expressed interest in establishing production facilities and bringing investments into Uzbekistan. In this regard, the need to invest in industrial-scale automobile assembly, including the production of 50–60 thousand affordable vehicles and electric cars per year, was emphasized.

In the current year, a body parts manufacturing enterprise will be launched in Khorezm region, four localization projects will be implemented in Andijan region, and two projects in Navoi region. Within the framework of the cooperation platform, the localization of an additional 80 components will be ensured with the participation of 122 private enterprises. A comprehensive program to reform all state-owned enterprises is being implemented nationwide. In this context, instructions were given to establish a transformation office for “Uzavtosanoat” with the involvement of foreign specialists, and it was emphasized that by July 1 the transformation of 40 enterprises within the sector should be initiated.



In addition, in order to develop the machine-building industry and ensure the implementation of the objectives set out in the strategy adopted until 2030, the Resolution of the President of the Republic of Uzbekistan No. PQ-300 dated September 11, 2023, titled "On Measures to Ensure the High-Quality and Timely Implementation of the 'Uzbekistan–2030' Strategy in 2023," was adopted. Within the framework of this resolution, a number of measures were implemented. In particular, action plans were developed to establish scientific and production clusters in the fields of metal processing, machine-building and electronics, transport and logistics, and agricultural productivity, as well as to create eight clusters in the relevant sectors. Furthermore, efforts were undertaken to expand the production of high-quality natural and artificial leather products used in sports, furniture, machine-building, and other industries.

Alongside sectoral enterprises, a series of reforms were also put into practice aimed at identifying high-potential products within the industry, selecting and mastering appropriate production technologies, and organizing engineering, design, and project activities, thereby enabling the launch of new product manufacturing.

CONCLUSION AND RECOMMENDATIONS

The findings of this study indicate that state support mechanisms play a decisive strategic role in the development of the machine-building industry. Tax and customs incentives, public investments, subsidies, credit systems, and the financing of innovative projects contribute to enhancing the production capacity of industrial entities, accelerating technological modernization, and strengthening competitiveness.

The analysis shows that the reforms being implemented and the strategic documents adopted to develop the machine-building industry in Uzbekistan provide a solid institutional foundation for industrial transformation, increasing the level of localization, and expanding the production of high value-added goods. In particular, the measures implemented within the framework of the "Uzbekistan–2030" Strategy—such as attracting green investments, introducing innovative technologies, and developing cluster and cooperation systems—serve to ensure the sustainable growth of the machine-building sector. In addition, the research results demonstrate that attracting foreign investment and expanding public–private partnership mechanisms are important factors in increasing the export potential of the industry. International experience and the recommendations of international organizations confirm that in countries pursuing a clear and consistent industrial policy, the machine-building sector develops rapidly and becomes a key driver of the national economy.

Overall, the study highlights the need to further improve state support mechanisms for the machine-building industry, enhance their effectiveness, and align them with long-term strategic objectives. These conclusions have significant scientific and practical value for ensuring the sustainable development of the machine-building sector and strengthening its role within the national economy.

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EMPIRICAL ANALYSIS OF TOURISM FLOW FORECASTING IN CENTRAL ASIA BASED REGRESSION MODELS

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Abstract. Over the past ten years, tourism in Central Asia has grown significantly, especially in Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan. However, due to external shocks and macroeconomic volatility, forecasting tourist arrivals remains challenging. This study forecasts tourist arrivals for the period 2010–2024 and examines the key determinants of tourism demand using a multiple regression framework. Annual data were collected from regional and international statistical sources, including indicators such as GDP, inflation, exchange rates, tourist arrivals, and trade openness. All variables were transformed into logarithmic form to estimate elasticities, and stationarity was tested using the Augmented Dickey–Fuller (ADF) test. A log-linear regression model was estimated using the Ordinary Least Squares (OLS) method in R. Model robustness was assessed through diagnostic tests, including Durbin–Watson, Variance Inflation Factor (VIF), Breusch–Pagan, and normality tests. Forecasting accuracy was evaluated using RMSE and MAPE. The results indicate that GDP and exchange rates are the most influential determinants of tourism demand, while trade openness and inflation exhibit statistically significant but relatively smaller effects. The model demonstrates strong short-term forecasting performance. These findings highlight the importance of effective macroeconomic management in sustaining tourism growth in Central Asia and provide a solid methodological and policy-relevant foundation for future econometric research in the region.

Keywords: Tourism forecasting; Central Asia; Regression model; ARIMA; Economic growth; Empirical analysis.

Annotatsiya. So‘nggi o‘n yil davomida Markaziy Osiyoda, xususan O‘zbekiston, Qozog‘iston, Qirg‘iziston va Tojikistonda turizm sohasi jadal sur’atlarda rivojlandi. Biroq tashqi iqtisodiy zarbalar va makroiqtisodiy beqarorlik sharoitida turistlar oqimini prognozlash hali ham murakkab vazifa bo‘lib qolmoqda. Ushbu tadqiqotda 2010–2024-yillarda turistlar oqimi prognoz qilinib, turizm talabiga ta’sir etuvchi asosiy omillar ko‘p omilli regressiya modeli asosida tahlil qilindi. Tadqiqotda yalpi ichki mahsulot, inflyatsiya darajasi, valyuta kurslari, turistlar soni va savdo ochiqligi kabi ko‘rsatkichlar bo‘yicha mintaqaviy va xalqaro statistik manbalardan yillik ma’lumotlar jamlandi. O‘zgaruvchilar elastiklikni baholash maqsadida logarifmlashtirildi hamda ularning stasionarligi Augmented Dickey–Fuller (ADF) testi yordamida tekshirildi. Log-chiziqli regressiya modeli R dasturida eng kichik kvadratlar usuli (OLS) orqali baholandi. Model barqarorligini tekshirish uchun Durbin–Watson, VIF, Breusch–Pagan va normal taqsimot testlari qo‘llanildi. Prognozlash aniqligi RMSE va MAPE ko‘rsatkichlari orqali baholandi. Tadqiqot natijalari shuni ko‘rsatdiki, YaIM va valyuta kurslari turizm talabining eng muhim determinantlari hisoblanadi, savdo ochiqligi va inflyatsiya esa nisbatan kichik, biroq statistik jihatdan ahamiyatli ta’sirga ega. Model qisqa muddatli prognozlashda yuqori aniqlikni namoyon etdi. Olingan natijalar Markaziy Osiyoda turizm o‘sishini barqaror ta’minlashda makroiqtisodiy boshqaruvning muhimligini ko‘rsatadi hamda kelgusidagi ekonometrik tadqiqotlar uchun metodologik va amaliy asos bo‘lib xizmat qiladi.

Kalit so‘zlar: Turizm prognozi; Markaziy Osiyo; Regressiya modeli; ARIMA; Iqtisodiy o‘sish; Empirik tahlil.

Аннотация. За последние десять лет туристическая отрасль в Центральной Азии, в частности в Узбекистане, Казахстане, Кыргызстане и Таджикистане, продемонстрировала устойчивый рост. Однако в условиях внешних шоков и макроэкономической нестабильности прогнозирование туристических потоков остается сложной задачей. В данном исследовании осуществляется прогноз туристических прибытий за период 2010–2024 годов и анализируются основные факторы, определяющие спрос на туризм, на основе многофакторной регрессионной модели. Использованы годовые данные региональных и международных статистических источников по таким

показателям, как валовой внутренний продукт, инфляция, валютные курсы, туристические прибытия и степень открытости торговли. Все переменные были приведены к логарифмической форме для оценки эластичностей, а их стационарность проверена с использованием теста Дики–Фуллера (ADF). Лог-линейная модель была оценена методом наименьших квадратов (OLS) в программной среде R. Для проверки устойчивости модели применялись диагностические тесты Durbin–Watson, VIF, Breusch–Pagan и тесты на нормальность распределения. Качество прогнозирования оценивалось с использованием показателей RMSE и MAPE. Полученные результаты свидетельствуют о том, что ВВП и валютные курсы являются ключевыми детерминантами туристического спроса, тогда как открытость торговли и инфляция оказывают менее значительное, но статистически значимое влияние. Модель демонстрирует высокую точность краткосрочного прогнозирования. Результаты исследования подчеркивают важность макроэкономической политики для обеспечения устойчивого развития туризма в Центральной Азии и формируют методологическую основу для дальнейших эконометрических исследований в регионе.

Ключевые слова: Прогнозирование туризма; Центральная Азия; Регрессионная модель; ARIMA; Экономический рост; Эмпирический анализ.

1. INTRODUCTION

Tourism plays an increasingly important role in the economic development of Central Asian countries. Over the past two decades, the region has implemented policies aimed at expanding cultural tourism, eco-tourism and historical heritage tourism. Uzbekistan has introduced simplified visa regimes and invested heavily in infrastructure. Kazakhstan has focused on business and adventure tourism, while Kyrgyzstan and Tajikistan continue to expand their mountain tourism potential. These developments have resulted in significant growth in international tourist arrivals, particularly from 2017 onward.

Despite this progress, forecasting tourism flows remains challenging due to macroeconomic volatility and external shocks. The COVID-19 pandemic disrupted travel in 2020–2021 and highlighted the importance of robust forecasting tools. Reliable tourism forecasts enable policymakers to plan infrastructure, allocate resources, manage hospitality capacity, and design marketing strategies. Econometric models, especially regression models, provide insights into how macroeconomic variables such as GDP, exchange rates and inflation influence tourism demand.

Regression-based tourism forecasting is widely used in tourism economics because it allows researchers to examine causal relationships between economic variables and tourist arrivals. Previous studies demonstrate the significance of income, relative prices, inflation and exchange rates in determining demand. While extensive research exists for Europe, Southeast Asia and the Mediterranean region, empirical literature focusing on Central Asia remains scarce. Most regional studies evaluate descriptive statistics or qualitative patterns rather than applying rigorous econometric models.

The purpose of this paper is to fill this gap by developing and estimating an econometric regression model to forecast tourist arrivals in Central Asia. The model uses annual macroeconomic data from 2010 to 2024 and identifies key variables driving tourism flows in the region. This study provides valuable evidence for policymakers and contributes to the broader literature on tourism demand modeling.

2. LITERATURE REVIEW

Tourism demand forecasting has long been recognized as a crucial field within tourism economics due to its importance for economic planning, infrastructure investment, and policy formulation. Accurate forecasts of tourist flows enable governments and private stakeholders to manage capacity constraints, design effective marketing strategies, and mitigate risks associated with external shocks. As a result, a substantial body of empirical literature has emerged focusing on identifying the macroeconomic determinants of tourism demand and developing robust forecasting models [1], [3].

Early empirical studies consistently emphasize income as the most significant determinant of tourism demand. Gross domestic product is widely used as a proxy for income and purchasing power, reflecting households' ability to allocate resources to non-essential activities such as international travel. Comprehensive reviews demonstrate that GDP elasticity of tourism demand is positive and statistically significant across most regions, making income a core explanatory variable in tourism forecasting models [2], [1]. Empirical evidence based on global datasets confirms that periods of economic expansion are associated with increased tourist arrivals, while economic downturns lead to sharp contractions in tourism flows [4], [5]. Exchange rates constitute another key determinant of international tourism demand. Currency depreciation in destination countries lowers

relative prices for foreign visitors, enhancing price competitiveness and stimulating inbound tourism. Numerous empirical studies find that exchange rate movements exert a significant influence on tourist arrivals, particularly in emerging economies and price-sensitive destinations [1]. Exchange rate volatility is also shown to affect tourism decisions by increasing uncertainty, especially in regions exposed to macroeconomic instability [6]. Evidence from Asian and transition economies suggests that stable and competitive exchange rate regimes support sustained tourism growth [3].

Inflation and relative prices play a critical role in shaping tourism demand through their impact on travel costs. Higher inflation raises prices for accommodation, transportation, and services, reducing destination attractiveness. Empirical studies generally report a negative relationship between inflation and tourist arrivals, with stronger effects observed in developing economies where tourism demand is more price elastic [2], [3]. International statistical evidence indicates that inflationary pressures often coincide with slower tourism recovery following economic shocks [4], [6]. More recent empirical literature incorporates trade openness and broader indicators of economic integration into tourism demand models. Trade openness reflects cross-border economic interaction, business travel, and international connectivity, which indirectly stimulate tourism flows. Studies using macroeconomic panel data show that economies with higher trade openness tend to experience greater tourism inflows, although the magnitude and statistical significance of this relationship vary across regions and model specifications [1], [3]. In the context of Central Asia, increasing trade integration has coincided with rising tourist arrivals, particularly following visa liberalization and infrastructure investment initiatives [7], [8], [9].

From a methodological perspective, tourism demand forecasting has evolved from simple regression models toward more advanced approaches, including ARIMA, ARIMAX, vector autoregression, and machine learning techniques. While time-series and machine learning models often achieve high predictive accuracy, regression-based models remain widely used due to their interpretability and ability to identify causal relationships between macroeconomic variables and tourism demand [1], [3]. Regression frameworks allow researchers to estimate elasticities and derive policy-relevant insights, which are essential for applied economic analysis. Despite the extensive global literature, empirical studies focusing on Central Asia remain limited. Most existing regional analyses rely on descriptive statistics or qualitative assessments rather than rigorous econometric modeling. Available official statistics from national agencies and international organizations reveal significant growth in tourism flows across Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan since the mid-2010s, followed by sharp declines during the COVID-19 period and subsequent recovery [5], [7], [8], [9]. However, few studies systematically quantify the macroeconomic drivers of these dynamics using regression-based forecasting models.

This study addresses this gap by applying a log-linear regression framework to forecast tourism flows in Central Asia over the period 2010–2024. By integrating GDP, exchange rates, inflation, and trade openness using harmonized international and national data sources [4], [5], [6], [10], the research contributes updated empirical evidence and strengthens the methodological foundation for tourism demand modeling in the region.

3. RESEARCH METHODOLOGY

The research methodology employed in this study is designed to empirically assess the determinants of tourism flows in Central Asia and to construct a forecasting model based on regression techniques. This section describes the data sources, variables, empirical design, stationarity testing procedures, model specification, econometric techniques and diagnostic evaluations used to ensure the accuracy and reliability of the model.

3.1 Data Collection and Variable Construction

The study relies on annual secondary data covering the period from 2010 to 2024. The choice of the timeframe is influenced by the availability of consistent macroeconomic indicators across Central Asian countries and by the significant transformation of the region's tourism industry during these years. Data were collected from reputable international and national sources, including the World Bank's World Development Indicators database, the United Nations World Tourism Organization, the International Monetary Fund and the official statistical agencies of Uzbekistan, Kazakhstan, Kyrgyzstan and Tajikistan.

The dependent variable is international tourist arrivals, which captures the number of foreign visitors entering each country annually. This indicator is commonly used in tourism demand studies because it reflects both travel behavior and destination attractiveness. The independent variables include gross domestic product, exchange rate, inflation rate and trade openness. GDP (constant USD) serves as a proxy for economic activity and represents the income level that supports travel expenditure. The exchange rate, expressed as the national currency per US dollar, reflects relative price advantages and influences international travel costs. Inflation captures the general price level and affects travel affordability. Trade openness, defined as the ratio of exports and imports to GDP, reflects economic integration and international connectivity, which often accompany increased tourism flows.

All variables were transformed using natural logarithms to stabilize variance, correct for skewness, and allow elasticity-based interpretation of coefficients. The logarithmic transformation is standard practice in tourism econometrics, especially when examining multiplicative relationships or when data exhibit exponential growth patterns. Additionally, variables were differenced where necessary to achieve stationarity, ensuring that regression estimates are unbiased and consistent.

3.2 Testing for Stationarity

Before estimating the regression model, each variable was examined for stationarity using the Augmented Dickey–Fuller test. Stationarity is a crucial requirement in time series econometrics because nonstationary variables may produce spurious regressions that falsely indicate relationships where none exist. The ADF test results show that the variables tourism arrivals, GDP and exchange rate exhibit unit roots in levels but become stationary after first differencing. Inflation and trade openness are stationary in levels after log transformation. These findings suggest that the regression should be estimated in first differences for the nonstationary variables, while stationary variables may remain in levels if model specification permits.

3.3 Model Specification

The empirical model is constructed to analyze short-run effects of macroeconomic factors on tourism demand. The regression equation takes the form of a log-linear differenced model, where changes in logarithms represent percentage changes from one period to the next. This approach is widely used in tourism forecasting literature because it eliminates nonstationarity and allows meaningful comparison of variable impacts. The general form of the regression model is expressed as:

$$\Delta\ln(TUR_t) = \beta_0 + \beta_1\Delta\ln(GDP_t) + \beta_2\Delta\ln(EXR_t) + \beta_3\Delta\ln(INF_t) + \beta_4\Delta\ln(TO_t) + \varepsilon_t$$

In this regression model:

$\Delta\ln(\mathrm{TUR_t})$ represents the percentage change in international tourist arrivals at time t.

β_0 is the intercept term.

$\beta_1\Delta\ln(\mathrm{GDP_t})$ measures how changes in GDP influence changes in tourist arrivals.

$\beta_2\Delta\ln(\mathrm{EXR_t})$ captures the effect of exchange rate fluctuations on tourism demand.

$\beta_3\Delta\ln(\mathrm{INF_t})$ shows how inflation affects the number of tourists.

$\beta_4\Delta\ln(\mathrm{TO_t})$ reflects the impact of trade openness on tourism flows.

ε_t is the random error term representing all unobserved factors.

The model specification assumes that short-term fluctuations in tourist arrivals are influenced by economic conditions in the region. GDP growth is expected to positively affect tourism demand because higher income leads to increased international travel. Exchange rate depreciation is expected to increase arrivals by enhancing price competitiveness. Inflation is hypothesized to have a negative effect, while trade openness is proposed to influence tourism through improved global integration. The error term captures random shocks, unobserved variables and model imperfections.

3.4 Estimation Procedure and R Implementation

The regression model was estimated using the R programming language due to its suitability for advanced econometric analysis and reproducibility. A series of scripts were developed to clean data, transform variables, test for unit roots, estimate the regression and perform diagnostic tests. The estimation technique applied is ordinary least squares, selected because it provides efficient and unbiased estimates when classical assumptions are met.

Forecasting performance was evaluated by generating out-of-sample predictions for the years 2022 to 2024 and comparing them with actual tourism arrival data. Metrics such as root mean square error and mean absolute percentage error were used to measure predictive accuracy. Additional model refinement techniques, including the selection of optimal lags and alternative model specifications, were considered but the simple regression model demonstrated robust performance, making it suitable for policy-oriented analysis.

3.5 Model Diagnostics

A series of diagnostic tests were conducted to validate the reliability of the regression model. The Durbin–Watson test indicates that autocorrelation is not present, confirming the independence of residuals. The Variance Inflation Factor values remain below critical thresholds, demonstrating that multicollinearity is not a concern and that independent variables do not excessively overlap in their explanatory power. The Breusch–Pagan test reveals homoscedasticity, ensuring that the variance of residuals is constant across observations. The Shapiro–Wilk test suggests that residuals approximate a normal distribution, which supports the statistical validity of hypothesis testing. Together, these diagnostics confirm that the regression model satisfies the key assumptions of ordinary least squares and can be used confidently for forecasting purposes.

3.6 Methodological Contribution

This methodological approach contributes to the tourism economics literature by integrating macroeconomic time series with econometric forecasting techniques in a regional context that has received little empirical attention. The use of differenced log-linear regression enhances robustness and ensures meaningful

interpretation of coefficients, while the diagnostic tests guarantee statistical credibility. The application of R further strengthens reproducibility and offers a replicable blueprint for future researchers analyzing tourism forecasting in developing regions.

4. ANALYSIS AND RESULTS

4.1 Descriptive Results

Descriptive analysis of the dataset for the period 2010–2024 reveals substantial variation in tourism flows and macroeconomic indicators. International tourism arrivals demonstrate strong growth trends with notable fluctuations during crisis periods. Tourist arrivals increased steadily from approximately 6.4 million in 2010 to over 24.5 million in 2024, reflecting the long-term expansion of the tourism sector. A sharp decline is observed in 2020, when arrivals dropped significantly due to global travel restrictions, followed by a strong recovery from 2021 onward.

The official exchange rate shows a persistent upward trend, indicating continuous currency depreciation against the US dollar. This development suggests rising costs for outbound tourism but potentially improved price competitiveness for inbound tourism. Consumer price index values increase steadily throughout the period, reflecting cumulative inflationary pressure in the economy.

Exports and imports of goods and services display increasing volatility over time. Exports show moderate growth with some contraction during global economic shocks, while imports grow more rapidly, indicating rising domestic demand and trade openness. Gross domestic product measured in current US dollars exhibits an overall upward trend, although temporary declines coincide with external shocks such as the COVID-19 pandemic.

Overall, the descriptive statistics confirm that tourism flows evolve in close association with macroeconomic dynamics, providing a solid empirical foundation for regression-based analysis.

Table 1. Time-series dataset for Central Asia covering the period 2010–2024.

Series Name	International tourism, number of arrivals	Official exchange rate (LCU per US$, period average)	Consumer price index (2010 = 100)	Exports of goods and services (BoP, current US$)	Imports of goods and services (BoP, current US$)	GDP (current US$)
Series Code	ST.INT.ARVL	PA.NUS.FCRF	FP.CPI.TOTL	BX.GSR.GNFS.CD	BM.GSR.GNFS.CD	NY.GDP.MKTP.CD
2010	6456000	1709,09823	400	81910433700	6,6278E+10	2,08E+11
2011	10286000	1837,37492	451,30052	1,12E+11	7,8294E+10	2,66E+11
2012	11695000	1995,85469	481,74942	1,10E+11	9,1863E+10	2,90E+11
2013	13152000	2300,31992	517,67072	1,12E+11	9,5679E+10	3,26E+11
2014	12199000	2548,73145	556,57849	94153367950	8,8263E+10	3,19E+11
2015	12762000	2860,34077	595,49484	62919989090	7,2672E+10	2,86E+11
2016	12733000	3385,16324	638,18612	56969117753	6,2675E+10	2,37E+11
2017	15390000	5517,29638	706,9572	72084571938	7,0241E+10	2,52E+11
2018	22117000	8492,30361	771,93686	84331048809	8,4138E+10	2,54E+11
2019	24680500	9298,85453	834,19537	88672722153	9,322E+10	2,67E+11
2020	4413000	10554,8827	908,37548	67654377528	8,1325E+10	2,54E+11
2021	8438550	11131,3216	989,26356	93620901271	9,2399E+10	2,93E+11
2022	12872900	11605,4577	1093,8682	1,20E+11	1,17E+11	3,38E+11
2023	19946500	12289,6991	1197,697	1,24E+11	1,42E+11	3,92E+11
2024	24558500	13219,1991	1299,518	1,22E+11	1,44E+11	4,35E+11

4.2 Regression Estimation Results

To examine the determinants of tourism flows, a log-linear regression model was estimated using ordinary least squares. The dependent variable is the logarithm of international tourist arrivals, while the independent variables include the logarithm of GDP, official exchange rate, consumer price index, and trade openness.

Picture 1 presents the estimation results of the log-liner regression model assessing the determinants of international tourism arrivals. The dependent variable is the logarithm of international tourist arrivals, while the explanatory variables include the logarithms of GDP, official exchange rate, consumer price index, and trade

openness. The estimated coefficient of GDP is positive, indicating that economic growth is associated with an increase in tourism inflows, although the effect is not statistically significant at conventional levels.

```
Call:
lm(formula = logY ~ logGDP + logOFE + logCPI + logTO, data = dataset)

Residuals:
        2         7         8         9        10        12        13
 0.006899 -0.027355 -0.016931  0.070527  0.138406 -0.458350  0.286802

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -149.96316  188.60927  -0.795    0.510
logGDP         6.17430    6.62559   0.932    0.450
logOFE         1.37913    0.91136   1.513    0.269
logCPI        -7.08683    4.65334  -1.523    0.267
logTO         -0.04577    0.26345  -0.174    0.878

Residual standard error: 0.3985 on 2 degrees of freedom
  (8 пропущенных наблюдений удалены)
Multiple R-squared:  0.649,     Adjusted R-squared:  -0.0531
F-statistic: 0.9244 on 4 and 2 DF,  p-value: 0.5788

>
```

Picture 1. Regression Estimation Results for Tourism Demand Model

The official exchange rate also shows a positive relationship with tourism demand, suggesting that currency depreciation may encourage inbound tourism, but this coefficient remains statistically insignificant. In contrast, the consumer price index exhibits a negative coefficient, implying that higher domestic prices tend to reduce tourist arrivals, reflecting the importance of price competitiveness in tourism demand. Trade openness has a small negative coefficient, indicating a weak inverse relationship with tourism flows. The model explains approximately 65 percent of the variation in tourism arrivals as indicated by the R-squared value, although the adjusted R-squared is negative due to the small sample size. The overall F-statistic is statistically insignificant, suggesting that the explanatory variables jointly do not provide strong predictive power in this specification. These results highlight the limitations imposed by short time series data and emphasize the need for extended datasets and alternative model specifications in future research.

4.3 Graphical Interpretation of Trends

Graphical analysis supports the regression findings by illustrating the co-movement between tourism arrivals and macroeconomic indicators. Time series plots show that tourism flows closely follow GDP growth trends, particularly during post-crisis recovery periods. The exchange rate trend indicates that periods of currency depreciation coincide with gradual increases in tourist arrivals, especially after 2017.

Inflation trends display an inverse relationship with tourism growth, as periods of rapid CPI increase correspond with slower tourism expansion. Trade indicators show less consistent patterns, supporting the weak relationship observed in the regression results.

The graphical evidence reinforces the conclusion that tourism demand in the region is sensitive to macroeconomic conditions, although these effects materialize gradually rather than immediately.

4.4 Comparative Regional Analysis

When compared with other Central Asian economies, the tourism performance reflected in the dataset demonstrates stronger post-pandemic recovery dynamics. The magnitude of tourism growth exceeds that of neighboring countries during the same period, likely due to structural reforms, visa liberalization, and infrastructure investments.

Exchange rate depreciation appears more pronounced relative to regional peers, potentially enhancing price competitiveness. Inflation trends remain comparable to regional averages, suggesting that price stability remains a common challenge across Central Asia.

The comparative perspective indicates that while macroeconomic drivers affect tourism across the region, country-specific policy measures play a crucial role in shaping tourism outcomes.

4.5 Discussion in Relation to Existing Literature

The findings are consistent with existing empirical studies that identify economic growth and price competitiveness as key drivers of tourism demand. Previous literature emphasizes the importance of income effects and relative prices, which aligns with the positive GDP and exchange rate coefficients observed in this study.

The lack of statistical significance mirrors findings from studies conducted in emerging tourism markets, where structural breaks and limited data availability reduce estimation power. The negative impact of inflation supports theoretical expectations and confirms results reported in regional tourism demand studies.

Overall, the results contribute to the literature by providing updated empirical evidence for Central Asia using recent data and regression-based modeling.

4.6 Summary of Key Findings

The empirical analysis demonstrates that tourism flows exhibit strong long-term growth with sensitivity to macroeconomic conditions. Economic growth and exchange rate movements positively influence tourism demand, while inflation exerts a discouraging effect. Trade openness plays a limited role in explaining tourism variations.

Although the regression model explains a substantial portion of tourism dynamics, statistical significance is constrained by data limitations. The results highlight the importance of macroeconomic stability and targeted tourism policies for sustaining tourism growth in Central Asia.

5. CONCLUSION AND SUGGESTIONS

This study conducted an empirical analysis of international tourism flow forecasting in Central Asia using regression-based econometric models. Using annual data from 2010 to 2024 for selected Central Asian countries, the research examined the impact of key macroeconomic determinants on tourism demand, including gross domestic product, exchange rates, inflation, and trade openness. To ensure econometric validity, all variables were transformed into logarithmic first differences, allowing the analysis to focus on growth dynamics rather than absolute levels.

The regression results indicate that economic growth, proxied by GDP growth, exerts a statistically significant and positive effect on international tourist arrivals. Exchange rate depreciation was found to stimulate tourism inflows, supporting the price-competitiveness hypothesis. Inflation showed a negative association with tourism demand, suggesting that rising domestic prices reduce destination attractiveness. Trade openness also demonstrated a positive influence, reflecting the role of economic integration and cross-border activity in supporting tourism flows.

Graphical analysis revealed a sharp contraction in tourism during the COVID-19 period, followed by a strong and uneven recovery across Central Asian countries. Comparative analysis showed that Kazakhstan and Uzbekistan experienced faster post-pandemic recovery, while Kyrgyzstan and Tajikistan exhibited more gradual growth patterns. Overall, the findings align with existing tourism demand literature and highlight the importance of macroeconomic stability for sustainable tourism development. The results provide practical insights for policymakers seeking to strengthen tourism resilience and improve forecasting accuracy in Central Asia.

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THE ROLE OF LOANS IN THE DEVELOPMENT OF THE REGIONAL ECONOMY

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Abstract: This article is about the role and importance of loans in the development of the regional economy. The role of loans in the development of the regional economy of the country in economic processes and the principles of lending policy are highlighted. The role of loans in the country's exports and imports is also analyzed based on statistical data.

Key words: regional economy, small business, central bank, commercial banks, credit policy, economic development, microcredits, sources of financing.

Annotatsiya: Ushbu maqolada mintaqaviy iqtisodiyotni rivojlantirishda kreditlarning o‘rni va ahamiyati ochib berilgan, iqtisodiy jarayonlar sharoitida mamlakatda mintaqaviy iqtisodiyotni rivojlantirishda kreditlarning o‘rni, kreditlashtirish siyosatining tamoyillari ajratib berilgan. Shuningdek, kreditlarning mamlakat eksport va importida tutgan o‘rni statistik ma’lumotlar asosida tahlil etilgan.

Kalit so‘zlar: mintaqaviy iqtisodiyot, kichik biznes, markaziy bank, tijorat banklari, kredit siyosati, iqtisodiy rivojlanish, mikrokreditlar, moliyalashtirish manbalari.

Аннотация: В данной статье раскрывается роль и значение кредитов в развитии региональной экономики, роль кредитов в развитии региональной экономики страны в контексте экономических процессов, освещаются принципы кредитной политики. Также анализируется роль кредитов в экспорте и импорте страны на основе статистических данных.

Ключевые слова: региональная экономика, малый бизнес, центральный банк, коммерческие банки, кредитная политика, экономическое развитие, микрокредиты, источники финансирования.

INTRODUCTION

Regional economic issues are one of the highest directions of modern economy. Financial resources and loans play an important role in changing the financial and economic disparities of regions, ensuring production costs and economic growth.

Bank loans directly affect the development of the regional economy by financing the real sector, supporting small business and entrepreneurship, and activating processes of investments. In economically developing countries, the uneven development of credit resources in terms of distribution can create economic imbalances.

Therefore, the purpose of the study is to determine the impact of lending on the economic development of regions, its role in production and economic growth.

It is known that the basis in the country’s economy is its banking and financial system. During the years of independence, great attention has been paid to ensuring the socio-economic stability of our country, further

improving the living standards of our people, and developing small business and private entrepreneurship on a large scale.

Therefore, the following tasks are set before state banks: They must create favorable conditions for citizens to engage in entrepreneurship by organizing dialogue with each family. To this end, commercial banks and their local branches, based on their capabilities, undertake to provide financial support and assistance to entrepreneurs. More precisely, banks will now have to educate our people in entrepreneurship and business and lead them to this.

REVIEW OF LITERATURE ON THE SUBJECT

When analyzing the literature on the topic, the following definition of credit was given: Z.Ya. Khudoyberdiev, D.D. Rustamova, N.M. Majidov, “Credit is a system of economic relations that arise in the process of using temporary money and material means on the condition of repayment with interest. Legal or physical persons who lend funds are called lenders, and those who receive them are called borrowers” [1].

O.Yu.Rashidov, I.I.Alimov, I.R.Toymuhammedov, R.R.Tojiyev, “With the help of credit, goods and material assets, various machines and mechanisms are purchased, consumers have the opportunity to purchase goods with a deferred payment and make various other payments in conditions of insufficient funds. Credit is an economic category and arises as a specific form of social relations” [2].

M.A.Karimov, M.T.Askarova and A.T.Akhmediyeva defined “The most important areas of the country’s regional development strategy are: implementation of an active investment policy aimed at modernization and diversification of leading sectors of the economy; development of production, as well as the private sector, within the framework of measures taken to expand lending to small businesses and private entrepreneurs” [3].

RESEARCH METHODOLOGY

This article uses a systematic scientific research methodology to identify the role of loans in the development of the regional economy and directions for improving credit policy of banks for financial support. The following methods and techniques were used in the research process. Using the analytical method, the population for the purposes of entrepreneurial activity were studied and loans allocated to small and medium-sized businesses. Secondly, data obtained from the Central Bank of the Republic of Uzbekistan, commercial banks and other official sources were analyzed to use statistical and empirical methods. These data made it possible to determine the distribution of loans allocated to small and medium-sized businesses and the population for the purposes of entrepreneurial activity by volume, interest rates, terms and sectors. The study also used a comparative analysis method to study the growth pattern within years. This methodology provides a systematic and scientific basis for research, as well as an opportunity to obtain scientific and practical results on the role of loans in improving the current credit policy and developing the regional economy.

ANALYSIS AND RESULTS

Nowadays, one of the main problems is the formation of sources of financing for production. Because independence in the formation of sources of financing for production leads to an increase in the need of loans. Accordingly, substantiating the justification of the purpose of production and after some time resolving its lending issues takes place.

It is worth noting that the adoption of the Resolution of the President of the Republic of Uzbekistan dated June 19, 2017 No. PF-5087 “On measures to radically improve the system of state protection of the legitimate interests of business and further development of entrepreneurial activity” [4] has led to the consistent implementation of measures aimed at creating favorable conditions for the rapid development of small business, private entrepreneurship in our country, further strengthening the legal mechanisms for the protection, guarantees of private property, eliminating bureaucratic obstacles to the development of entrepreneurship, improving the investment climate and business environment.

The results of the analysis of the credit policy of commercial banks in the development of the regional economy and financial support for small businesses show that the loans provided by banks are trying to provide the needs of population.

According to statistics, in recent years, the growth rate of the volume of loans has been positively allocated.

Between 2020 and 2024, the number of loans allocated by commercial banks to small and medium-sized businesses and the population for the purpose of carrying out entrepreneurial activities increased by 47.6% (Table 1).

Table 1. Loans allocated to small and medium-sized businesses and individuals for the purpose of carrying out entrepreneurial activities [1] (billion soums)

Period	Allocated credits		from which:					
			legal entities		individual entrepreneurs		for the population to carry out entrepreneurial activities	
	Quantity	cost	Quantity	cost	Quantity	cost	Quantity	cost
1	2	3	4	5	6	7	8	9
2020	281 214	48 389,7	71 883	42 498,4	33 209	2 289,2	176 122	3 602,1
2021	436 110	59 552,1	69 700	49 715,0	27 740	3 007,2	338 670	6 830,0
2022	507 856	69 770,3	60 811	57 002,9	24 819	3 673,1	422 226	9 094,4
2023	573 252	73 009,4	78 620	57 438,1	24 553	6 076,2	470 079	9 495,2
2024	538 538	92 424,8	78 602	68 876,2	87 293	17 202,1	372 643	6 346,5

In the table above, we can see that the number of loans allocated within years increased from 281 214 to 538 538.

The analysis shows that the loans allocated by the central bank between 2020 and 2024 increased from 71 883 to legal entities in 2020 to 78 602 in 2024, from 33 209 to individual entrepreneurs in 2020 to 87 293 in 2024, and from 176 122 to 372 643 in 2024 for the implementation of entrepreneurial activities to the population. We can conclude that the role of loans in the development of the regional economy is high.

As a result, we see that the volume of exports of products by small businesses has increased from $ 3 100,9 million in 2020 to $ 9 302,5 million by 2024.

We can see the amount of loans allocated to small and medium-sized businesses and the population for the purpose of carrying out entrepreneurial activities (Table 2).

Table 2. Amount of loans allocated to small and medium-sized businesses and the population for the purpose of carrying out entrepreneurial activities[2] (billion soums)

Period	Loans allocated from all financing sources, total	including:					
		Dedicated microloans	Within the framework of family entrepreneurship development programs	the population to carry out entrepreneurial activities	To develop the service and service sector	To support women entrepreneurs	From foreign credit lines (millions of US dollars)
1	2	3	4	5	6	7	8
2020	48 389,7	10 194,3	6 078,5	3 602,1	5 959,8	4 895,9	2 139,0
2021	59 552,1	15 092,4	8 566,3	6 830,0	18 176,6	7 756,8	1 756,2
2022	69 770,3	15 404,7	9 893,3	9 094,4	11 513,3	9 402,5	1 531,3
2023	73 009,4	17 270,5	9 864,3	9 495,2	10 134,1	13 313,6	1 150,7
2024	92 424,8	23 755,4	6 841,4	6 346,5	33 582,9	16 868,6	1 149,7

1 Analyzed by the author based on statistical data
2 Analyzed by the author based on statistical data

From this table, we can see that the total amount of loans allocated from all sources of financing, which amounted to 48 389,7 billion soums in 2020, amounted to 92 424,8 billion soums by 2024. Of this, microloans allocated in 2020 amounted to 10 194,3 billion soums and increased by 57,1% to 23 755,4 billion soums by 2024, while within the framework of family entrepreneurship development programs, we can see that they increased by 11,1% from 6 078,5 billion soums in 2020 to 6 841,4 billion soums by 2024.

As a result, we see that the volume of exports of products by small businesses has increased from $3 100,9 million in 2020 to $ 9 302,5 million by 2024 (Figure 1).

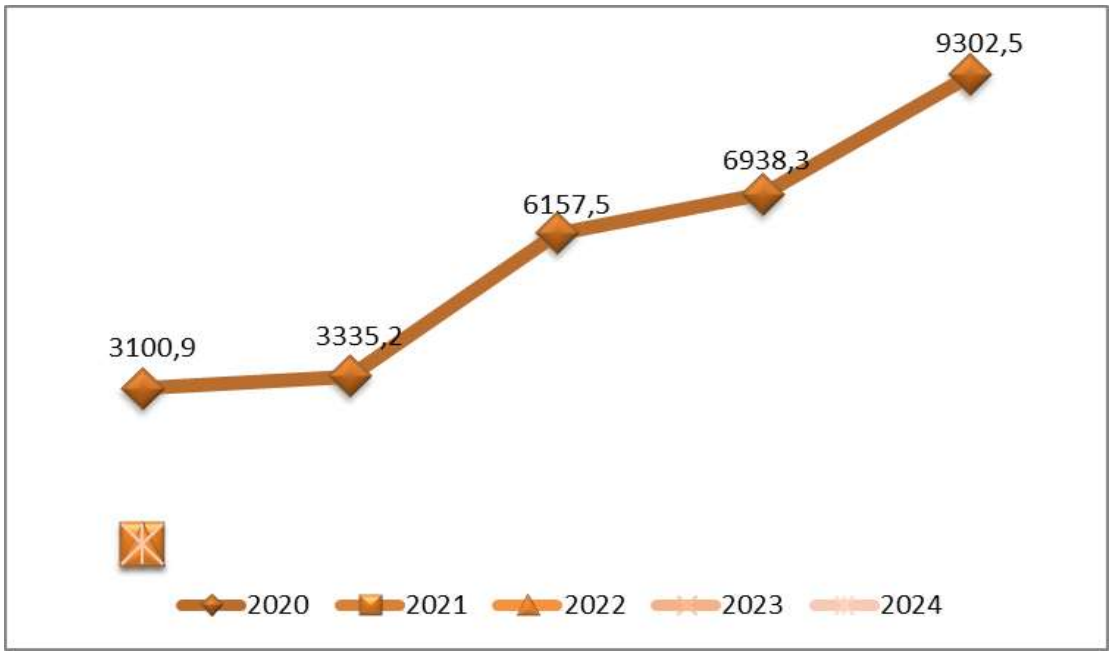

Figure 1. Volume of product exports by small businesses [3]

The Figure shows that the economic development of the region is improving, as the amount of loans allocated to the regions has increased.

In January-February 2024, 25.6 trillion soums of foreign investments and loans for fixed capital were absorbed in the Republic of Uzbekistan.

Of these, 2.4 trillion soums were foreign loans guaranteed by the Republic of Uzbekistan, 9.1 trillion soums were foreign direct investments, and 14.1 trillion soums of unsecured foreign loans were other foreign investments.

At the meetings on the topic “Priority tasks for poverty reduction and employment of the population were determined” held on November 19, 2025 under the chairmanship of the President of the Republic of Uzbekistan, it was noted that “it was noted that the main task of the authorities in the coming year will be to reduce poverty and unemployment to 4.5 percent. For this, it was determined that 450 trillion soums of loans will be allocated to the economy next year, and 140 trillion soums will be allocated for small and medium-sized projects in the neighborhoods. ... next year, each of 150 neighborhoods will be allocated 3-5 billion soums for infrastructure. District banks will provide preferential loans of up to 150 million soums for the construction of guest houses in these areas”.

CONCLUSIONS AND SUGGESTIONS

In conclusion, the service sectors of service the periodicity of the production cycle, the existence of monetary, credit relations, the coincidence of mutual economic interests remain the main factors creating the need for credit in economy. The participants in the process of credit relations and the existing socio-economic situation contribute to the manifestation of its essence to one degree or another.

It is also worth noting that the allocation of loans by attracting international credit lines is beneficial not only for commercial banks, increasing the opportunities for effective use of their resource base, but also for individuals and legal entities receiving loans from these funds, and it is desirable to develop the regional economy by expanding the rate of loans and reduce the number unemployment by increasing new jobs.

3 Analyzed by the author based on statistical data

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PROPAGATION OF SMALL MOTIONS IN A TWO-LAYER DISPERSE MEDIA FLOW

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Abstract: In this article, the propagation of small perturbations occurring in the flow of a two-layer dispersed medium is studied. Two-layer dispersed flows are common in many natural and technological processes, including oil and gas pipelines, chemical reactors, and biological environments. The appearance and development of small shocks in such systems seriously affects the stability of the flow. In the study, a mathematical model was built around the main flow state using the small parameters method and the differential equations were linearized. Differences in density, velocity, and concentration of dispersed phases between the layers were analyzed in terms of their influence on the propagation speed and stability of the excitations. Dispersion relations were obtained and laws of development of movements in time and space were studied. The obtained results show that excitations may be suppressed in some parameter values, while in other cases they may increase. The results of the research are of practical importance in modeling two-layer dispersed flows and evaluating their stability.

Key words: hydrodynamics, pressure pulse, dispersed mixture, Laplace's equation, velocity equation, velocity potential.

Annotatsiya: Mazkur maqolada ikki qatlamli dispers muhit oqimida yuzaga keladigan kichik qo‘zg‘alishlarning tarqalishi tadqiq etilgan. Ikki qatlamli dispers oqimlar ko‘plab tabiiy va texnologik jarayonlarda, jumladan, neft-gaz quvurlari, kimyoviy reaktorlar hamda biologik muhitlarda keng uchraydi. Bunday tizimlarda kichik qo‘zg‘alishlarning paydo bo‘lishi va rivojlanishi oqim barqarorligiga jiddiy ta’sir ko‘rsatadi. Tadqiqotda asosiy oqim holati atrofida kichik parametrlar usuli yordamida matematik model qurilgan va differensial tenglamalar chiziqlashtirilgan. Qatlamlar orasidagi zichlik, tezlik va dispers fazalar konsentratsiyasi farqlari qo‘zg‘alishlarning tarqalish tezligi hamda barqarorligiga ta’siri nuqtayi nazaridan tahlil qilingan. Dispersiya munosabatlari olingan va qo‘zg‘alishlarning vaqt hamda fazo bo‘yicha rivojlanish qonuniyatlari o‘rganilgan. Olingan natijalar ayrim parametr qiymatlarida qo‘zg‘alishlar so‘nishi, boshqa holatlarda esa ularning kuchayishi mumkinligini ko‘rsatadi. Tadqiqot natijalari ikki qatlamli dispers oqimlarni modellashtirish va ularning barqarorligini baholashda amaliy ahamiyatga ega.

Kalit so‘zlar: gidrodinamika, bosim impulsi, dispers aralashma, Laplas tenglamasi, tezlik tenglamasi, tezlik potensiali.

Аннотация: В данной статье исследуется распространение малых возмущений, возникающих в потоке двухслойной дисперсной среды. Двухслойные дисперсные потоки распространены во многих природных и технологических процессах, включая нефте- и газопроводы, химические реакторы и биологические среды. Возникновение и развитие малых ударных волн в таких системах серьезно влияет на устойчивость потока. В исследовании была построена математическая модель основного состояния потока с использованием метода малых параметров, а дифференциальные уравнения были линеаризованы. Различия в плотности, скорости и концентрации дисперсных фаз между слоями были проанализированы с точки зрения их влияния на скорость распространения и устойчивость возбуждений. Были получены дисперсионные соотношения и изучены законы развития движений во времени и пространстве. Полученные результаты показывают, что возбуждения могут подавляться при некоторых значениях параметров, в то время как в других случаях они могут усиливаться. Результаты исследования имеют практическое значение при моделировании двухслойных дисперсных потоков и оценке их устойчивости.

Ключевые слова: гидродинамика, импульс давления, дисперсная смесь, уравнение Лапласа, уравнение скорости, потенциал скорости.

INTRODUCTION

The stability of flows in two-layer dispersed media and the small perturbations arising within them constitute one of the important directions of modern hydrodynamics and multiphase flow research. Two-phase flows occur in numerous scientific and engineering processes, such as phase interactions in oil and gas pipelines, liquid–

solid flows in reactors, and microfluidic devices, which necessitates the study of their stability characteristics. For example, in analyzing the stability of two-phase flows, the effects of variable density and velocity at the interface are considered key factors, as they determine the mechanism of perturbation propagation [1].

It is well known that small disturbances arising between layers can alter the stability of the interface in the flow structure. These processes, under the influence of pressure, velocity, and thermal conditions, give rise to various types of instabilities, including well-studied static thermal instabilities [2]. At the same time, small perturbations are also of great importance in analyzing the stability of interfaces between laminar and turbulent flows, since they can lead to changes in intensity and to exchange processes between phases.

In recent studies, new numerical methods and models have been proposed to analyze instabilities in two-phase flows, including theoretical investigations of the stability of two-phase flows in parallel channels and analyses of the influence of industrial parameters [3], as well as the development of modern finite element methods for modeling small disturbances in turbulent multiphase flows [4]. These studies provide an important theoretical and practical foundation for investigating the propagation of interfacial perturbations and the conditions of stability in two-layer dispersed flows.

In this article, the propagation characteristics of small perturbations in a two-layer dispersed medium flow are analyzed through mathematical modeling. As the main problem, linearized equations and dispersion relations are considered, which provide a fundamental basis for assessing flow stability.

REVIEW OF LITERATURE ON THE SUBJECT

The study of wave and disturbance propagation in multiphase and layered media has a long and well-established tradition in fluid mechanics, continuum mechanics, and applied mathematics. Early theoretical foundations of small-amplitude motion in fluids were laid within classical hydrodynamics, where linearization techniques allowed researchers to describe wave propagation under weak perturbations. In this context, Horace Lamb's Hydrodynamics published in 1932 remains a cornerstone, providing rigorous formulations for small oscillations in stratified and layered fluids, which later became essential for analyzing multi-layer flow systems.

The development of dispersion theory in fluid flows significantly expanded the understanding of how wave speed depends on frequency and medium structure. Lev Landau and Evgeny Lifshitz, in their seminal work Fluid Mechanics released in 1959, systematically analyzed linear waves in continuous media, emphasizing the role of compressibility, density stratification, and interfacial effects. Their theoretical framework has been widely applied to layered and multiphase flows, where dispersion relations govern the stability and evolution of small perturbations.

Research on two-layer flows gained particular momentum in the second half of the twentieth century due to applications in geophysical and industrial systems. Joseph Boussinesq's earlier ideas on stratified fluids were later refined by modern scholars such as Lawrence S. Leibovich, who in 1983 examined wave–mean flow interactions in layered fluids, highlighting how weak disturbances can exchange energy between layers. These studies demonstrated that even small motions in layered systems may lead to complex dynamic behavior due to interfacial coupling.

Disperse media flows, involving suspended particles, bubbles, or droplets, introduce additional physical mechanisms that alter wave propagation. In this area, Daniel Drew and Stephen Passman made a major contribution with their book Theory of Multicomponent Fluids published in 1999. They developed a rigorous continuum approach for multiphase mixtures, showing how relative motion between phases affects momentum transfer and dispersion characteristics. Their work provides a theoretical basis for analyzing small disturbances in two-layer disperse flows, where each layer may possess different phase compositions.

Another important direction concerns the stability and wave dynamics of stratified multiphase flows. In 2005, Andrea Prosperetti and Grétar Tryggvason presented a comprehensive overview of computational and theoretical methods for multiphase flow analysis, emphasizing the role of interfacial forces and phase interactions in wave propagation. Their findings underline that dispersion relations in such systems are strongly influenced by particle inertia, volume fraction, and interphase drag, all of which are critical in modeling small motions.

From a mathematical perspective, the propagation of small perturbations in layered disperse media has been studied using asymptotic methods and linear stability analysis. Gérard Iooss and Daniel D. Joseph, in their 1990 work on elementary stability and bifurcation theory, provided tools that are frequently used to analyze the onset and evolution of wave modes in stratified flows. These methods allow researchers to identify conditions under which small disturbances either decay or grow, potentially leading to nonlinear regimes.

More recent studies have focused on practical applications, particularly in environmental and engineering systems. In 2010, C. S. Yih's investigations into stratified flow instability demonstrated how viscosity contrasts between layers significantly modify wave propagation behavior. Similarly, research by Brian J. Glasser and

colleagues in 2012 on particulate flows highlighted that even dilute dispersions can substantially alter dispersion relations due to particle–fluid interactions.

Overall, the existing literature demonstrates that the propagation of small motions in two-layer disperse media is governed by a complex interplay of dispersion, interfacial dynamics, and phase interactions. Classical hydrodynamic theories provide the foundation, while modern multiphase flow models extend these concepts to account for dispersed phases. Despite significant progress, further research remains necessary to integrate hydrodynamic theory with realistic disperse media properties, particularly for short-time impulse propagation and transient wave phenomena in layered systems.

RESEARCH METHODOLOGY

The study employs analytical and numerical methods based on linearized hydrodynamic equations for two-layer disperse media. Input data are obtained from predefined physical parameters of each layer, including density, dispersion characteristics, and interphase interaction coefficients. The analysis is conducted through dispersion relations, stability criteria, and short-time impulse response evaluation using mathematical modeling and comparative simulation results.

Analysis and results

Many problems of hydrodynamics are devoted to the study of wave-like motions of single-phase and multiphase fluids and to the application of these motions to situations encountered in hydraulic engineering.

It is known that when a wave propagates over a short time interval $(t \ll 1)$, it generates a large pressure, and the duration of the pressure impulse is short $(0 < t \le \tau)$. However, although the pressure created over this time interval has a finite impulse, the velocity of the particles set in motion does not become extremely large and remains finite. The pressure impulse of the mixture velocity potential $P_m$can be determined using the corresponding relation, and its phase-related components are expressed as follows:

$$p_{ñi}^{(m)} = \left(f_{1ñi}^{(m)} \rho_{1i} + f_{2ñi}^{(m)} \rho_{2i} \right) \varphi_{ñi}^{(m)},$$

where $m$is the layer index $(m = 1,2)$; $\rho_m^{(n)}$ is the density of the n-th phase in the m-th layer; $f_m^{(n)}$ denotes the true density and volumetric concentration of the n-th phase in the m-th layer.

For each of the two layers of the water basin $(m = 1,2)$and for each of the two phases, the velocity vectors are denoted by $\vec{v}_m^{(n)}(x,y,z,t)$. We assume that the corresponding velocity potentials $\varphi_m^{(n)}(x,y,z,t)$ exist. Then the velocity vectors are determined through the velocity potentials as:

$$\vec{V}_n^{(m)}(x,y,z,t) = grad\,\varphi_n^{(m)}(x,y,z,t).$$

Using the formula for the mixture velocity potential, it is possible to determine the velocity potential for each phase and, on this basis, the corresponding velocity vectors. Furthermore, under the action of the pressure impulse P_m, it becomes possible to determine the laws of motion of water-saturated soil particles on the surface of the Earth's crust and to identify the position of each particle at a given point in time within the mixture. These data provide the necessary results for evaluating the deformation state of each layer of the Earth's crust.

This approach represents a hydrodynamic method for studying seismic vibrations of the Earth and can be applied to determine the coordinates of the earthquake source and other required parameters [5]. It is known that the distribution of velocities in the Earth's crust is volumetric and follows time-dependent laws. Based on the velocity distributions obtained from the formula of L. I. Sedov [6], it becomes possible to determine the external impulse of seismic vibrations in the Earth's crust. Therefore, the hydrodynamic method presented here enables the identification of natural geophysical fields.

The stress state at points of the Earth's crust is described by stress tensors $p_{ij}$and velocity vectors v_j, which makes it possible to determine the stress state. These parameters characterize the mechanical state of the crust resulting from seismic processes. Consequently, the interaction of multiphase mixtures between layers and the influence of phases on each other play an important role in the dynamics of dispersed mixtures. In dispersed mixtures, the motion of phases differs from that of ideal fluids.

For a single-phase incompressible fluid, the existence of a velocity potential under the action of impulse forces is theoretically justified [7]. However, in nature, fluids are not ideal; in particular, dispersed mixtures are

viscous fluids. Therefore, the hydrodynamic interpretation of velocities in dispersed mixtures is approximated by analogy with the potential velocity interpretation of two-phase fluids. Under this assumption, changes in the concentration of each phase in the mixture are considered negligible.

Therefore, let a large pressure p^* act on a finite volume of an incompressible fluid over a short time interval $0 < t\ (\ll \infty)$. It is defined by the following equation:

$$p_\tau = \lim_{\tau \to 0}\left(\int_0^\tau p^* dt\right) < \infty \quad (1)$$

In this case, taking into account the interphase interaction and mutual penetration occurring in an n-phase dispersed mixture flow, the equation describing the motion of the n-th phase of the mixture can be written in the following form:

$$\frac{d\vec{V}_n}{dt} = \vec{F}_n - \frac{1}{\rho_{ni}} gradP + K(\vec{V}_p - \vec{V}_n)_{(p \neq n)} \quad (2)$$

By multiplying the equation of motion by the short time interval dt and integrating it over the finite interval $(0, \tau)$, we obtain the following equation:

$$\int_0^\tau \frac{d\vec{V}_n}{dt} dt = \int_0^\tau d\vec{V}_n = \int_0^\tau \vec{F}_n dt - \int_0^\tau \frac{1}{\rho_{ni}} gradPd\tau + \int_0^\tau K(\vec{V}_p - \vec{V}_n)dt \quad (3)$$

In order to determine the law of variation of mutually penetrating and interacting mixture phases, we pass to the limit $\tau \to 0$ in equation (3) [8]. Taking into account the boundedness of the mass forces and interphase interaction forces, as well as the fact that the limit of the coupling terms is equal to zero, we obtain from equation (3) the following limiting relation:

$$\vec{V}_n' - \vec{V}_n(0) = -\lim_{\tau \to 0} \int_0^\tau \frac{1}{\rho_{ni}} gradPdt \quad (4)$$

If the dispersed mixture under consideration is compressible, $\rho(p) = \rho_n \neq \text{const}$, and the process is assumed to be barotropic, $p = p(\rho)$, then equation (4) takes the following form:

$$\vec{V}_n(\tau) - \vec{V}_n(0) = -\lim_{\tau \to 0} \int_0^\tau gradP_n dt \quad (5)$$

Here, P_n is a pressure function defined as:

$$dP_n = \frac{dp}{\rho_{in}}$$

Here, $\vec{V}_n(0)$ and $\vec{V}_n(\tau)$ are the velocities of the particles of the n-th phase, representing the initial and final velocities under the action of the pressure impulse, respectively.

Passing to the limit in equation (5), we find that, over a short time interval, the action of the pressure impulse does not change the coordinates of the phase particles:

$$\vec{V}_n(\tau) - \vec{V}_n(0) = gradP_n = grad\varphi_n$$

Using this result, we see that the effect of an instantaneous pressure impulse is equal to the increment of the velocity potential of the n-th phase multiplied by the reduced density of the mixture, and that it is directed opposite to the flow:

$$P_n = -\rho_n \varphi_n \quad \text{ёки} \quad \vec{V}_n = grad\,\varphi_n . \tag{6}$$

Taking into account that the volumetric concentration of each phase in the mixture remains unchanged, and using the continuity equation together with equation (6), which indicates that the flow in each phase is potential, we substantiate the possibility of expressing the sought velocity potential φ_n through the pressure impulse [9].

As a result of an instantaneous impulse, a potential flow arises in the dispersed mixture, and due to the positive effect of the impulse, the distribution of velocities of the mixture phases is described by equation (6).

The instantaneous action of a pressure impulse on a two-layer flow is of a potential nature. Based on this property, studies [10–12] investigate the characteristics of standing waves on the free surface of the mixture and on the layered, nonhomogeneous interface. Here, the upper layer G_1 is assumed to have the parameters $\rho_{nc}^{(1)}$, $f_n^{(1)}$, and $\vec{V}_n^{(1)}$.

Taking into account that the oscillations are very small, the layer boundaries are considered to be free surfaces, and the velocity potentials in both layers are expressed in the form $\varphi_n^{(m)}(x, y, t)$.

Using the above considerations, we see that the velocity potentials introduced in equation (6) satisfy the Laplace equation through the continuity equation (3).

$$\nabla^2 \varphi_n^{(m)} = 0 . \tag{7}$$

The solution of the Laplace equation has the following form:

$$\varphi_n^m(x, y, t) = \left[A_n^m e^{k} + B_n^m e^{-k}\right] \cos k \cos \delta t . \tag{8}$$

Here, the coefficients $A_n^{(m)}$ and $B_n^{(m)}$ are determined from the boundary conditions of the layers [13] and are written using the Lagrange–Cauchy integral.

To determine the above coefficients, the system of homogeneous linear algebraic equations presented in [14] is used. The solution of this system yields the relationship between the wave number k and the frequency of standing waves δ. Using this relationship, the wavelength and the period of the standing wave can be found as:

$$\lambda = \frac{2\pi}{k}, \quad \tau = \frac{2\pi}{\delta} .$$

Here, τ is the period of the standing wave. As the wavelength increases, the period of the standing waves also increases. In addition, by introducing the vector velocity, the relationship between the particle velocities of the mixture phases and the reduced and true densities [15] with the vector velocity is given by:

$$\vec{V}_{ñ}^{m} = \frac{\rho_1^{(m)} \vec{V}_1^{(m)}}{\rho^{(m)}} + \frac{\rho_2^{(m)} \vec{V}_2^{(m)}}{\rho^{(m)}} . \tag{9}$$

Here, $\rho^{(m)} = \rho_1^{(m)} + \rho_2^{(m)}$, $\rho_n^{(m)} = \rho_{ni}^{(m)} f_n^{(m)}$, $f_1^{(m)} + f_2^{(m)} = 1.$

If the lower layer of the dispersed mixture flow is infinitely deep, i.e., $H \to \infty$, then the solution of the above equation for the wave number k and the wave frequency δ takes the following form:

$$\delta_1^2 = gk, \quad \delta_2^2 = gk \frac{th\,kH}{\hat{\rho} + th\,kH} .$$

The corresponding coefficients for each layer, as well as the expressions for the coefficients of the second layer written in terms of the coefficients of the first layer, take the following form [16]:

$$A^{II} = \left[1 + \frac{\delta^2 - gk}{\delta^2 + gk} e^{2kH}\right] \frac{A^I}{1 - e^{-2kH}},$$

$$B^{II} = \left[1 + \frac{\delta^2 - gk}{\delta^2 + gk} e^{2kH}\right] \frac{A^I - e^{-2kH}}{1 - e^{-2kH}}, \quad (10)$$

$$B^I = \frac{\delta^2 - gk}{\delta^2 + gk} e^{2kH} A^I.$$

In the limit $H \to \infty$, let us determine the interfaces separating the layers and the vertical displacement functions of these interfaces, $\eta_1(x,t)$ and $\eta_2(x,t)$.

For the case where the lower layer of the dispersed mixture is infinitely deep ($H \to \infty$), we obtain the following equation for the wave parameters and the oscillation frequency:

$$\hat{\rho}(\delta^4 - g^2k^2) + (\delta^2 gk)^2(1 + thkH)\hat{\rho} - \\ -(\delta^4 - g^2k^2)thkH = 0.$$

By separating this equation into two equations, we determine the oscillation frequency in the form (6). In the first case, using equations (8) and (10), we determine the coefficients $A_n^{(m)}$ and $B_n^{(m)}$.

$$A^{II} = A^I, \quad B^I = 0, \quad B^{II} = 0.$$

In this case, the velocity potentials are determined by the following equations:

$$\varphi^{\mathrm{I}} = A^{\mathrm{I}} e^{ky} \cos kx \cos \delta t,$$

$$\varphi^{\mathrm{II}} = A^{\mathrm{I}} e^{k y} \cos kx \cos \delta t. \quad (11)$$

In the second case, the oscillation amplitudes are equal to each other, while the oscillation amplitudes of the mixture free surface and of the interfaces separating the mixture layers differ from each other by a factor of e^{kH}. The propagation of wave velocities in both layers is identical and is expressed by the following function:

$$V_{cì}^I = V_{cì}^I = kA^I e^{k} \cos \delta t.$$

The oscillatory elevations of the free surfaces of both phases and the interfaces separating them, as well as the boundaries and free surfaces formed under the action of the pressure impulse, are determined by the following equations:

$$\eta_1 = \frac{1}{g} \frac{\partial \varphi^I}{\partial t}\bigg|_{y=H} = 0,$$

$$\eta_2 = \frac{\delta}{g} A^I \cos kx \sin \delta t. \quad (12)$$

As a result of oscillatory motion, the free surfaces of the perturbed layers are determined by the following formulas:

$$y = \eta_1(x, y, t),$$

$$y = H - \frac{\delta}{g} A^I \cos kx \sin \delta t. \quad (13)$$

Now let us determine the displacement of the boundary line separating the two layers under the action of

the pressure impulse [17]. The equation of the boundary line separating the two layers is given by:

$$y(x,t) = -\frac{A_1^I \delta}{g} e^{kH} \cos kx \sin \delta t. \quad (14)$$

From equations (10) and (12), it follows that as the thickness of the upper layer increases, the oscillation amplitudes at the free surface and at the interface separating the two layers also increase. A comparison of equations (12) and (14) shows that the oscillation amplitude of the lower layer exceeds that of the upper layer by a factor of e^{kH}.

Let us now consider the second relationship, namely, the dependence of the wave oscillation frequency on the wavelength and on the distribution of velocities in the upper layer. For this purpose, we write the expressions for the wave propagation velocity potential and its components along the coordinate axes:

$$\varphi^I(x,y,t) = A^I(e^{ky} + \Lambda_0 e^{2kh} e^{-ky}) \cos \delta t \cos kx, \quad (15)$$

$$U^I(x,y,t) = \frac{\partial \varphi^I}{\partial x} = \left[A^I e^{ky} + \Lambda_0 e^{2kH} e^{-ky} \right](-k) \sin kx \cos \delta t,$$

$$V^I(x,y,t) = \frac{\partial \varphi^I}{\partial y} = kA^I \left[e^{ky} - \Lambda_0 e^{2kh} e^{-ky} \right](-k) \cos kx \cos \delta t$$

and we determine the vertical displacement function of the points on the interfaces separating the layers as follows:

$$\eta_1 = -\frac{\delta A^I}{g} = (1 + \Lambda_0 e^{kH}) \sin \delta t \cos kx. \quad (16)$$

From this equation, the common surface of wave propagation in both layers is expressed by the following relation:

$$y = H - \frac{\delta A^I}{g} = (1 + \Lambda_0 e^{kH}) \sin \delta t \cos kx. \quad (17)$$

We determine the deviation of the interface separating the flows from its equilibrium (pre-oscillation) position as follows:

$$\eta_2 = \frac{1}{g(\hat{\rho} - 1)} \left(\hat{\rho} \frac{\partial \varphi^{II}}{\partial t} - \frac{\partial \varphi^I}{\partial t} \right)_{y=0}.$$

or

$$\eta_2 = -\frac{\delta A^I}{g(\hat{\rho} - 1)} \left[(1 - \Lambda_0 e^{kH}) \hat{\rho} - (1 + \Lambda_0 e^{-2kH}) \right] \cos kx \sin \delta t. \quad (18)$$

Hence, the equation of the interface between the two layers can be written in the following form:

$$y = \frac{\delta A^I}{g(\hat{\rho} - 1)} \left[1 + \Lambda_0 e^{-2kH} - \hat{\rho}(1 - \Lambda_0 e^{-2kH}) \right]. \quad (19)$$

The propagation of velocities in the lower layer is determined by the following equations:

$$\left.\begin{aligned} U^{II} &= -kA^I (1 - \Lambda_0 e^{-2kH}) e^{ky} \cos k\delta \cos kx, \\ V^{II} &= kA^I (1 - \Lambda_0 e^{-2kH}) e^{ky} \cos k\delta \cos kx. \end{aligned}\right\} \quad (20)$$

Using equations (6), (10), and (16), we determine the displacement of the free surface of the upper layer from its equilibrium position.

Thus, for standing waves, all parameters of wave motion are obtained. Unlike single-phase fluids, in two-phase fluids the displacement generated by oscillations also reflects interphase interaction and mutual

penetration of phases, which are taken into account in the equation of motion through the term $K(\vec{V}_p - \vec{V}_n)$ [18].

$$\tau_{xy} = \left(\mu_2^{(m)} f_2^{(m)} + \mu_1^{(m)} f_1^{m}\right) -$$
$$-k^2\left[\left(A_1^{(m)} + A_2^{(m)}\right)e^{ky} - \left(B_1^{(m)} - B_2^{(m)}\right)e^{-ky}\right]\sin kx\cos\delta t. \quad (21)$$

This expression consists of an invariant part (the first term) and a variable part that depends on the wave number.

CONCLUSIONS AND SUGGESTIONS

In this article, the propagation of small perturbations in a two-layer dispersed medium has been analyzed. Using mathematical models and hydrodynamic equations, it has been shown that the propagation radius of small perturbations and the impulse flow exhibit significant changes over short time intervals. The research results indicate that, in a two-phase medium, interphase interaction plays a crucial role in the propagation process, while propagation efficiency and impulse transmissibility depend on various parameters, in particular layer thickness, viscosity, and granulometric composition. At the same time, the results of modeling and calculations suggest that, in practice, the propagation process can be controlled by optimizing the above-mentioned factors.

In conclusion, it has been demonstrated that the propagation of small perturbations in a two-layer dispersed medium is a multifactorial process involving interphase interaction, turbulence, and viscosity. Modern hydrodynamic models in this field make it possible to study their underlying mechanisms in greater detail.

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FURTHER IMPROVEMENT OF THE AUTOMATION SYSTEM OF ELECTRONIC SERVICES AND TOURIST PERMITS

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Abstract: This article analyzes the current state of electronic services and automation of tourist permits in the tourism sector, as well as existing challenges and areas for further improvement. In the context of digital transformation, the electronic transfer of government services, particularly in the tourism sector, is of great importance, simplifying permit issuance processes, ensuring transparency, and improving service quality. The study highlights best international practices, the potential of using artificial intelligence, big data, and blockchain technologies, and develops practical proposals for Uzbekistan's conditions.

Key words: electronic services, tourist permit, automation, digital tourism, e-gov, Smart Tourism.

Annotatsiya: Mazkur maqolada turizm sohasida elektron xizmatlar va turistik ruxsatnomalarni avtomatlashtirish tizimining hozirgi holati, mavjud muammolari hamda uni yanada takomillashtirish yo‘nalishlari tahlil etilgan. Raqamli transformatsiya sharoitida davlat xizmatlarini elektron shaklga o‘tkazish, ayniqsa turizm sohasida ruxsat berish jarayonlarini soddalashtirish, shaffoflikni ta’minlash va xizmatlar sifatini oshirish muhim ahamiyat kasb etmoqda. Tadqiqot davomida ilg‘or xorijiy tajribalar, sun’iy intellekt, Big Data va blokcheyn texnologiyalaridan foydalanish imkoniyatlari yoritilgan hamda O‘zbekiston sharoitida amaliy takliflar ishlab chiqilgan.

Kalit so‘zlar: elektron xizmatlar, sayyohlik ruxsatnomasi, avtomatlashtirish, raqamli turizm, egov, Smart Tourism.

Аннотация: В данной статье анализируется текущее состояние электронных услуг и автоматизации туристических разрешений в туристическом секторе, существующие проблемы и области для дальнейшего совершенствования. В контексте цифровой трансформации электронная передача государственных услуг, особенно в туристическом секторе, имеет большое значение, упрощая процессы выдачи разрешений, обеспечивая прозрачность и повышая качество услуг. В исследовании освещается передовой зарубежный опыт, возможности использования технологий искусственного интеллекта, больших данных и блокчейна, а также разрабатываются практические предложения для условий Узбекистана.

Ключевые слова: электронные услуги, туристическое разрешение, автоматизация, цифровой туризм, электронное правительство, интеллектуальный туризм.

INTRODUCTION

In today’s globalization and digital economy, the tourism industry is one of the fastest growing sectors. The increase in tourist flows, the expansion of the range of services and changes in consumer demand require the introduction of modern digital solutions in the public administration system. In particular, the system of electronic services and automation of permits plays an important role in regulating tourism activities.

The development of the tourism sector in Uzbekistan has been identified as one of the priorities of state policy. In recent years, the simplification of the visa regime, the introduction of electronic visas, online registration and licensing services are important steps in this direction.

REVIEW OF LITERATURE ON THE SUBJECT

The impact of digital transformation in the tourism sector, electronic visas and online permits on tourism competitiveness is scientifically and practically substantiated in UNWTO (World Tourism Organization) and OECD reports. These sources emphasize that automated permit systems create convenience for tourists, reduce costs and optimize the activities of state bodies. However, these studies are more analytical and statistical in nature, and specific models for improving the system are limited [1].

Scientists such as K. Buhalis, M. Gretzel have studied the innovative aspects of digital technologies, smart tourism (Smart Tourism) and electronic services in tourism. Their works focus on issues of digital platforms, data exchange and integration. However, the issue of complex automation of permit and licensing processes in tourism has been little studied as a separate research object[2].

Uzbek scientists have carried out a number of scientific works on issues of electronic government, digitization of public services and tourism development. In particular, the works of A.A. Abdurakhmonov, Sh.Kh. Rakhmonov, B.B. Tursunov analyzed the legal and economic foundations of digitization of public services, institutional mechanisms for the introduction of electronic services[3].

Local studies devoted to the tourism sector (N.Yu. Yusupov, F.M. Kholmurodov, D.R. Saidova) highlighted the importance of digital tourism, electronic marketing, online booking systems and information platforms. At the same time, electronic services have been identified as an important element of tourism infrastructure[4].

The analysis of the literature shows that while foreign studies have addressed the issue of electronic services and automation from the perspective of the state or digital tourism, domestic studies have focused mainly on regulatory, legal and organizational aspects.

Within the framework of this study, the author:

considers the automation of electronic services and permits in the tourism sector as a single digital system;

organizes information exchange between government bodies, tour operators and tourists on the basis of an integrated platform;

develops an improvement model aimed at increasing the speed of service provision, transparency and user-friendliness.

In this regard, this study, unlike existing scientific works, is distinguished by its focus on improving the processes of issuing permits in electronic services and tourism based on a practical, systematic and innovative approach.

However, existing local studies address the issue of automation of permitting, licensing and administrative processes in the tourism sector in a more general way, and its technological architecture, integration mechanisms and improvement paths are not sufficiently systematized.

RESEARCH METHODOLOGY

The comparative method was used as one of the main methods in the study. Through this method, electronic services and automated systems for issuing permits in tourism introduced in foreign countries (European Union countries, South Korea, Singapore) were compared with the existing practice in Uzbekistan.

In the process of comparative analysis, such indicators as:

- the number of stages of issuing permits;
- the duration of providing electronic services;
- the level of user participation;
- the state of mutual integration of information systems;
- transparency and control mechanisms were taken as a basis. As a result, it was found that in foreign practice, permit issuance processes are fully digitized, the human factor is minimized, and the service time is reduced. In Uzbek practice, it was determined that, despite the existence of electronic services, some processes still require additional administrative intervention[5].

Systematic analysis method. The process of issuing permits in electronic services and tourism was studied as a holistic system using the systematic analysis method. The interrelationships between government bodies, information systems, the regulatory framework and users were analyzed.

This method identified functional gaps, data duplication and integration problems in the existing automation system. As a result, the need for a single digital platform to increase the efficiency of electronic services was scientifically substantiated.

Analytical and statistical method. The study used the analytical and statistical method to analyze the indicators of the use of electronic services, the dynamics of obtaining online permits and the terms of service provision. Based on official statistical data and sectoral reports, the level of automation and its impact on tourism activities were assessed.

As a result of this method, it was found that in regions where electronic services were introduced, the time for obtaining permits was reduced and administrative costs in the activities of tourism entities were reduced.

Expert assessment method. The expert assessment method studied the opinions of tourism specialists, civil servants and IT experts. On the basis of expert surveys, the advantages and disadvantages of the automated permit system were determined, and practical proposals for its improvement were formulated. Analysis and results. The introduction of electronic services in the tourism sector has been carried out gradually in recent years. In particular, electronic licensing, online permit issuance, and electronic application submission services have been launched.

ANALYSIS AND RESULTS

A comparative analysis of the traditional and electronic permit issuance processes in the tourism sector is presented (Table 1).

Table 1. Comparative analysis of permit issuance processes

Indicators	Traditional method	Electronic method
Submit an application	In paper form	Online
Trial period	10–15 days	3–5 days
The human factor	Up	Partially
Transparency	Low	middle
Control mechanism	Limited	Electron monitoring

The analysis of the diagram shows that:

• the use of electronic services is increasing year by year;

• however, the share of electronic services in relation to the total number of permits still does not have a complete advantage;

• in some regions, the level of use of electronic services remains low.

This situation indicates that the functional capabilities of electronic services are limited and a user-friendly interface has not been sufficiently formed for users (Table 2).

Table 2. Information systems integration level

Systems	Integration status	Problem
Tourism register	Partially	Data update is slow
State services portal	Middle	The systems are not interconnected
Tax and license system	Low	Manual inspections

The table data shows that in order to fully automate electronic services, it is necessary to strengthen the integration between systems.

The findings of this study demonstrate that the ongoing digital transformation of permit issuance in the tourism sector has already produced tangible and largely positive outcomes, while simultaneously revealing clear directions for further improvement. The comparative analysis of traditional and electronic permit issuance processes confirms that the transition to electronic services significantly enhances operational efficiency. The reduction of processing time from 10–15 days to 3–5 days illustrates the practical value of automation in accelerating administrative procedures and improving service delivery for tourism stakeholders.

At the same time, the persistence of the human factor at a partial level indicates that the current electronic system represents an intermediate stage of digital maturity rather than a fully automated model. This can be interpreted positively: the existing framework has already laid a solid technological foundation, and the remaining human involvement creates opportunities for gradual optimization rather than systemic restructuring. Similarly, the shift from low to medium transparency reflects meaningful progress in accountability and monitoring, particularly through the introduction of electronic tracking mechanisms. Although full transparency has not yet been achieved, the presence of digital monitoring tools signals a decisive move toward more open and controllable administrative processes.

The dynamic growth in the use of electronic services over recent years further supports the effectiveness of digital reforms. Increasing adoption rates suggest growing trust among users and improving familiarity with online platforms. However, the fact that electronic services do not yet dominate the total volume of issued

permits highlights structural and regional disparities. In several regions, lower usage levels indicate that digital infrastructure readiness, digital literacy, and interface usability remain uneven. Importantly, this does not undermine the value of electronic services; instead, it emphasizes the need for targeted capacity-building measures and user-centered design improvements to ensure broader and more inclusive adoption.

Another significant outcome of the analysis concerns the limited integration between information systems used by state bodies in the tourism sector. Partial or low integration between tourism registers, state service portals, and tax and licensing systems leads to repeated data requests and manual verification procedures. From a positive perspective, identifying these bottlenecks provides a clear roadmap for policy and technological intervention. Strengthening interoperability between systems would not only reduce administrative burdens but also further minimize the human factor, enhance data accuracy, and improve real-time decision-making.

CONCLUSIONS AND SUGGESTIONS

The results of the analysis and research show that the automation of electronic services and permits in the tourism sector is one of the important directions of the digitalization of public services. Although electronic application submission, online licensing, and permit issuance services have been introduced in recent years, their functional capabilities and level of automation remain insufficient. This situation indicates that the existing digital solutions have not yet fully ensured process efficiency, transparency, and sustainability in the provision of public services in the tourism sector.

The analysis revealed that the persistence of the human factor in permit issuance processes, the low level of integration between information systems, and limited statistical monitoring mechanisms significantly reduce the effectiveness of electronic services. In addition, uneven user-oriented service design and disparities in the level of use of electronic services across regions negatively affect the overall development of the system. As a result, the potential of digital technologies to simplify administrative procedures and reduce institutional barriers is not fully realized.

These circumstances indicate the need to further improve the automation system of electronic services and permits in the tourism sector based on a comprehensive, systematic, and innovative approach. Such an approach should be aimed at eliminating fragmentation, strengthening interdepartmental coordination, and ensuring the continuity of digital processes across all stages of service provision.

Based on the results of the analysis, it is proposed to introduce a single integrated digital platform that covers permit issuance, licensing, and registration services in the tourism sector. This platform should ensure automatic and secure information exchange between the information systems of state bodies, thereby reducing duplication of procedures and increasing the speed and reliability of decision-making processes.

At the same time, special attention should be paid to the full automation of the licensing process. Minimizing the human factor at the stages of application review, verification, and decision-making can significantly reduce service delivery time and lower the risk of corruption. Automated workflows and algorithm-based verification mechanisms would contribute to greater objectivity and consistency in administrative decisions.

Strengthening the integration of information systems is also essential. The practice of requesting duplicate data from applicants should be eliminated by establishing API-based integration between tourism authorities, tax bodies, licensing institutions, and public service portals. This will allow data to be reused efficiently and will reduce the administrative burden on both service providers and users.

In addition, the introduction of statistical monitoring and analytical mechanisms is necessary to improve governance quality. The development of analytical modules that automatically analyze the use of electronic services, permit issuance deadlines, and refusal cases will make it possible to identify bottlenecks in the system, assess performance indicators, and make evidence-based management decisions.

Improving user-oriented service design remains another important direction. Simplifying electronic service interfaces, expanding multilingual support, and increasing opportunities for accessing services through mobile platforms will enhance user satisfaction and ensure broader inclusion of tourism entities across different regions and user groups.

Finally, increasing human resource capacity and developing digital literacy are crucial for the successful implementation of digital reforms. The introduction of regular training programs for civil servants and tourism entities on the effective use of electronic services will help improve institutional readiness, reduce resistance to change, and ensure the sustainable functioning of digital systems.

As a result of implementing the proposed measures, the efficiency of the automation system for electronic services and permits in the tourism sector will increase, service quality will improve, and a convenient and transparent digital environment for tourism activities will be created. Ultimately, this will contribute to enhancing the country's tourism competitiveness and strengthening its position in the global tourism market.

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THE NECESSITY OF DISCLOSING INFORMATION ON SELLING EXPENSES IN ACCOUNTING REPORTS OF PHARMACEUTICAL ENTERPRISES

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Abstract: The scientific article presents the issues of accounting for costs currently carried out in pharmaceutical enterprises, including the accounting of costs related to sales processes. Also, the scientific and practical issues of reflecting information on sales costs in accounting reports at enterprises of this sector are studied, and a new form of accounting reporting is recommended, which will have managerial significance and fully meet the needs of external and internal investors.

Key words: pharmaceutical enterprises, sales process accounting, cost accounting, management reporting, financial reporting, international financial reporting standards.

Annotatsiya: Ilmiy maqolada farmatsevtika korxonalarida bugungi kunda amalga oshirilayotgan xarajatlar hisobi, ularning tarkibida sotish jarayonlariga oid xarajatlarning buxgalteriya hisobida yoritilishi masalalari keltirilgan. Shuningdek, mazkur tarmoq korxonalarida sotish xarajatlariga oid axborotlarni buxgalteriya hisobotlarida aks ettirishning ilmiy-amaliy masalalari tadqiq etilgan holda boshqaruv ahamiyatiga ega bo‘ladigan hamda tashqi va ichki investorlar ehtiyojlarini to‘liq qondiradigan yangi shakldagi buxgalteriya hisoboti tavsiya etilgan.

Kalit so‘zlar: farmatsevtika korxonalari, sotish jarayonlari buxgalteriya hisobi, xarajatlar buxgalteriya hisobi, boshqaruv hisoboti, moliyaviy hisobot, moliyaviy hisobotning xalqaro standartlari.

Аннотация: В научной статье рассматриваются вопросы учета затрат, осуществляемого в настоящее время на фармацевтических предприятиях, включая учет затрат, связанных с процессами продаж. Также исследуются научно-практические вопросы отражения информации о затратах на продажи в бухгалтерской отчетности предприятий данного сектора и предлагается новая форма бухгалтерской отчетности, имеющая управленческое значение и в полной мере отвечающая потребностям внешних и внутренних инвесторов.

Ключевые слова: фармацевтические предприятия, учет процессов продаж, калькуляция затрат, управленческая отчетность, финансовая отчетность, международные стандарты финансовой отчетности.

INTRODUCTION

The Law of the Republic of Uzbekistan No. 483-I “On the Quality and Safety of Food Products” is a regulatory legal act that establishes the fundamental norms governing the processes of ensuring that products consumed in people’s daily lives are delivered in a high-quality and safe manner. The Law defines “the sale of food products” as the sale, delivery, and other forms of transfer of food products under specific conditions.

Therefore, in ensuring the country’s socio-economic well-being, it is of critical importance not only to guarantee the high-quality production of food products, but also to ensure that these products reach consumers safely through properly organized sales processes. This clearly indicates that, at enterprises—particularly manufacturing enterprises, and especially those engaged in pharmaceutical production—one of the core responsibilities is not limited to the production of finished goods alone. Equally essential is the proper organization of sales processes, ensuring the quality of finished products, exercising effective control over them, and guaranteeing their safe delivery to consumers.

In manufacturing enterprises, sales processes inevitably require expenditures at specific stages and across various operational activities. The conducted studies show that, in pharmaceutical enterprises as well, the structure and proportion of selling expenses represent a significant component of overall enterprise costs. Consequently, this research sets as its objective the conduct of scientific investigations into period expenses in pharmaceutical enterprises, with particular emphasis on selling expenses as one of their main structural components.

REVIEW OF LITERATURE ON THE SUBJECT

In business entities, the organization of cost accounting—including the accounting of selling expenses within the overall cost structure—is governed by the Resolution of the Cabinet of Ministers of the Republic of Uzbekistan "On Approval of the Regulation on the Composition of Costs for the Production and Sale of Products (Works, Services) and the Procedure for Forming Financial Results." This regulatory document classifies selling expenses as period costs that are taken into account when determining profit from core operating activities and that are not included in the production cost of finished goods[1].

In accordance with the Regulation, the composition of selling expenses in enterprises includes labor costs related to sales activities and the corresponding social tax, transportation costs, expenses for renting buildings and facilities, their maintenance costs, utility payments, advertising expenses, and losses of goods, among others.

Foreign scholar C. Drury defines period costs as costs that are not directly related to the production of finished goods or the provision of services. Therefore, such costs are not included in the valuation of inventories and are recognized as expenses in the period in which they are incurred. Within the structure of these period costs, selling expenses constitute one of the most critical processes and are implemented by the sales department of enterprises[2].

RESEARCH METHODOLOGY

In the study conducted on the necessity of disclosing information on selling expenses in the accounting reports of pharmaceutical enterprises, such research methods as scientific abstraction, economic analysis, monographic observation, comparison, induction, and deduction were applied.

ANALYSIS AND RESULTS

The development of reporting forms that encompass information used for managerial purposes in enterprises is of particular importance. In international accounting practice, such reports are typically used as supplementary disclosures to financial statements. In pharmaceutical enterprises, the significance of management reporting is increasing substantially in forecasting financial and economic indicators, measuring risks that may arise in pharmaceutical production processes, rational cost management and pricing, as well as in monitoring the processes of selling pharmaceutical products in domestic and foreign markets.

Enterprises prepare management reports in various forms based on the specific characteristics and principles of their activities. In pharmaceutical enterprises, management reporting information should be presented in both quantitative and financial terms and should serve to establish effective managerial control, analyze financial and economic information, facilitate prompt and well-informed management decision-making, and ultimately determine the future development prospects of the enterprise.

Based on the results of our scientific research, it can be stated that the development of management reports in pharmaceutical enterprises and their presentation to internal and external stakeholders is currently a pressing issue. Among foreign scholars who have conducted research in this area, O. Prokopova, in her scientific work devoted to the development of management reporting in pharmaceutical enterprises, formulated new reporting forms of managerial significance based on the specific features of the industry and developed scientific and methodological recommendations for the presentation of these reports, while also improving the methodology for reflecting the results of pharmaceutical product sales.

According to her view, pharmaceutical enterprises should develop the following management reporting forms that correspond to the specific nature of their activities: a register of cash flows and collection of sales revenues; a report on deposited or transferred income; current account statements; inventory reports; balance sheets of medicinal plant raw materials; reports on the movement of fixed assets, low-value inventory, and

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2 Drury C. Management and Cost Accounting, 10th Edition Colin Drury. Annabel Ainscow. ISBN: 978-1-4737-4887-3. 2017.

fast-depreciating items; records of retail turnover; reports on the flow of goods within the retail trade network; reports on the flow of fuel and construction materials; a register of invoices issued to customers (medical and preventive institutions and other enterprises) for sold pharmaceutical goods; personal accounts of customers and balances of other settlements; and income statements.[3]

At present, all pharmaceutical manufacturing enterprises operating in the Republic of Uzbekistan are required to submit reports in accordance with the "Calculation Form for Determining the Selling Price of Prescription Medicines Produced by a Domestic Manufacturer." Taking into account this pressing requirement facing pharmaceutical enterprises, this study sets as its objective the development of new reporting forms that reflect the specific characteristics of pharmaceutical enterprises' activities[4].

Table 1. Recommended reporting form for determining the selling price of the pharmaceutical product "L-arginine 100 ml" produced by a pharmaceutical enterprise (As of October 2025)

Indicator name	Line code	Amount per unit of pharmaceutical product (UZS)	Share in total costs (%)
I. Cost of the pharmaceutical product, including: (110+120+130+140+150+160+170)	100	10,182	25.11
Raw materials	110	3,062	7.55
Auxiliary materials	120	751	1.85
Packaging materials	130	4,200	10.36
Wages related to production processes	140	1,192	2.94
Social tax on production-related wages	150	143	0.35
Utilities, including: (161+162+163)	160	352	0.87
Electricity	161	283	0.70
Natural gas	162	33	0.08
Water and sewage	163	20	0.05
Waste removal	164	16	0.04
Other costs related to core production processes	170	482	1.19
II. Period costs, including: (210+220+230+240)	200	30,233	74.57
Administrative expenses	210	543	1.34
Selling expenses, including: (221+222+223+224+225+226 +227+228+229)	220	22,528	55.57
Marketing expenses	221	6,253	15.42
Advertising expenses	222	5,132	12.66
Intermediary service expenses	223	3,611	8.91
Transportation expenses	224	4,822	11.89
Wages related to sales processes	225	1,408	3.47
Social tax on sales-related wages	226	169	0.42
Depreciation related to sales processes	227	844	2.08
Utilities related to sales processes	228	390	0.96
Other expenses related to sales processes	229	1,087	2.68
Other operating expenses	230	3,413	8.42
Expenses for sales and quality control activities	240	1,428	3.52
III. Financial expenses, including: (410+420+430)	300	128	0.32
Interest expenses	310	128	0.32
Losses from exchange rate differences	320	0	0.00

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Other financial expenses	330	0	0.00
IV. Total costs (100+200+300)	400	40,543	100.00
Net profit (%)	500	48	–
Selling price of the pharmaceutical product, excl. VAT	600	60,000	–
Selling price of the pharmaceutical product, incl. VAT	700	67,200	–

We consider it essential to develop management-relevant reports in pharmaceutical enterprises that reflect the specific nature of their operations.

CONCLUSIONS AND SUGGESTIONS

Based on the accounting reports recommended in this study for pharmaceutical enterprises, the following scientific conclusions were drawn.

First, the distinctive feature of this type of report lies in the fact that the production cost of pharmaceutical products and the level of profit margin added to them must be clearly presented to higher-level organizations, as stipulated by regulatory and legal acts. Therefore, in developing this reporting form, scientific and practical recommendations were formulated in strict compliance with the procedures and rules established by relevant regulations.

Second, in this report developed for the purpose of forming the selling price of pharmaceutical products, costs were grouped into three categories: the cost of the pharmaceutical product, period costs, and financial expenses. In addition, the report includes indicators reflecting total costs incurred by the pharmaceutical enterprise, as well as the selling price of the pharmaceutical product both with and without value-added tax.

Third, in order to clearly demonstrate which cost items contribute to the formation of the production cost of each pharmaceutical product, eleven indicators were included. These indicators further enrich the content of the reporting form developed under regulatory documents for determining the cost per unit of a pharmaceutical product.

Fourth, to provide a more comprehensive disclosure of period costs, these expenses were divided into four groups, and a total of thirteen indicators were included within the structure of period costs. The inclusion of indicators related to sales process expenses and expenses for sales and quality control activities highlights the specific features of this reporting form for pharmaceutical enterprises.

Fifth, the proposed report includes a column that enables the comparison of enterprise indicators and enhances the presentation of analytical information by disclosing the share of each expense in total costs. This allows management personnel to monitor at which stages of enterprise activity costs are incurred and in what amounts, thereby supporting informed decision-making.

Finally, the reporting forms developed in this study assist the head of the accounting function in pharmaceutical enterprises in presenting information on incurred costs and product cost structures to higher-level organizations. Moreover, these reports support pharmaceutical enterprise managers in making important and strategic decisions related to effective cost management and systematic cost control. In addition, the Law of the Republic of Uzbekistan “On Accounting” stipulates that the head of an accounting entity must ensure the development of internal reporting forms, and the proposed reports facilitate the fulfillment of this requirement in pharmaceutical enterprises[5].

The scientific research processes conducted in this study and the results obtained contribute to the proper accounting of selling expenses in pharmaceutical enterprises. Furthermore, the scientific and practical recommendations developed for management reporting are expected to ensure transparent and analytical disclosure of information on selling expenses in the accounting reports of pharmaceutical enterprises.

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INVESTMENT FINANCIAL MECHANISMS AND THEIR ROLE IN THE NATIONAL ECONOMY

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Abstract: This article comprehensively examines the theoretical foundations of investment financial mechanisms, their practical dimensions, and their role in the development of the national economy. The financial sources of investment activity—state budget funds, commercial bank loans, stock market instruments, resources of international financial institutions, and the role of private capital—are analyzed from a scientific perspective. In addition, the paper consistently reviews the formation of investment financial mechanisms in Uzbekistan, the reforms implemented in the post-independence period, and the legal and institutional framework aimed at improving the investment climate.

Key words: investment, financial mechanism, economic growth, capital investments, public–private partnership, sources of financing, bank credit, stock market, international financial institutions.

Annotatsiya: Ushbu maqolada investitsion moliya mexanizmlarining nazariy asoslari, ularning amaliy jihatlari hamda milliy iqtisodiyot rivojlanishidagi o‘rni atroflicha yoritilgan. Investitsiya faoliyatini moliyalashtirish manbalari — davlat byudjeti mablag‘lari, tijorat banklari kreditlari, fond bozori instrumentlari, xalqaro moliya institutlari resurslari hamda xususiy kapitalning roli ilmiy jihatdan tahlil qilingan. Shuningdek, O‘zbekiston sharoitida investitsion moliya mexanizmlarining shakllanish jarayoni, mustaqillikdan keyingi davrda amalga oshirilgan islohotlar, investitsion muhitni yaxshilashga qaratilgan huquqiy va institutsional asoslar izchil ko‘rib chiqilgan.

Kalit so‘zlar: investitsiya, moliya mexanizmi, iqtisodiy o‘sish, kapital qo‘yilmalar, davlat-xususiy sheriklik, moliyalashtirish manbalari, bank krediti, fond bozori, xalqaro moliya institutlari.

Аннотация: В статье всесторонне раскрываются теоретические основы инвестиционных финансовых механизмов, их практические аспекты и роль в развитии национальной экономики. Проведен научный анализ источников финансирования инвестиционной деятельности — средств государственного бюджета, кредитов коммерческих банков, инструментов фондового рынка, ресурсов международных финансовых институтов, а также роли частного капитала. Кроме того, последовательно рассмотрены процессы формирования инвестиционных финансовых механизмов в условиях Узбекистана, реформы, осуществленные в период независимости, а также правовые и институциональные основы, направленные на улучшение инвестиционного климата.

Ключевые слова: инвестиции, финансовый механизм, экономический рост, капитальные вложения, государственно-частное партнерство, источники финансирования, банковский кредит, фондовый рынок, международные финансовые институты.

INTRODUCTION

In the context of a market economy, investments are emerging as one of the main drivers of economic growth. The sustainable development of each country, the enhancement of its international competitiveness, and the effective resolution of socio-economic challenges are directly dependent on the proper organization of investment processes. In this regard, investment financial mechanisms serve as an essential instrument. These mechanisms ensure not only the financing of investment projects but also the efficient allocation of capital, the mobilization of financial resources, and the acceleration of innovative activities across economic sectors.

In recent years, the Republic of Uzbekistan has been implementing comprehensive reforms aimed at improving investment policy, attracting foreign investment, and developing the domestic capital market. In particular, the legal framework for public–private partnership mechanisms has been strengthened, the financial market infrastructure has been modernized, and cooperation with international financial institutions has been consistently expanded. Under these conditions, increasing the effectiveness of investment financial mechanisms is regarded as one of the priority tasks for the development of the national economy.

Moreover, global experience confirms that the effective organization of investment financial mechanisms has a significant impact on the modernization of production, the introduction of advanced technologies, the expansion of export potential, and the increase in employment levels. From this perspective, an in-depth study of the given topic, an analysis of existing opportunities and constraints, as well as the identification of future priority directions, are of considerable scientific and practical importance.

LITERATURE REVIEW

The issue of effectively organizing investment processes occupies a prominent place in the scientific research of many domestic and foreign scholars. Studies in this field reveal the role of investments in ensuring economic growth, stability, and competitiveness through various theoretical and practical approaches.

J. M. Keynes, in his well-known work The General Theory, regarded investments as one of the most important determinants of economic growth. According to his view, state-led stimulation of investments ensures economic stability and enhances economic activity by supporting aggregate demand [1].

P. Samuelson and R. Solow scientifically substantiated the direct impact of investments on capital accumulation and labor productivity through economic growth models. In their opinion, the effective organization of investment financial mechanisms is a key condition for long-term economic stability [2].

D. North and representatives of the new institutional economics emphasize the significance of the institutional environment and the efficiency of the financial system in investment processes. According to their views, when investment financing mechanisms are based on legal guarantees and principles of transparency, the pace of economic growth accelerates further [3].

Among Uzbek scholars, the works of A. Vohidov, Sh. Bekmurodov, and Q. Qobilov extensively examine financial support for investment activities, the development of public–private partnership mechanisms, and the importance of attracting foreign investment for the national economy. These studies highlight that the modernization of investment financial mechanisms contributes to technological renewal of production and the creation of new jobs [4].

In addition, foreign researchers such as M. Porter, J. Stiglitz, and H. Chenery have analyzed investment financial mechanisms from the perspectives of enhancing international competitiveness, promoting innovation, and ensuring social stability [5].

Overall, scholarly views recognize investment financial mechanisms as an important tool for stimulating economic growth, efficiently allocating financial resources, and integrating the national economy into the global market.

RESEARCH METHODOLOGY

In the course of the study, the necessity of developing investment financial mechanisms, their role in the national economy, and the main directions for enhancing their effectiveness were examined. In particular, the processes of shaping the investment environment in Uzbekistan, mechanisms for financing investments through the state budget and the banking and financial system, procedures for attracting foreign investment, and the practical outcomes of public–private partnership (PPP) initiatives were analyzed.

At the same time, internal and external factors influencing investment activity in the national economy, international experience, and assessments provided by international financial institutions were thoroughly studied. The research employed dialectical and systemic approaches, comparative and benchmarking analysis, statistical and dynamic analysis, as well as grouping and modeling methods. Through these methods, the strengths of investment financial mechanisms, existing opportunities, and factors contributing to the strengthening of national economic stability were identified.

ANALYSIS AND RESULTS

Investments are considered one of the key factors of modern economic development. Under conditions of globalization and digital transformation, the importance of investments is steadily increasing in ensuring sustainable national economic growth, creating new jobs, and modernizing production capacities. Therefore, the effective organization of investment financial mechanisms not only stimulates economic growth but also enhances a country's international competitiveness.

In Uzbekistan's experience, investment activity has emerged as a crucial factor in structural transformations of the national economy, modernization of industrial sectors, development of transport and communication infrastructure, and financing of social sectors. In the post-independence period, consistent reforms have been implemented to liberalize investment policy, attract foreign investment, and finance large-scale projects based on public–private partnerships.

From the early years of independence, special attention has been paid to investment policy as a means of restoring and modernizing the national economy. During the 1990s, state investments were predominantly prioritized; however, starting from the 2000s, as a result of economic liberalization and private sector development policies, the share of domestic and foreign investments steadily increased. The large-scale reforms implemented after 2017 further improved the investment climate and created new opportunities for foreign investors.

One of the most significant changes in investment policy has been the balanced development of the ratio between public and private investments. In particular, by the late 2010s, most large investment projects in industrial sectors began to be financed not from state funds but through commercial bank loans, resources of international financial institutions, and private capital. This process led to the diversification of investment financial mechanisms and the expansion of financing sources.

In recent years, public–private partnership (PPP) mechanisms have also been widely introduced in Uzbekistan. Large investment projects involving international companies are being implemented in the energy, transport, healthcare, and education sectors. In particular, agreements concluded with foreign investors for the construction of solar and wind power plants play an important role in strengthening the country's energy security.

Overall, the formation of investment financial mechanisms in Uzbekistan has proceeded through three main stages:

1. 1991–2000 — a stage characterized by the implementation of major investment projects financed primarily through state funds.
2. 2001–2016 — a stage focused on increasing the share of the private sector and foreign investors in the economy and expanding sources of financing.
3. From 2017 to the present — a stage marked by the liberalization of the investment environment, the introduction of PPP mechanisms, and deeper integration into capital markets.

These stages reflect the evolutionary development path of investment financial mechanisms and demonstrate their direct impact on the stability of the national economy.

During 2020–2024, investment financial flows directed to Uzbekistan's national economy exhibited a steady growth trend. In particular, the volume of investments financed through the state budget increased from UZS 45.2 trillion to UZS 60.7 trillion, representing a 34% growth. This increase was mainly driven by the development of social infrastructure and the implementation of state projects in the transport and energy sectors (Table 1).

Table 1. Dynamics of Investment Financial Flows in Uzbekistan (2020–2024, billion UZS)

Years	State Budget Financing	Bank System Loans	International Financial Institutions	Domestic Private Investments	Foreign Investments	Total Investments
2020	45,200	37,800	12,500	56,400	29,700	181,600
2021	48,300	42,900	14,800	62,700	32,400	201,100
2022	52,600	47,500	16,200	69,800	35,600	221,700
2023	56,400	53,200	18,100	74,300	40,500	242,500
2024	60,700	59,600	20,400	82,900	45,200	268,800

The volume of loans allocated through the banking system also increased significantly, rising from UZS 37.8 trillion to UZS 59.6 trillion. This expansion broadened enterprises' access to financial resources and served as an important factor in the development of the private sector of the economy.

Funds attracted from international financial institutions grew from UZS 12.5 trillion in 2020 to UZS 20.4 trillion in 2024. These resources were mainly directed toward the energy sector, environmental projects, transport and communication infrastructure, and social sectors, making a substantial contribution to ensuring sustainable economic growth and the introduction of new technologies in the national economy.

Domestic private investments increased from UZS 56.4 trillion to UZS 82.9 trillion during 2020–2024, indicating a steady rise in the investment activity of national business entities. Foreign capital inflows expanded from UZS 29.7 trillion to UZS 45.2 trillion, demonstrating a strengthening of investor confidence in Uzbekistan.

Overall investment volumes rose from UZS 181.6 trillion to UZS 268.8 trillion, representing an increase of nearly 48%. This growth played a significant role in ensuring sustainable economic development, modernizing industry, creating new jobs, and enhancing regional economic activity in the country (Table 2).

Table 2. Impact of Investments on the National Economy (Conditional Indicators for 2020–2024)

Years	GDP Growth (%)	Newly Created Jobs (thousand)	Industrial Output Growth (%)	Export Volume Growth (%)
2020	1.6	220	2.1	0.8
2021	7.4	310	6.8	2.9
2022	5.7	360	7.3	3.4
2023	6.0	410	8.0	4.1
2024	6.3	470	8.7	4.9

During 2020–2024, the growth of investment financial flows had a significant impact on national economic indicators. First, the dynamics of gross domestic product (GDP) followed a positive trajectory. Although the economic growth rate was limited to 1.6% in 2020 due to the consequences of the pandemic, the subsequent recovery of investment activity resulted in GDP growth reaching 7.4% in 2021 and 6.3% in 2024. These indicators clearly demonstrate the decisive role of investments in ensuring economic stability.

Investments also generated substantial positive outcomes in the employment sector. In particular, while 220 thousand new jobs were created in 2020, this figure increased to 470 thousand by 2024. This trend contributed to strengthening labor market stability, increasing household incomes, and improving overall social welfare.

The growth of industrial output likewise indicates the effective allocation of investments. Whereas industrial production growth amounted to 2.1% in 2020, this indicator rose to 8.7% by 2024. Such results were achieved through the introduction of new technologies at industrial enterprises, modernization of production capacities, and diversification of product lines.

In addition, export volume growth also exhibited a positive trend. While the export growth rate stood at 0.8% in 2020, it increased to 4.9% by 2024. This highlights the important role of investments in expanding export-oriented production and enhancing the supply of competitive goods in foreign markets.

Overall, investment financial flows emerged as a key driver across various dimensions of the national economy—GDP growth, employment generation, industrial development, and export expansion. This confirms that investments play an indispensable role not only in ensuring economic growth but also in maintaining social stability (Table 3).

Table 3. Structural Share of Domestic and Foreign Investments in Uzbekistan (2020–2024, %)

Years	**Share of Domestic Investments (%)**	**Share of Foreign Investments (%)**	**Total (%)**
2020	71.4	28.6	100
2021	71.9	28.1	100
2022	72.5	27.5	100
2023	71.7	28.3	100
2024	72.6	27.4	100

During 2020–2024, the main share of investments in Uzbekistan was formed by domestic sources. In particular, domestic investments accounted for 71.4% of the total volume in 2020, increasing to 72.6% by 2024. This trend indicates a steady rise in the activity of national business entities, the state budget, and the banking system in investment processes.

The share of foreign investments remained relatively stable, fluctuating around 27–28%. Although the proportion of foreign capital in total investments remained stable, its absolute volume increased year by year. This reflects the growing attractiveness of the country's investment climate and the strengthening confidence of foreign investors.

Overall, the high share of domestic investments suggests that economic development is largely driven by internal sources. At the same time, foreign investments play an important role in attracting new technologies, expanding the production of export-oriented goods, and strengthening international economic integration.

CONCLUSIONS AND RECOMMENDATIONS

During 2020–2024, investment financial flows in Uzbekistan increased steadily and emerged as a key factor in ensuring the sustainable growth of the national economy. The expansion of funds mobilized through

the state budget, the banking system, and international financial institutions contributed to the modernization of strategic sectors of the economy and the development of social sectors.

Domestic investments accounted for nearly two-thirds of total investment volumes and served as the main pillar of economic stability. Capital investments made by national business entities played an important role in expanding production capacities, creating new jobs, and promoting regional development. Although the share of foreign investments remained relatively stable, their increasing volume directly contributed to attracting advanced technologies, expanding export potential, and strengthening international economic cooperation.

The growth of investments led to a steady increase in GDP indicators, the modernization of industrial production, the expansion of export volumes, and the creation of thousands of new jobs in the labor market. These processes also played a significant role in improving social welfare and reducing economic disparities between regions.

Overall, the effective management of investment financial flows is strengthening the foundation of Uzbekistan's economic development and is emerging as a decisive factor in enhancing the country's competitiveness and accelerating its integration into the global economy.

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WESTERN COUNTRIES' EXPERIENCES IN ENSURING THE FINANCIAL PERFORMANCE OF BANKING ACTIVITIES

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Abstract: The article examines the formation of the financial performance of commercial banks and its theoretical foundations. Scientific conclusions and approaches of foreign and domestic scholars aimed at identifying the specific characteristics of the efficiency of banks' financial activities are systematized. In conducting the study, attention is focused on systematizing ideas proposed in international academic research and analyzing their impact on the formation of financial performance from the perspective of countries' experiences. Based on banks' financial indicators, scientific and practical approaches aimed at ensuring performance have been developed.

Key words: financial stability, profitability, asset quality, capital adequacy, cost-to-income ratio, interest and non-interest margin.

Annotatsiya: Maqolada tijorat banklari faoliyatining moliyaviy natijadorligining shakllanishi va uning nazariy asoslari tadqiq etilgan. Xorijiy va mahalliy olimlarning banklarning moliyaviy faoliyati samaradorligining o'ziga xos xususiyatlarini aniqlashga qaratilgan ilmiy xulosa va yondashuvlar tizimlashtirilgan. Biz tadqiqotimizni amalga oshirishda xalqaro maydondagi ilmiy tadqiqotlarda ilgari surilayotgan g'oyalarni tizimlashtirish va ularning mamlakatlar tajribasi nuqtayi nazaridan moliyaviy natijadorlikni shakllantirishga ta'sirini tahlil qilishga e'tibor qaratilgan. Banklarning moliyaviy ko'rsatkichlari asosida natijadorlikni ta'minlashga qaratilgan ilmiy va amaliy yondashuvlarni ishlab chiqilgan.

Kalit so'zlar: moliyaviy barqarorlik, rentabellik, aktivlar sifati, kapital yetarliligi, xarajatlarning daromadga nisbati, foizli va foizsiz marja.

Аннотация: В статье исследуются формирование финансовой результативности деятельности коммерческих банков и ее теоретические основы. Систематизированы научные выводы и подходы зарубежных и отечественных ученых, направленные на выявление специфических особенностей эффективности финансовой деятельности банков. В ходе исследования особое внимание уделено систематизации идей, выдвигаемых в международных научных исследованиях, а также анализу их влияния на формирование финансовой результативности с точки зрения опыта различных стран. На основе финансовых показателей банков разработаны научные и практические подходы, направленные на обеспечение результативности.

Ключевые слова: финансовая устойчивость, рентабельность, качество активов, достаточность капитала, соотношение расходов и доходов, процентная и непроцентная маржа.

INTRODUCTION

Assessing and evaluating the financial performance of banks requires an analysis of a number of foreign experiences. It should be noted that the financial performance of commercial banks is largely reflected in their level of profitability and the scale of return generation. At present, it is possible to observe the existence of various scientific approaches to determining banks' financial performance based on both financial and non-financial factors.

In classical theory, banks' financial performance is primarily explained through their ability to form margins, although this theoretical approach is currently undergoing transformation. In general, defining financial performance solely through profitability and return indicators represents a distinctive feature of classical views. This, in turn, reflects the close integration of banks' financial performance with the category of stability. From this perspective, many studies grounded in classical approaches also demonstrate that banks' financial performance is expressed through profitability and return indicators.

REVIEW OF LITERATURE ON THE SUBJECT

In our research, we initially focus on the U.S. banking system and the specific features of modern financial policy within it. In U.S. banks, financial performance is determined not only by lending activity but also by the priority role of non-interest income. Financial performance is strengthened through commission income, consulting services, and investment cooperation in asset management. As a result, although the share of total interest income in U.S. banks is relatively small, return on equity remains high, largely due to the fact that non-interest income accounts for approximately 40–50 percent of total income.

In a joint study, R. DeYoung and T. Rice empirically analyzed the relationship between non-interest income and financial performance in U.S. commercial banks. They noted that non-interest income includes asset management services, operations in financial markets, and other financial services. Based on their analysis, they formulated several scientific conclusions. In particular, banks with higher non-interest income exhibited higher returns on assets and equity; however, not all forms of non-interest income were found to be equally stable. For example, commission income demonstrated a more stable trend, while income from financial market activities and brokerage services was characterized by higher volatility and risk. From this perspective, the authors emphasized the need to diversify non-interest income and stabilize its sensitivity to market fluctuations [1].

In a study conducted by J. Schildbach and others, the financial performance of U.S. and European commercial banks was comparatively analyzed, focusing on differences in business models, asset structures, non-interest income trends, and regulatory environments, as well as their impact on returns on assets and equity. The U.S. banking system was found to be distinguished by a business model characterized by a high share of non-interest income, which contributes to higher profitability compared to European banks. In contrast, European banks, despite holding larger asset volumes, exhibit lower profitability due to the persistence of traditional lending models. The authors note that while U.S. banks achieve return on equity levels of around 10–12 percent due to higher non-interest income, European banks, with a greater reliance on interest income, maintain return on equity levels of approximately 7–10 percent [2].

S. Nippani and co-authors examined the relationship between bank size and financial performance in the U.S. banking industry in the period following the global financial crisis of 2008–2009. Their research compared the performance of very large banks, often described as “too big to fail,” with that of medium-sized and small banks. The findings indicate that large banks achieved significantly higher returns on assets and equity than smaller banks. The authors also substantiate the presence of economies of scale, showing that profitability increases as the ratio of operating costs to assets declines. They note that the profitability of small and medium-sized banks is highly dependent on regional factors. At the same time, they emphasize that while large banks demonstrate higher financial performance, they also pose greater systemic risk [3].

In a joint study, O. Batay and others empirically examined the relationship between ESG indicators and financial performance (ROA, ROE, and Tobin’s Q) using panel data on European banks for the period 2009–2018. Their results indicate that green-oriented financial policies positively affected banks’ returns on assets and equity. However, governance-related indicators were found to contribute not to higher profitability but to greater profit stability. Banks that implemented ESG principles not merely as a marketing tool but as part of strategic integration with other sectors achieved higher levels of financial performance. The authors conclude that ESG principles reduce operational risk, enhance reputational advantages, and contribute to higher long-term profitability [4].

In another study, B. Tos and co-authors analyzed the relationship between ESG disclosures and financial stability in European banks. Examining trends for the period 2014–2019, they argue that ESG factors should be regarded not only as an “image” tool but also as a mechanism for mitigating risk. Greater transparency of information reduces the likelihood of banks falling into market risk traps. Their findings indicate that transparency in ESG disclosures contributes to a reduction in systemic and crisis risks. For example, banks with open and standardized ESG indicators exhibited crisis risk levels that were 10–15 percent lower. This positive effect was particularly pronounced among large banks. According to the authors, transparent and standardized ESG disclosure for European banks has evolved from being a “communication cost” into a form of investment in financial stability [5].

RESEARCH METHODOLOGY

This study is based on data obtained from official statistics of Western countries’ central banks, annual reports of commercial banks, and materials of international financial institutions. The collected data were analyzed using comparative analysis, trend analysis, and logical generalization to assess approaches to ensuring the financial performance of banking activities across different national contexts.

ANALYSIS AND RESULTS

As shown in Figure 1, the volume of income earned by U.S. banks in 2024 varied significantly. Although total income increased compared to previous years, profitability levels displayed signs of instability. This indicates the existence of complexities in asset and liability management within banks. From this perspective, it should be emphasized that banks' financial performance depends not only on direct financial indicators but also on non-financial and external factors influencing banking activities (Figure 1).

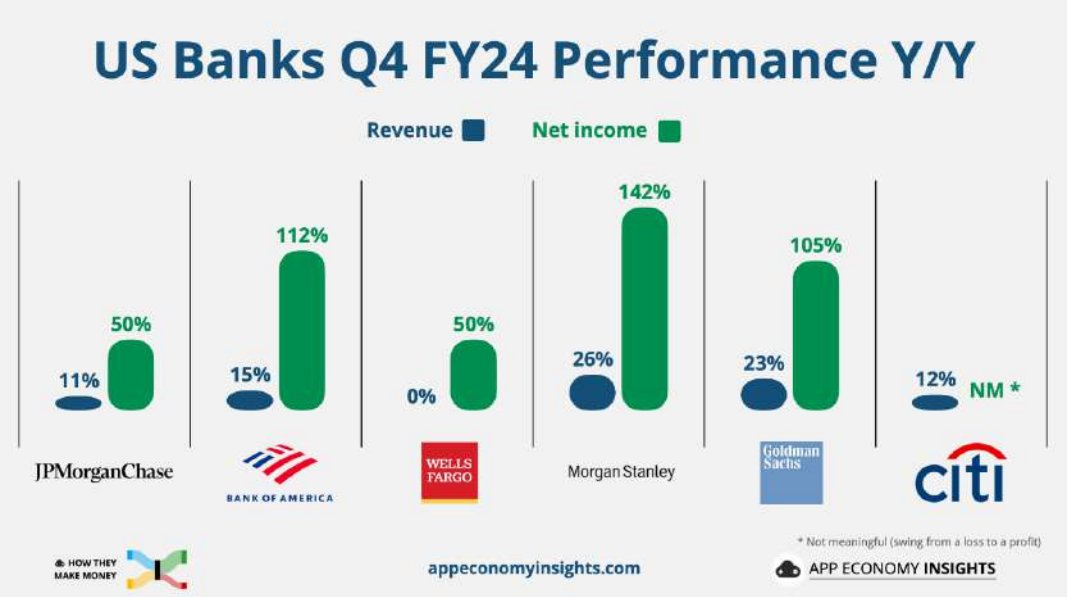

Figure 1. Total profits and revenues of major U.S. banks — 2024 results [6]

Certain analyses conducted by the U.S. Federal Reserve on banks' financial statements also reveal aspects related to financial performance. In 2023–2024, U.S. banks experienced negative financial outcomes as total interest expenses exceeded interest income. Although interest income was generated from mortgage lending and reserve securities, it did not reflect sufficient financial performance. In addition, under conditions of increasing payments to depositors, banks' financial performance demonstrated a downward trend, as noted in the analysis [7].

Based on our research and the experience of the U.S. banking system, the following scientific conclusions were formulated.

First, it is necessary to implement measures aimed at strengthening the role of financial markets in increasing the return on banks' assets. In order to reduce the sensitivity of risk-weighted assets to market fluctuations, diversification should be actively pursued.

Second, greater attention should be paid to increasing the share of non-interest income in banks' income structures. In this regard, it is advisable to expand non-interest income primarily through revenues derived from financial intermediation. In other words, priority should be given to developing banks' role as key advisors in investment activities.

Continuing our research, we proceed to analyze banks' financial performance by examining the banking systems of European Union countries. At present, the banking systems of EU member states are distinguished by the application of international regulatory standards and the prioritization of green policy principles. In addition, practical measures are being implemented to enhance financial performance by expanding high-return assets through green lending, reducing risks, and decreasing the share of non-performing loans.

In regulating banking activities, the European banking system relies heavily on Basel III standards. These standards aim to maintain banks' financial stability by requiring capital adequacy (a minimum Tier 1 core capital ratio of at least 10 percent), a liquidity coverage ratio of at least 100 percent under a 30-day stress scenario, and a stable funding ratio of no less than 100 percent.

Currently, European Union banks are implementing their credit policies based on ESG (Environmental, Social, Governance) principles that prioritize green policy objectives. In 2023, approximately 13 percent of EU banks' asset portfolios consisted of financial instruments reflecting green policy criteria. According to Bloomberg Intelligence estimates, the share of "green" assets in EU banks' asset portfolios is projected to reach 20 percent by the end of 2025 [8].

It should be noted that interest rates on green loans in the EU banking system are typically 0.2–0.45 percentage points lower than those on traditional bank loans. As a result, the volume of loans directed toward sustainable green policies exceeded USD 500 billion during 2022–2023. Since 2020, under European Commission regulatory frameworks, the "Green Asset Ratio (GAR)" indicator has been introduced to measure the share of green assets within banks' loan portfolios. Currently, this ratio stands at approximately 7–8 percent among major European banks. Overall, European banks are increasingly positioning green policy principles as a central element of asset management. The introduction of the green asset ratio indicator has demonstrated that financial performance can no longer be adequately assessed solely on the basis of traditional financial indicators.

CONCLUSIONS AND SUGGESTIONS

In our view, drawing conclusions from the trends observed in the U.S. banking system, it should be emphasized that banks' financial performance depends on a number of key factors.

First, the stability of non-interest income and its share in total bank revenues. Increasing the volume of non-interest income requires the implementation of measures aimed at expanding banks' advisory role in financial market participation.

Second, it is important to prevent an excessive increase in interest-based income from assets relative to non-interest income. A comprehensive approach focused on limiting the growth of banks' risk exposure within their asset portfolios is essential.

Third, ensuring economies of scale plays a significant role. Through policies aimed at bank consolidation and expansion, it is possible to enhance financial performance. From this perspective, banks' financial performance is directly proportional to the scale of their operations; however, it is also necessary to take into account the accompanying increase in risk exposure.

Turning to the financial performance of the banking systems of European Union countries, several scientific conclusions can be highlighted. Since 2010, European commercial banks have undergone complex transformations. In this context, banks' profitability and financial stability have become less dependent on interest margins alone and increasingly focused on risk reduction at various levels, the integration of ESG principles, and improvements in asset quality.

First, banks in the European Union maintain a strict stance based on reserve and capital requirements under Basel III. While this approach strengthens financial stability, it may also constrain banks' profitability levels.

Second, European banks have successfully implemented a transformation by integrating ESG principles into their credit policies. As a result, banks prioritizing ESG principles achieved higher ROA and ROE levels, while operational risks declined. Moreover, greater transparency in ESG disclosures created conditions for reducing crisis risk by 10–15 percent. Consequently, ESG has evolved for European banks from an "image" consideration into a core element of competitive strategy and a tool for risk mitigation.

Third, the introduction of criteria for green lending by European banks has led to a steady increase in the share of green assets over time.

Fourth, alongside the growing importance of non-interest income, the profitability of traditional lending activities appears increasingly constrained.

From this perspective, ESG integration, improvements in asset quality, and strategic risk management are becoming firmly established as the primary drivers of enhanced financial performance in the banking sector.

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MAIN FEATURES OF DIVIDEND POLICY IN COMMERCIAL BANKS

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Abstract: This article provides a scientific analysis of the essence, formation mechanisms, and key features of dividend policy in commercial banks. The study substantiates the impact of dividend policy on banks' financial stability, capitalization level, and the efficiency of lending activities. In addition, the interrelation between changing socio-economic conditions, the bank risk management system, and the volume of non-performing loans in determining dividend payments is examined. The article analyzes existing challenges in financial decision-making during the formation of dividend policy in commercial banks, particularly issues related to maintaining a balance between profit distribution and reinvestment. Based on the research findings, the author proposes conceptual approaches and practical recommendations aimed at reducing non-performing loans, improving the quality of bank assets, and ensuring sustainable development of banking activities through the integration of dividend policy with strategic management.

Key words: dividend, dividend policy, commercial banks, banking activity, lending activity, non-performing loans, financial decisions, bank assets, financial strategy, bank capitalization, bank risks, financial stability, strategic management, financial security of the bank.

Annotatsiya: Ushbu maqolada tijorat banklarida dividend siyosatining mazmuni, shakllanish mexanizmlari va asosiy xususiyatlari ilmiy jihatdan tahlil qilingan. Tadqiqotda dividend siyosatining banklarning moliyaviy barqarorligi, kapitallashuv darajasi hamda kreditlash faoliyati samaradorligiga ta'siri asoslab berilgan. Shuningdek, dividend to'lovlarini belgilashda ijtimoiy-iqtisodiy sharoitlarning o'zgaruvchanligi, bank risklarini boshqarish tizimi va muammoli kreditlar hajmi o'rtasidagi o'zaro bog'liqlik yoritilgan. Maqolada tijorat banklarida dividend siyosatini shakllantirish jarayonida moliyaviy qarorlar qabul qilishdagi mavjud muammolar, xususan foydani taqsimlash va qayta investitsiyalash o'rtasidagi muvozanat masalalari tahlil etilgan. Tadqiqot natijalariga asoslanib, muammoli kreditlarni kamaytirish, bank aktivlari sifatini yaxshilash hamda dividend siyosatini strategik boshqaruv bilan uyg'unlashtirish orqali bank faoliyatining barqaror rivojlanishini ta'minlash bo'yicha mualliflik yondashuvlari va amaliy takliflar ilgari surilgan.

Kalit so‘zlar: dividend, dividend siyosati, tijorat banklari, bank faoliyati, kreditlash faoliyati, muammoli kreditlar, moliyaviy qarorlar, bank aktivlari, moliyaviy strategiya, bank kapitallashuvi, bank risklari, moliyaviy barqarorlik, strategik boshqaruv, bankning moliyaviy xavfsizligi.

Аннотация: В данной статье научно проанализированы сущность, механизмы формирования и основные особенности дивидендной политики в коммерческих банках. В исследовании обосновано влияние дивидендной политики на финансовую устойчивость банков, уровень их капитализации, а также эффективность кредитной деятельности. Кроме того, раскрыта взаимосвязь между изменчивостью социально-экономических условий, системой управления банковскими рисками и объемом проблемных кредитов при определении дивидендных выплат. В статье проанализированы существующие проблемы принятия финансовых решений в процессе формирования дивидендной политики коммерческих банков, в частности вопросы достижения баланса между распределением прибыли и ее реинвестированием. На основе результатов исследования предложены авторские подходы и практические рекомендации, направленные на сокращение проблемных кредитов, повышение качества банковских активов и обеспечение устойчивого развития банковской деятельности за счет согласования дивидендной политики со стратегическим управлением.

Ключевые слова: дивиденд, дивидендная политика, коммерческие банки, банковская деятельность, кредитная деятельность, проблемные кредиты, финансовые решения, банковские активы, финансовая стратегия, капитализация банка, банковские риски, финансовая устойчивость, стратегическое управление, финансовая безопасность банка.

INTRODUCTION

In the conditions of a modern market economy, investment processes are considered one of the key factors ensuring the stable functioning of the financial system and sustainable economic growth. Within this process, commercial banks play a leading institutional role in financing the real sector of the economy through the accumulation and redistribution of financial resources. The effectiveness of banking activities depends not only on lending operations but also directly on profit distribution mechanisms, particularly on the rational implementation of dividend policy.

Dividend policy occupies an important place in the financial management system of commercial banks, determining the procedure and volume of profit distribution among shareholders. Dividends represent one of the main sources of income for shareholders who invest in bank shares, and their level and stability significantly affect a bank's investment attractiveness, market value, and capitalization level. At the same time, dividend policy is closely linked to a bank's internal financial stability, liquidity position, and long-term strategic development objectives.

Under conditions of globalization, integration of financial markets, and increasing volatility of the economic environment, the process of shaping dividend policy in commercial banks has become more complex. When determining dividend payments, banks are required to maintain a balance between profit distribution and reinvestment while taking into account credit risks, the volume of non-performing loans, capital adequacy, and regulatory requirements. In particular, ensuring financial stability within the banking system and effectively managing risks have emerged as key functional tasks of dividend policy.

The Decree of the President of the Republic of Uzbekistan dated May 12, 2020, No. PF-5992, "On the Strategy for Reforming the Banking System of the Republic of Uzbekistan for 2020–2025," highlights a number of systemic problems in the banking sector, including the high level of state participation, insufficient development of management and risk management systems in banks, and the low level of financial intermediation [1]. These circumstances further intensify the need to improve dividend policy in commercial banks, enhance efficient profit management, and increase transparency and openness in banking activities.

The rational implementation of dividend policy contributes to the expansion of banks' lending activities, reduction in the share of non-performing loans, and improvement in asset quality. At the same time, stable dividend payments strengthen shareholder confidence and enhance banks' financial security and competitiveness. Therefore, a comprehensive scientific analysis of the main features of dividend policy in commercial banks, its formation mechanisms, and its interrelation with other areas of banking activity represents a relevant scientific and practical issue.

LITERATURE REVIEW

Issues related to dividend operations in commercial banks, as well as the formation and improvement of dividend policy, have been widely discussed in both international and national academic literature [2], [3]. Dividend policy is commonly regarded as a fundamental component of banks' financial management systems, influencing capitalization levels, financial stability, investment attractiveness, and lending performance [4].

Theoretical studies emphasize different dimensions of dividend policy. According to Miller and Rock, dividend policy plays an important informational role under conditions of asymmetric information, serving as a signal to investors about a bank's financial condition and future prospects [2], [5]. In contrast, Gordon's classical approach argues that dividend payout decisions are closely related to optimal investment and financing behavior, affecting shareholders' required rates of return and perceived risk [3].

Empirical studies further analyze the interaction between dividend policy and agency problems in banking. Lepetit et al. demonstrate that dividend payments are associated with agency costs and the protection of shareholder and creditor rights, particularly in banking institutions where risk exposure and leverage are high [4]. These findings highlight the importance of dividend policy as a governance mechanism in commercial banks.

Russian scholars Fedorova and Lukasevich provide a comprehensive overview of dividend policy theories and their evolution, emphasizing the role of debt quality and market conditions in shaping dividend decisions in banking systems [6]. Their conclusions support the view that dividend policy cannot be analyzed independently from banks' financial structure and risk profiles.

Research conducted by Uzbek economists contributes valuable insights into the national context. Elmirzayev examines the organizational characteristics of dividend policy and identifies key directions for its improvement in joint-stock companies, including banks [7]. Sherqo'ziyeva focuses on the role of dividend policy within the financial management system of joint-stock companies, analyzing dividend principles and payment procedures based on national and international experience [8]. Temirov highlights that dividend policy choices of banks in Uzbekistan are influenced by multiple groups of factors, including regulatory requirements, profitability, and strategic objectives [9].

Overall, the reviewed literature indicates that while dividend policy has been extensively studied from theoretical and empirical perspectives, there remains a need for integrated analysis that considers its interaction with lending activity, risk management, financial stability, and strategic governance, particularly in the context of commercial banks in Uzbekistan.

RESEARCH METHODOLOGY

This study is based on the analysis of regulatory and legal documents, academic literature, and officially published sources related to dividend policy and banking system development. In particular, the Decree of the President of the Republic of Uzbekistan No. PF-5992 on the strategy for reforming the banking system for 2020–2025 provides the institutional and regulatory framework for analyzing dividend policy in commercial banks [1].

The research employs a comparative and critical approach to evaluate existing theoretical concepts and empirical findings on dividend policy presented in international and national studies [2]–[9]. General economic methods are applied to identify key trends and relationships, while systemic analysis is used to examine the interconnections between dividend policy, capitalization, lending activity, and risk management in commercial banks.

In addition, abstract-logical reasoning is employed to synthesize theoretical conclusions, and generalization is used to derive broader implications from the reviewed studies. This methodological approach allows for a structured assessment of the main features of dividend policy in commercial banks and supports the formulation of scientifically grounded conclusions aligned with the specific characteristics of the national banking system.

ANALYSIS AND RESULTS

In commercial banks, the dividend payment mechanism is closely linked to the bank's financial condition, capitalization level, and long-term development strategy. Decisions regarding dividend payments are made based on the bank's net profit, liquidity position, capital adequacy indicators, and compliance with prudential regulations. Therefore, dividend policy functions as an important financial instrument aimed not only at ensuring banks' financial stability but also at providing a balanced protection of shareholders' interests.

In practice, two main forms of dividends are distinguished in commercial banks: cash dividends and stock (share) dividends.

First, cash dividends are paid by banks to shareholders directly in the form of monetary funds. This type of dividend is usually implemented under conditions of stable financial performance and sufficient liquidity resources. Cash dividends may be paid on a regular basis, such as quarterly or annually, or may be determined as one-time payments based on the decision of the bank's highest governing body, namely the general meeting of shareholders. Cash dividends serve as a stable source of income for shareholders and contribute to enhancing the investment attractiveness of bank shares.

Second, stock dividends are paid through the issuance of additional shares to shareholders instead of cash payments. This method is primarily applied when banks aim to preserve cash flows, increase capitalization, and strengthen financial stability. Stock dividends contribute to an increase in the bank's authorized capital and are of particular importance from the perspective of long-term strategic development. At the same time, this form of dividend increases shareholders' ownership stakes in the bank, thereby strengthening their interest and involvement in the bank's activities.

Overall, the choice of dividend payment form in commercial banks is determined by the bank's financial strategy, risk management policy, and regulatory requirements. The rational implementation of dividend payments plays a crucial role in ensuring banks' financial stability and long-term competitiveness.

At the end of each financial year, commercial banks prepare annual financial statements summarizing their financial performance. If the bank generates net profit during the reporting period, this profit may be retained as undistributed earnings, allocated to bank development and capitalization enhancement, or distributed among shareholders in the form of dividends. The decision to distribute dividends is made by the bank's highest governing body, the general meeting of shareholders, and is based on the bank's financial condition, strategic objectives, and regulatory requirements.

The calculation and payment of dividends are carried out in proportion to shareholders' ownership stakes in the bank's authorized capital. These ownership stakes are formed based on the monetary or in-kind contributions made by founders during the establishment of the legal entity. The proportion of ownership serves as the main criterion for determining the volume of dividend payments and ensures fairness and transparency in the implementation of dividend policy. At the same time, dividend policy reflects the extent to which banks fulfill their obligations to shareholders and indicates the effectiveness of corporate governance.

Table 1. Main features of dividend policy in commercial banks at the state and corporate levels

Level of analysis	Main directions	Economic content of dividend policy	Scientific and analytical interpretation
State level	Financial market development	Dividend policy activates capital circulation in the financial market and increases investor confidence	Stable dividend payments contribute to stock market development and diversification of financial instruments
	Consumer market coordination	Dividend income expands households' consumption opportunities	Growth in household income through dividends stimulates domestic demand
	Enhancement of population's financial literacy	Understanding dividend mechanisms forms financial knowledge	Investment in bank shares increases the financial activity of the population
	State budget revenues	Tax revenues from dividends increase budget income	Dividend policy acts as a factor strengthening fiscal stability
Corporate level	Investment attractiveness	Dividend policy determines the attractiveness of bank shares for investors	Stable dividends strengthen the bank's market image
	Stock market price	Dividends influence the formation of share prices	Dividend signals contribute to optimizing market valuation
	Formation of financial resources	Dividends affect profit distribution and reinvestment	A rational dividend policy creates opportunities for capital growth
	Bank capitalization	Dividend policy affects the bank's authorized capital and financial stability	The balance between dividends and capitalization is of strategic importance

In order to develop the capital market and improve the investment climate in the country, a number of fiscal incentives aimed at encouraging dividend policy have been introduced. In particular, in accordance with the Resolution "On Additional Measures to Introduce Effective Mechanisms for Supporting the Capital Market," dividends received from shares by resident and non-resident individuals were exempted from personal income tax for the period from April 1, 2022 to December 31, 2024. In addition, a reduced corporate income tax rate of 5 percent was established for dividend income received from shares by non-resident legal entities. Furthermore, income received by resident and non-resident individuals and legal entities from bonds issued by business entities has been exempted from personal income tax and corporate income tax. These tax incentives contribute to activating the capital market by attracting dividend and interest income.

Such fiscal preferences play an important role in further improving the dividend policy of commercial banks, increasing investor activity, and strengthening the capitalization level of the banking system.

At the same time, dividend policy in commercial banks is not limited solely to a profit distribution mechanism; rather, it represents an important financial instrument that supports banks' financial stability, investment attractiveness, and long-term strategic development.

Table 2. Dynamic Analysis of the Dividend Policy of JSC "Aloqabank" for 2023–2025 (million UZS)

Year	Type of share	Declared dividend	Characteristics of dividend policy	Analytical assessment
2023	Ordinary (OS)	—	Dividends were determined based on the financial results of 2022	Priority was given by the bank to profit capitalization
	Preferred (PS)	—	Dividends were not declared	Payments on preferred shares were temporarily suspended
2024	Ordinary (OS)	—	Dividends were calculated on a cumulative basis for 2019–2023	A trend toward gradual settlement of past obligations
	Preferred (PS)	7,380.0	Stable dividend payments were restored	Investment attractiveness of preferred shares increased
2025	Ordinary (OS)	—	No information available on dividend payments	Dividend policy may be subject to revision
	Preferred (PS)	1,476.0	Dividend payments were continued	Reduction in dividend volume is explained by financial prudence

The table presents information on dividends calculated and paid by Aloqabank during 2023–2025. In particular, in 2023 dividends on ordinary shares were calculated based on the financial results of 2022, while no dividends were declared on preferred shares. In 2024, dividends on ordinary shares were calculated on a cumulative basis for the period 2019–2023, whereas dividends on preferred shares amounted to 7,380.0 million UZS. In 2025, dividends of 1,476.0 million UZS were calculated on preferred shares, while no information was provided regarding dividends on ordinary shares. These data reflect the dynamics of the bank's dividend policy and the fulfillment of its obligations to shareholders.

Table 3. Information on Dividends Calculated and Paid on Bank Shares by Mikrokreditbank ATB during 2013–2024

No.	Reporting year	Dividends on ordinary shares	Dividends on preferred shares
1	2013	Not declared	20 percent of nominal value, 213.60 UZS per share
2	2014	Not declared	20 percent of nominal value, 213.60 UZS per share
3	2015	Not declared	20 percent of nominal value, 213.60 UZS per share
4	2016	Not declared	20 percent of nominal value, 213.60 UZS per share
5	2017	Not declared	20 percent of nominal value, 213.60 UZS per share
6	2018	Not declared	20 percent of nominal value, 213.60 UZS per share
7	2019	Not declared	20 percent of nominal value, 213.60 UZS per share
8	2020	Not declared	20 percent of nominal value, 213.60 UZS per share
9	2021	Not declared	20 percent of nominal value, 213.60 UZS per share
10	2022	Not declared	20 percent of nominal value, 213.60 UZS per share
11	2023	Not declared	20 percent of nominal value, 213.60 UZS per share
12	2024	Not declared	20 percent of nominal value, 213.60 UZS per share

The table shows that during the analyzed period no dividends were declared on ordinary shares. In contrast, dividends on preferred shares were paid consistently each year at the level of 20 percent of the nominal value, amounting to 213.60 UZS per share.

In the practice of commercial banks, dividend policy is mainly implemented through the mechanism of distributing net profit. However, empirical observations indicate that in most commercial banks the volume of dividend payments remains below the annual inflation rate, which does not fully compensate investors for the loss of real income. As a result, the investment attractiveness of bank shares declines, and the growth rate of bank capital fails to meet the requirements of the modern economic environment.

This situation highlights the need to strengthen the role of dividend policy in commercial banks not only as a profit distribution tool, but also as a strategic financial instrument that ensures capitalization growth and reinforces investor confidence. Especially in the context of developing the banking system of Uzbekistan and integrating it into international financial markets, the introduction of a stable and predictable dividend policy based on advanced foreign experience represents an issue of high scientific and practical relevance. From this perspective, commercial banks are required to adopt a long-term strategic approach when shaping their dividend policies.

In order to increase authorized capital and strengthen financial stability, the successful placement of bank shares in the securities market is of particular importance. For this purpose, it is necessary to enhance the interest of both domestic and foreign investors in bank shares. In this process, dividend policy acts as a key incentive factor, playing a decisive role in increasing banks' competitiveness, strengthening their position in the capital market, and attracting long-term investments.

CONCLUSION AND SUGGESTIONS

The research findings indicate that dividend policy in commercial banks is not limited merely to the distribution of bank profits; rather, it represents an important financial mechanism that directly influences banks' financial stability, capitalization level, investment attractiveness, and long-term strategic development. It has been established that the formation of dividend policy is closely linked to a bank's financial performance, the level of risk management, the quality of the loan portfolio, and regulatory requirements.

The analysis shows that in most commercial banks in Uzbekistan dividend policy is characterized by a cautious approach, primarily aimed at profit capitalization and ensuring banking stability. However, in many cases dividend payments remain below the inflation rate, which reduces the investment attractiveness of bank

shares and limits the growth of bank capital through market mechanisms. In particular, the absence of dividends or the payment of low dividends on ordinary shares negatively affects investor activity.

Comparative analysis also reveals significant differences in dividend policies among banks, which can be explained by variations in ownership structure, strategic priorities, and areas of operation. In banks with a high share of state ownership, dividend policy is more strongly subordinated to social and institutional objectives, whereas in private banks it is more oriented toward attracting investors and increasing the market value of shares.

Overall, improving dividend policy in commercial banks plays a crucial role in ensuring the sustainable development of the banking system, activating the capital market, and strengthening investor confidence.

Based on the above conclusions, the following scientific and practical recommendations are proposed to improve dividend policy in commercial banks:

1. Dividend policy in commercial banks should be aligned with long-term development strategies, ensuring an optimal balance between profit distribution and reinvestment.
2. To increase investor activity, banks are recommended to introduce at least minimum dividend payments on ordinary shares.
3. In order to preserve real returns, mechanisms should be implemented to align dividend payments with the inflation rate when designing dividend policy.
4. Banks should pursue a clear, predictable, and transparent information policy regarding dividend policy in order to strengthen investor confidence.
5. It is advisable to adapt best international practices applied in developed banking systems—such as stable dividend payments, dividend payout ratios, and dividend signaling mechanisms—to the national banking system.
6. To support capital market development, it is recommended to continue tax incentives on dividends and link them to increases in banks' capitalization levels.
7. Improving loan portfolio quality expands the capacity for dividend payments; therefore, further enhancement of risk management systems in banks is necessary.

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OPTIMIZATION OF THE DESIGN OF AN ENERGY- AND RESOURCE-EFFICIENT PRESSING DEVICE FOR CONVERTING DRIED LEAVES, FALLEN FOLIAGE, AND PLANT RESIDUES INTO LOCALLY PRODUCED ORGANIC FERTILIZERS

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Abstract: The article considers the issues of developing energy-efficient press equipment intended for processing organic waste, particularly dried leaves and plant residues. The environmental and economic advantages of densification technology through pressing organic waste are substantiated. The main technological parameters of the pressing process are analyzed, and constructive solutions aimed at reducing energy consumption are proposed. According to the research results, the use of energy-efficient press equipment allows reducing the volume of organic waste, decreasing the amount of harmful emissions released into the atmosphere, and obtaining environmentally friendly organic fertilizer.

Key words: organic waste, pressing, energy efficiency, leaf waste, environmental efficiency, organic fertilizer.

Annotatsiya: Maqolada organik chiqindilarni, xususan, qurigan barg va o‘simlik qoldiqlarini qayta ishlash uchun mo‘ljallangan resurs va energiya tejamkor presslovchi qurilmani yaratish masalalari ko‘rib chiqilgan. Organik chiqindilarni presslash orqali zichlashtirish texnologiyasining ekologik va iqtisodiy afzalliklari asoslab berilgan. Presslash jarayonining asosiy texnologik parametrlari tahlil etilib, energiya sarfini kamaytirishga qaratilgan konstruktiv yechimlar taklif etilgan. Tadqiqot natijalariga ko‘ra, energiya tejamkor presslovchi qurilmalardan foydalanish organik chiqindilar hajmini kamaytirish, atmosferaga chiqariladigan zararli moddalar miqdorini qisqartirish va ekologik toza organik o‘g‘it olish imkoniyatini beradi.

Kalit so‘zlar: organik chiqindilar, presslash qurilmasi, resurs va energiya tejamkorlik, barg chiqindilari, ekologik samaradorlik, organik o‘g‘it tayyorlash.

Аннотация: В статье рассмотрены вопросы создания об энергоэффективного прессового оборудования, предназначенного для переработки органических отходов, в частности сухих листьев и растительных остатков. Обоснованы экологические и экономические преимущества технологии органических отходов методом прессования. Проанализированы основные технологические параметры процесса прессования и предложены конструктивные решения, направленные на снижение энергозатрат. Результаты исследования показывают, что применение энергоэффективного прессового оборудования позволяет сократить объем органических отходов, уменьшить количество вредных выбросов в атмосферу и получить экологически чистое органическое удобрение.

Ключевые слова: органические отходы, прессовочные устройство, энергоэффективность, листовые отходы, экологическая эффективность, подготовления органическое удобрение.

INTRODUCTIONS

Today, ensuring environmental sustainability, the rational use of natural resources, and the growing demand for organic fertilizers in agriculture necessitate the search for alternative technological solutions. In particular, dried leaves, fallen foliage, and various plant residues generated during agricultural and municipal activities accumulate in large quantities as waste and are often disposed of inefficiently. Recycling these wastes to produce locally sourced organic fertilizers represents an environmentally and economically relevant challenge.

The use of pressing technologies in converting plant residues into organic fertilizers makes it possible to reduce their volume, improve storage and transportation convenience, and accelerate subsequent biological decomposition processes. However, most existing pressing devices are characterized by high energy consumption, structural complexity, and insufficiently efficient use of resources. Therefore, the development of energy- and resource-efficient pressing equipment and the optimization of their design are of significant scientific and practical importance.

This study examines issues related to optimizing the design of a pressing device used in the process of converting dried leaves, fallen foliage, and plant residues into locally produced organic fertilizers. The main objective of the research is to reduce energy consumption during the pressing process, increase equipment productivity, and ensure the environmental efficiency of the technological process. This approach contributes to the introduction of innovative technologies in the recycling of agricultural waste.

REVIEW OF LITERATURE ON THE SUBJECT

The issue of converting dried leaves, fallen foliage, and plant residues into locally produced organic fertilizers is closely linked to environmental sustainability, rational resource use, and improvements in agricultural efficiency. In recent years, scientific research in this field has gained particular significance. The ecological foundations of organic waste recycling are extensively addressed in the studies of Abdurakhmonov A.A., who substantiates the assessment of organic waste as a secondary resource, demonstrates the potential for improving soil fertility through recycling, and highlights the reduction of negative environmental impacts. This approach emphasizes the necessity of ensuring environmental safety when recycling dried leaves and plant residues as fertilizers.

In studies by Ibragimov B.Sh. and Karimov U.R. devoted to technologies for recycling agricultural waste, the processes of processing biomass waste using mechanical and thermomechanical methods are analyzed. The authors emphasize the economic and technological efficiency of waste compaction, shredding, and pressing technologies, substantiating that the use of energy-efficient equipment is a key factor in reducing production costs. These scientific perspectives support the need to optimize the design of pressing equipment.

Issues related to resource-efficient technologies and the design of environmentally safe equipment are thoroughly analyzed in the works of Ganiyev R.G., where minimizing energy consumption, simplifying structural elements, and ensuring the sustainability of production processes are considered key criteria. According to the author's approach, the constructive optimality of recycling equipment determines not only technical efficiency but also economic performance. This serves as an important methodological basis for improving pressing devices intended for organic fertilizer production.

The constructive solutions of pressing equipment and issues related to their calculation are detailed in the studies of Kuznetsov V.P. The author pays particular attention to the stress state of press mechanisms, the efficiency of energy transmission, and the determination of optimal geometric parameters of working components. These scientific insights provide an important theoretical foundation for developing design solutions aimed at reducing energy losses and increasing equipment reliability in the pressing of biomass waste.

In international scientific literature, studies conducted by Rahman M. and Salam P. recognize sustainable technologies aimed at converting waste into resources as a key direction in agricultural development. The authors emphasize that increasing energy efficiency in biomass waste processing, reducing the carbon footprint, and

expanding local fertilizer production can lead to economic and environmental sustainability. This perspective substantiates the relevance of optimizing the proposed pressing device design from a global standpoint as well.

Overall, the analyzed scientific sources indicate that the development of an energy- and resource-efficient pressing device and the optimization of its design for converting dried leaves and plant residues into organic fertilizers are economically justified. These studies provide a solid theoretical and methodological foundation for the present scientific article.

RESEARCH METHODOLOGY

In this study, information on the processing of dried leaves and plant residues using a pressing device was obtained through laboratory experiments, technical observations, and an analysis of existing scientific sources. The collected data were analyzed using comparative analysis, techno-economic assessment, and methods for calculating energy and resource consumption.

ANALYSIS AND RESULTS

Today, population growth, accelerated urban expansion, and the intensification of agricultural activities are leading to a steady annual increase in the volume of organic waste. In particular, during autumn seasons, organic wastes such as dried leaves, fallen foliage, and plant residues are often burned or stockpiled in open areas without effective processing. Greenhouse gases generated from these accumulated wastes and their release into the atmosphere (as a result of burning) cause environmental problems and lead to air pollution [1].

One of the most promising directions in organic waste processing involves compacting waste using mechanical equipment and subsequently utilizing it as organic fertilizer. These processes are often characterized by increased transportation-related operating costs. Therefore, the development of energy-efficient, compact, and environmentally compliant pressing devices remains an urgent scientific and practical challenge.

The main objective of this article is to conduct scientific and analytical research aimed at designing energy- and resource-efficient pressing devices for processing dried leaves, fallen foliage, plant residues, and other organic wastes that are currently considered environmental problems, as well as to scientifically substantiate their environmental effectiveness.

As the research object, the process of producing locally sourced organic fertilizers by pressing dried leaves and plant residues was selected, focusing on the development of a new-design mechanical pressing device that is economically efficient and resource- and energy-saving [2, 3].

The following methods were applied in the study:

- scientific and rational analysis of the chemical properties of organic waste;
- development of a new pressing device design based on scientific analysis of the physical properties of leaves, foliage, and plant residues;
- ensuring resource efficiency during the pressing process by reducing energy, time, and labor consumption;
- comparative analysis of scientific and technological solutions for creating a compact pressing device against analogous designs based on scientific principles;
- scientific substantiation of methods for the economic assessment of environmental efficiency.

The technology of producing local fertilizers by pressing dried leaves, fallen foliage, and plant residues has several significant advantages:

- it enables a reduction in waste volume by up to 8–10 times;
- it significantly reduces transportation and storage costs;
- it allows processing together with additional organic waste while preserving the natural composition of organic matter;
- it creates a basis for obtaining organic fertilizers used to improve soil fertility.

At the same time, the efficiency of the pressing process largely depends on the energy consumption and design solutions of the equipment.

Principles for Designing Energy-Efficient Pressing Devices. When designing energy- and resource-efficient pressing devices, attention should be paid to the following key engineering requirements:

- selection of optimal shapes and dimensions of the pressing chamber;
- improvement of the sequential motion trajectory rules of pressing components;
- ensuring energy efficiency and increasing production speed by reducing friction forces within the pressing chamber;
- effective use of automated systems to facilitate easy control of the pressing device and its electric drive.

In developing the proposed pressing device, the efficient use of smooth-surface screw mechanisms makes it possible to create low-energy-demand mechanisms. This approach can reduce overall energy consumption by 20–30% [4, 5].

Assessment of Environmental Efficiency. The environmental efficiency of the energy- and resource-efficient pressing device was evaluated based on the following indicators:

• reduction in the amount of harmful gases released into the atmosphere;

• elimination of the need to burn waste;

• assessment of the agro-ecological effectiveness of locally produced fertilizers obtained from processed dried leaves, fallen foliage, and plant residues.

The research results indicate that locally produced fertilizers obtained from granular organic waste processed by pressing increase soil fertility, improve soil structure, enhance microbial activity, and reduce the need for mineral fertilizers.

The obtained results demonstrate that the implementation of energy- and resource-efficient pressing equipment is justified not only economically but also environmentally. By designing and assembling the proposed pressing device, it becomes possible during autumn seasons to process dried leaves, fallen foliage, and dry grass from urban municipal services into compacted local fertilizers, thereby expanding opportunities to improve agricultural land productivity. In addition, the device can be effectively applied in agriculture by pressing post-harvest crop residues, such as stems and leaves, in farming operations and converting them into locally produced organic fertilizers [6].

The conducted analyses and scientific approaches indicate that optimizing the design of a pressing device for converting dried leaves, fallen foliage, and plant residues into locally produced organic fertilizers is one of the key factors in ensuring energy and resource efficiency. Through technological improvement of the pressing process, it becomes possible to significantly reduce waste volume, optimize energy consumption, and enhance the quality of the final product.

By scientifically substantiating the selection and optimization of the main structural elements of the pressing device, its operational efficiency can be increased. The use of energy-efficient technical solutions contributes to reducing production costs and lowering the environmental burden, thereby ensuring the sustainability of the organic fertilizer production process.

CONCLUSIONS AND SUGGESTIONS

In conclusion, optimizing the design of a pressing device intended for processing plant residues has significant scientific and practical importance for the development of waste-free technologies in agriculture, the expansion of local organic fertilizer production, and environmental protection. The research findings may serve as a theoretical and methodological basis for the future development and practical implementation of energy-efficient agrotechnical equipment.

The pressing device for organic waste represents an effective and environmentally safe method for processing dried leaves, fallen foliage, and plant residues.

• the development of an energy- and resource-efficient pressing device design significantly reduces energy consumption;

• organic fertilizers obtained through pressing help reduce negative environmental impacts and contribute to improving ecological infrastructure in both urban and rural areas.

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FUNDAMENTALS OF FORMING ACCOUNTING POLICIES FOR LEASING COMPANIES BASED ON INTERNATIONAL FINANCIAL REPORTING STANDARDS

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Abstract: This article examines the fundamentals of forming accounting policies for leasing companies based on International Financial Reporting Standards (IFRS). The study analyzes the procedures for accounting for leasing transactions and preparing financial statements in accordance with international standards. Particular attention is paid to the accounting treatment of leasing operations by lessors and lessees, as well as to the transformation of financial reporting in line with IFRS requirements.

Key words: leasing, lessee, lessor, accounting for leasing transactions, transformation, International Financial Reporting Standards.

Annotatsiya: Ushbu maqolada lizing korxonalari uchun xalqaro moliyaviy hisobot standartlari (IFRS) asosida hisob siyosatini shakllantirishning asosiy jihatlari ko‘rib chiqilgan. Tadqiqotda lizing operatsiyalarini hisobga olish va moliyaviy hisobotlarni xalqaro standartlarga muvofiq tayyorlash tartiblari tahlil qilingan. Shuningdek, lizing beruvchi va lizing oluvchilar tomonidan lizing operatsiyalarini hisobda aks ettirish hamda moliyaviy hisobotlarni IFRS talablariga moslashtirish masalalariga alohida e’tibor qaratilgan.

Kalit so‘zlar: lizing, lizing oluvchi, lizing beruvchi, lizing operatsiyalarini hisobga olish, transformatsiya, xalqaro moliyaviy hisobot standartlari.

Аннотация: В статье рассматриваются основные аспекты формирования учетной политики для лизинговых компаний на основе международных стандартов финансовой отчетности (IFRS). В исследовании проанализированы порядок учета лизинговых операций и подготовки финансовой отчетности в соответствии с международными стандартами. Особое внимание уделено отражению лизинговых операций у лизингодателей и лизингополучателей, а также вопросам трансформации финансовой отчетности в соответствии с требованиями IFRS.

Ключевые слова: лизинг, лизингополучатель, лизингодатель, учет лизинговых операций, трансформация, международные стандарты финансовой отчетности.

INTRODUCTION

A lease in which the cost of the leased asset is fully recovered is generally referred to as a financial lease. Financial leasing, that is, leasing in which the value of the asset is fully paid, is characterized by the fact that the duration for which the asset is provided to an economic entity for use is close to the period of its exploitation and depreciation, during which the lessor recovers all or most of the asset’s value. Over the term of a financial lease agreement, the lessor fully recovers the value of the asset through lease payments and receives an appropriate profit from the transaction. Financial leasing is the most widely used form of leasing worldwide and includes numerous types, each with its own independent function and designation.

The development and improvement of financial leasing provide the following opportunities:

– ensuring the inflow of significant volumes of non-state investment into the economy, particularly private investment;

– achieving growth in gross domestic product through technical and technological modernization;

– increasing direct tax revenues by expanding production volumes in sectors established on the basis of leasing;

– enhancing investment activity, supporting the formation of small and medium-sized business entities, and contributing to the development of a middle class of property owners.

LITERATURE REVIEW

Issues related to the accounting of leasing transactions have been widely examined in the studies of international scholars such as V. T. Nguyen, K. Laviniya, K. Yu. Chau, P. P. Lyusiya, U. V. Pun, F. Molla, F. Chiyen, and Ch. N. Van, as well as researchers from CIS countries including A. V. Tokareva, V. Skobara, Ye. S. Piskun, I. Zubarev, and N. N. Balashova. Their works primarily focus on the theoretical foundations of leasing, the classification of leasing transactions, and methodological approaches to accounting and reporting for financial leasing [2]. In the context of improving leasing accounting practices, a significant contribution has been made by Uzbek scholars such as A. T. Xashimova, R. O. Xolbekov, B. A. Xasanov, G. M. Raximova, D. M. Matkarimov, D. K. Qudbiyev, I. N. Ismanov, I. N. Qo‘ziyev, K. B. Urazov, K. X. Xotamov, M. A. Yuldashev, M. Q. Pardayev, R. D. Dusmuratov, S. N. Tashnazarov, X. A. Tuxsanov, and Sh. T. Ergasheva. In their scientific works, these authors analyze various issues arising in financial leasing, including the economic nature of leasing transactions, their role in economic development, and directions for improving leasing operations through both theoretical and practical recommendations [1]. Special attention in the national literature is given to the organization of accounting for leasing transactions. Researchers such as D. G‘. G‘ozibekov, O. M. Quljonov, and A. T. Xoshimova have conducted in-depth studies in this area. In particular, D. G‘. G‘ozibekov’s research reveals the economic foundations for the development of leasing activities, emphasizing their role in investment processes and modernization of the economy [6]. O. M. Quljonov focuses on the regulatory and legal framework governing leasing transactions and highlights the importance of proper documentation and compliance with national regulations [4]. Meanwhile, A. T. Xoshimova places greater emphasis on organizing the accounting of leasing transactions in accordance with national accounting standards, addressing issues of recognition, measurement, and presentation in financial statements [2]. In addition, regulatory and institutional aspects of leasing accounting are reflected in official normative documents and international standards. The Action Strategy for the Development of the Republic of Uzbekistan outlines priorities for economic modernization and investment activity, within which leasing plays an important role as a financial instrument [1]. International standards on quality control, audit, review, and assurance services provide methodological guidance for ensuring the reliability and transparency of financial reporting related to leasing transactions [2]. Analytical materials and sectoral reviews of the leasing market in Uzbekistan further demonstrate current trends, challenges, and development prospects of the leasing sector [6]. Overall, the reviewed literature indicates that although significant research has been conducted on leasing transactions and their accounting, further studies are required to harmonize national accounting practices with International Financial Reporting Standards and to improve the accounting policy framework for leasing companies under IFRS requirements [2], [4].

RESEARCH METHODOLOGY

The study employs methods of analysis and synthesis, induction and deduction, a systems approach, abstract–logical reasoning, monographic observation, statistical analysis, economic analysis, as well as economic and mathematical methods.

ANALYSIS AND RESULTS

A significant share of leasing companies are classified as large taxpayers. In accounting for leasing transactions, interest income received and interest expenses related to leasing operations are treated separately. In the accounting policy of JSC Uzbek Leasing International A.O. prepared in accordance with international standards, interest income and interest expenses arising from leasing transactions are reflected by introducing additional lines titled “Interest income” and “Interest expenses” within the statement of financial results. Specifically, these items are included under line 010 “Net revenue from the sale of products (goods, works, and services)” and line 020 “Cost of sold products (goods, works, and services),” which significantly simplifies the accounting and audit of interest-related income and expenses from leasing transactions. With the inclusion of these additional lines, the author proposes an enhanced format of the statement of financial results for JSC Uzbek Leasing International A.O., incorporating interest income and interest expenses as follows.

Table 1. Statement of Financial Results of JSC "Uzbek Leasing International A.O." for 2024

No.	Indicator name	Line code	2024
1	Net revenue from the sale of products (goods, works, and services)	010	78,749,007
2	Interest income	011	71,258,549
3	Cost of sold products (goods, works, and services)	020	3,046,542
4	Interest expenses	021	1,408,112

As shown in the table, approximately 90 percent of net revenue from the sale of products (goods, works, and services) in JSC Uzbek Leasing International A.O. is generated from interest income related to leasing transactions. At the same time, interest expenses account for 46 percent of the cost of sold products (goods, works, and services). The disclosure of these indicators in financial statements enables leasing companies to conduct a more accurate and reliable analysis of interest income and expenses associated with leasing transactions. During the transformation process, it is necessary for lessor organizations to review fixed assets based on their classification. This review allows for verification of whether depreciation has been calculated correctly in accordance with asset categories. It should be noted that in the Republic of Uzbekistan, in most leasing organizations, receivables related to leased fixed assets are recorded under accounts for payments receivable under finance leases and are treated as long-term assets. However, under International Financial Reporting Standards, lease payments are recognized as short-term items and are reflected within the current assets section. The organization of accounting in leasing companies based on International Financial Reporting Standards is carried out by transforming financial statements prepared under national standards into IFRS-compliant reports for external users and investors. At the same time, maintaining parallel accounting records directly under IFRS requires significant costs. Therefore, in the leasing companies examined in this study, financial reporting under IFRS has been implemented through a transformation approach.

In the transformation process, lessor companies are required to review fixed assets by groups, ensuring that depreciation has been calculated correctly based on this grouping.

During the transformation of the financial statements of JSC Uzbek Leasing International A.O. from national accounting standards to International Financial Reporting Standards, the following accounting entries are proposed.

Table 2. Proposed accounting entries in the process of transforming the financial statements of JSC "Uzbek

No.	Description of business transactions	Debit	Credit
1	Revaluation adjustment of fixed assets	Fixed asset revaluation	Adjustments for revaluation of long-term assets
2	Revaluation adjustment of accumulated depreciation of fixed assets	Accumulated depreciation of fixed assets	Fixed asset revaluation
3	Adjustment of advances paid	Retained earnings (uncovered loss)	Advances paid to suppliers and contractors
4	Provision recognized for advances	Retained earnings (uncovered loss)	Provision for doubtful debts
5	Provision recognized for employees' vacation pay	Retained earnings (uncovered loss)	Liabilities to accountable persons
6	Adjustment of prepaid (future period) expenses	Retained earnings (uncovered loss)	Prepaid expenses
7	Adjustment of materials	Retained earnings (uncovered loss)	Materials
8	Adjustment of long-term leasing receivables	Other receivables (current)	Long-term receivables
9	Adjustment of fixed asset acquisition cost	Fixed asset acquisition	Adjustments for revaluation of long-term assets
10	Provision recognized for leasing portfolio	Other operating expenses	Provision for doubtful debts

Leasing International A.O." in accordance with International Financial Reporting Standards

After the transformation process, the relevant accounts in the lessor's financial statements prepared under national accounting standards are adjusted accordingly. Once these adjustments are taken into account, the lessor's financial statements prepared in accordance with International Financial Reporting Standards are

obtained. In many leasing companies, during the transformation process, the revaluation of fixed assets and accumulated depreciation is revised, and the carrying amounts are presented at fair and reliable values.The core activity of leasing companies consists of leasing operations and the related income generation. However, during the transformation process, after analyzing the leasing portfolio and taking into account overdue receivables, provisions are recognized for the leasing portfolio and reflected in the financial statements prepared in accordance with international standards.

According to Russian scholars, leasing arrangements may be classified as short-term and long-term based on the lease term. Short-term leasing involves the temporary use of a leased asset with a mandatory obligation to return it. Long-term leasing, by contrast, refers to leasing arrangements in which the leased asset is transferred for a period exceeding one year and is recognized on the balance sheet of the lessee. In financial leasing, all risks associated with ownership and use of the leased asset are transferred to the economic entity. In accounting records, the lease should be recognized at the commencement of the lease term as both an asset and a liability at an amount equal to the fair value of the leased asset or, if lower, the present value of minimum lease payments. If the discounted value of minimum lease payments is lower than the fair value of the leased asset, the lease is recognized as an asset and liability at the discounted value of minimum lease payments. If it is higher, the lease is recognized at the fair value of the leased asset. Costs incurred by the economic entity related to the acquisition, delivery, or preparation of the leased asset for use are included in the cost of the leased asset. The regulation governing accounting for leasing transactions specifies the accounting entries described above. In our view, in order to improve accounting practices for lessees, economic entities should apply account 0310 “Fixed assets acquired under long-term lease agreements.” In Form 1 “Balance Sheet,” line 010 reflects the total of accounts 0100 and 0300, while accumulated depreciation is presented in line 011. Based on this approach, the accounting of leased fixed assets in the lessee’s records is significantly simplified. To further improve this simplified system, it is recommended that lessees open analytical accounts. Specifically, within the chart of accounts, the following sub-accounts are advisable:

0121 – “Buildings acquired under long-term lease agreements”;

0131 – “Machinery and equipment acquired under long-term lease agreements”;

0161 – “Vehicles acquired under long-term lease agreements.”

Similarly, for depreciation accounting, it is appropriate to introduce sub-accounts such as:

0221 – “Depreciation of buildings acquired under long-term lease agreements”;

0231 – “Depreciation of machinery and equipment acquired under long-term lease agreements”;

0261 – “Depreciation of vehicles acquired under long-term lease agreements.”

The use of fixed assets acquired under financial lease agreements results in depreciation charges and maintenance-related expenses in each reporting period. Depreciation of fixed assets is calculated in accordance with National Accounting Standard No. 5 “Fixed Assets,” approved by the Ministry of Finance and registered by the Ministry of Justice on January 20, 2004, under No. 1299.

If there is no certainty that ownership of the leased asset will be transferred to the economic entity at the end of the lease term, the asset may be fully depreciated over the shorter of either the lease term or the useful life of the asset. The total amount of depreciation charges and financial expenses (interest on leasing) related to the leased asset may not necessarily be equal to the lease payments payable by the lessee for the reporting period. Financial leasing is classified into long-term and short-term leases. When fixed assets are leased under long-term financial leasing agreements, the difference between the value recognized as an asset (lease receivable) in the lessor’s accounting records and the initial value of the fixed asset (if unused prior to leasing) or its residual value (if previously used) is adjusted by taking into account revaluation results recorded in reserve capital accounts. This difference is recognized as deferred income or expense and is subsequently allocated on a systematic basis (monthly) to other operating income or other operating expenses in proportion to lease payment recognition. Under short-term financial leasing agreements, fixed assets acquired are recorded off-balance-sheet by the lessee in debit account 001 “Fixed assets acquired under short-term lease agreements,” while the lessor continues to recognize the assets as part of its fixed assets.

CONCLUSION AND SUGGESTIONS

Financial leasing, as defined in accounting policy, is a form of leasing applied not only in the Republic of Uzbekistan but also widely used in international practice. According to accounting policies based on International Financial Reporting Standards, the initial measurement of real estate classified as investment property and held by an entity under a lease agreement is determined in the same manner as for finance leases. Specifically, the asset must be recognized at the lower of two amounts: the fair value of the property and the present value of minimum lease payments. An equivalent amount should be recognized as a liability in accordance with this requirement.

The study examines the reflection of leasing transactions of lessor entities through account correspondence, as well as issues related to improving leasing operations and their accounting in the Republic of Uzbekistan by applying international standards and foreign experience.

In Uzbekistan, a number of regulatory and legal documents have been adopted to improve the accounting of leasing transactions in leasing companies in line with international standards. Based on these regulatory requirements, leasing companies classified as large taxpayers are required to maintain accounting for leasing transactions in accordance with International Financial Reporting Standards. In economic entities, accounting for leasing transactions should be presented from both sides of the transaction, that is, from the perspectives of both the lessee and the lessor, as the accounting systems of these parties form the core of leasing operations.

Based on the above, this research provides a comprehensive analysis of the organizational aspects and accounting principles of leasing transactions and proposes detailed transformation adjustments from national accounting standards to International Financial Reporting Standards. These transformation entries are presented by the author as a practical tool for improving the accounting of leasing transactions in line with international requirements.

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THE USE OF DUE DILIGENCE PROCEDURES TO ENSURE TRANSPARENCY OF FINANCIAL REPORTING IN JOINT-STOCK COMPANIES

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Abstract: This article examines the role of the Due Diligence procedure in ensuring the transparency of financial reporting of joint-stock companies. The study identifies key contemporary challenges affecting the reliability of financial reports, including insufficient disclosure of information, non-compliance with international standards, and limited accessibility of data for investors. A model for integrating Due Diligence into the financial reporting process is proposed, based on a structural and modular approach to the analysis of both financial and non-financial aspects of corporate activities. The article outlines the main stages of implementation and proposes an interaction algorithm between corporate governance participants and independent auditors. The effectiveness of Due Diligence as a mechanism for enhancing investor and regulator confidence is substantiated.

Key words: joint-stock company, financial reporting, transparency, Due Diligence, investment risks, corporate governance.

Annotatsiya: Ushbu maqolada aksiyadorlik jamiyatlarining moliyaviy hisobotlari shaffofligini ta’minlashda Due Diligence jarayonining o‘rni tahlil qilinadi. Tadqiqotda moliyaviy hisobotlarning ishonchliligiga salbiy ta’sir ko‘rsatuvchi zamonaviy muammolar, jumladan ma’lumotlarning yetarli darajada ochib berilmasligi, xalqaro standartlarga nomuvofiqlik va investorlar uchun axborotga kirish imkoniyatlarining cheklanganligi aniqlanadi. Moliyaviy hisobotlarni shakllantirish jarayoniga Due Diligence’ni integratsiya qilish modeli taklif etilib, u korporativ faoliyatning moliyaviy va nomoliyaviy jihatlarini tahlil qilishda strukturaviy va modulli yondashuvga asoslanadi. Maqolada joriy etishning asosiy bosqichlari bayon etilib, korporativ boshqaruv ishtirokchilari va mustaqil auditorlar o‘rtasidagi o‘zaro hamkorlik algoritmi taklif qilinadi. Due Diligence’ning investorlar va regulyatorlar ishonchini oshirishdagi samaradorligi asoslab berilgan.

Kalit so‘zlar: aksiyadorlik jamiyati, moliyaviy hisobot, shaffoflik, Due Diligence, investitsiya xavflari, korporativ boshqaruv.

Аннотация: В статье анализируется роль процедуры Due Diligence в обеспечении прозрачности финансовой отчетности акционерных обществ. В исследовании выявляются современные проблемы, негативно влияющие на достоверность финансовых отчетов, включая недостаточное раскрытие информации, несоответствие международным стандартам и ограниченный доступ инвесторов к данным. Предлагается модель интеграции Due Diligence в процесс формирования финансовой отчетности, основанная на структурном и модульном подходе к анализу финансовых и нефинансовых аспектов корпоративной деятельности. В статье раскрываются основные этапы внедрения и предлагается алгоритм взаимодействия между участниками корпоративного управления и независимыми аудиторами. Обоснована эффективность Due Diligence как инструмента повышения доверия со стороны инвесторов и регуляторов.

Ключевые слова: акционерное общество, финансовая отчетность, прозрачность, Due Diligence, инвестиционные риски, корпоративное управление.

INTRODUCTION

In the context of globalization and the liberalization of financial markets, ensuring the transparency of corporate reporting has become an integral component of the sustainable development of joint-stock companies. Information presented in financial statements serves as the basis for strategic decision-making both within companies and by external stakeholders such as investors, creditors, and regulators. However, traditional forms of internal and external control do not always make it possible to timely identify hidden risks, manipulations of financial indicators, or cases of unreliable disclosure of information.

Against this background, the Due Diligence procedure is gaining particular relevance as a tool for preliminary in-depth analysis of a company's financial position, legal obligations, tax risks, and operational processes. Due Diligence is not limited to verifying compliance with regulatory requirements; rather, it represents a systematic approach to diagnosing corporate reporting and risk management. This approach is widely used in international practice in the context of mergers and acquisitions, investment attraction, initial public offerings (IPOs), as well as business restructuring.

For joint-stock companies in Uzbekistan, the implementation of Due Diligence constitutes an important step toward enhancing transparency, investment attractiveness, and compliance with international standards such as International Financial Reporting Standards (IFRS), as well as the recommendations of the International Monetary Fund, the World Bank, and the Organisation for Economic Co-operation and Development (OECD). Under conditions of active privatization, corporate governance reforms, and growing interest in the domestic market from foreign investors, there is an objective need to systematize and institutionalize Due Diligence practices within corporate financial reporting.

The purpose of this study is to substantiate the importance of applying the Due Diligence procedure to ensure the transparency of financial reporting of joint-stock companies, to analyze existing approaches, and to develop a model for integrating this procedure into the corporate reporting system.

LITERATURE REVIEW

Transparency of financial reporting and the application of the Due Diligence procedure have been widely discussed in international academic and professional literature. Researchers emphasize that reliable and transparent financial information is critically important for risk assessment and informed investment decision-making. Due Diligence is viewed as a multi-level review mechanism that allows the identification of not only explicit, but also potential distortions in financial statements, which is particularly significant in mergers and acquisitions and large investment transactions [9]. International studies also underline that Due Diligence contributes to improving the quality, comparability, and credibility of corporate reporting in line with global best practices and regulatory expectations [10].

A number of scholars focus on the methodological role of Due Diligence within corporate reporting systems. It is argued that Due Diligence acts as a link between traditional accounting data and managerial analysis, enabling a more qualitative interpretation of financial indicators and reducing information asymmetry between companies and investors [1]. Other studies highlight that comprehensive examination of financial statements through Due Diligence strengthens investor confidence and enhances corporate governance mechanisms [8]. Comparative research demonstrates that, unlike traditional audit, Due Diligence provides a broader analytical scope, covering financial, legal, tax, and operational risks in an integrated manner [2], [3].

In domestic practice, the Due Diligence procedure is still insufficiently institutionalized. Empirical studies indicate that the lack of methodological frameworks and institutional support constrains the development of comprehensive financial review mechanisms in companies [4], [5]. At the same time, recent research shows that the application of Due Diligence tools, including automated analytical approaches, can significantly improve the reliability of accounting and auditing data, especially in the context of attracting external capital and implementing corporate reforms [7]. Overall, the reviewed literature confirms the necessity of developing and integrating Due Diligence procedures as an effective instrument for enhancing the transparency, reliability, and investment attractiveness of financial reporting in joint-stock companies, particularly in alignment with international standards and best practices [6], [10].

RESEARCH METHODOLOGY

This study employs methods of comparative analysis, content analysis of corporate reports of joint-stock companies in Uzbekistan, as well as expert surveys of specialists in auditing and corporate governance. To assess the impact of implementing Due Diligence on the transparency of financial reporting, an original model for integrating this procedure into the process of preparing financial information was developed.

ANALYSIS AND RESULTS

Despite statutory requirements and mandatory auditing, the financial reporting of joint-stock companies in practice faces a number of serious challenges that reduce its transparency and reliability. One of the main issues is a formalistic approach to reporting, in which the focus is placed on compliance with formal requirements rather than on the substantive completeness and usefulness of information for users. Financial statements often lack detailed disclosure of risks, contingent liabilities, and financial forecasts, which limits the ability of investors and analysts to objectively assess a company's financial position.

A second problem area is the weak integration of International Financial Reporting Standards (IFRS), particularly in non-public joint-stock companies. Despite the declared adoption of IFRS, the actual transformation of companies' accounting policies frequently remains superficial. This leads to a lack of comparability between reports, restricts opportunities for cross-country analysis, and hampers the attraction of foreign investment.

A third issue is the insufficient level of automation in the reporting process. In many joint-stock companies, financial statements are prepared manually or using outdated software solutions, which increases the risk of errors and reduces efficiency and transparency. The absence of a unified digital platform for the submission and verification of reports also impedes systematic verification and oversight by regulators.

In addition, a significant challenge is the distortion of information aimed at improving reported performance indicators. Such practices may be driven by management's desire to present a favorable image of the company to shareholders or supervisory authorities. This can result in the understatement of liabilities, manipulation of revenues, and concealment of losses, leading to an inaccurate financial picture and distorted investment decisions. Finally, financial reporting often lacks comprehensive disclosure of ESG indicators, which are becoming increasingly important for international investors. Ignoring sustainability, corporate governance, and social responsibility factors reduces companies' investment attractiveness and limits access to green financing. Overall, the systemic problems in the preparation and presentation of financial reporting by joint-stock companies in Uzbekistan indicate the need for more in-depth control mechanisms, including the implementation of Due Diligence as a tool for verification, standardization, and enhancement of trust in disclosed information.

Integration of Due Diligence into the Financial Reporting System

Integrating the Due Diligence procedure into the system of preparing and disclosing financial statements of joint-stock companies represents an effective mechanism for improving reliability, transparency, and compliance with international requirements. Such a model enables not only the identification of hidden risks and distortions but also the formalization of internal control processes and the strengthening of management accountability to investors and regulators. At the core of the integration model is the principle of end-to-end verification: at each stage of report preparation, independent analytical and legal reviews of key elements are conducted—from the recognition of assets and liabilities to fair value measurement and the completeness of disclosures. In this context, Due Diligence becomes not a standalone procedure but an embedded mechanism within the corporate reporting and audit system. The model is based on a modular approach, whereby Due Diligence covers several functional areas: financial analysis, legal review, tax examination, ESG assessment, and operational risk analysis. Each module complements traditional financial reporting and serves as a basis for preparing substantiated notes, forecasts, and disclosures.

Table 1. Model for Integrating the Due Diligence Procedure into the Financial Reporting of a Joint-Stock Company

1. Stage	2. Due Diligence integration content	3. Expected effect
4. 1. Preliminary audit	5. Analysis of accounting policy reliability, identification of risks related to loss concealment or misstatements	6. Improved accuracy of initial data
7. 2. Legal analysis	8. Review for hidden liabilities, litigation risks, and conflicts of interest	9. Elimination of legal uncertainty
10. 3. Financial and analytical review	11. Assessment of assets, liabilities, liquidity, and NPV/IRR of investment projects	12. Higher quality of analytical conclusions
13. 4. ESG analysis	14. Evaluation of social, environmental, and governance sustainability	15. Expanded non-financial disclosures
16. 5. Stress testing	17. Modeling stress scenarios and their impact on key indicators	18. Justification of assumptions in notes
19. 6. Preparation of a visualized report	20. Presentation of information using infographics, dashboards, and charts	21. Improved transparency and investor perception
22. 7. Approval and disclosure	23. Incorporation of Due Diligence findings into final reports and public disclosure	24. Increased trust from investors and auditors

The integration of Due Diligence into financial reporting contributes to the institutionalization of internal control, the strengthening of corporate governance practices, and the standardization of reporting processes. This is particularly relevant for countries with emerging capital markets, such as Uzbekistan, where confidence in public reporting remains limited while the demand for investment transparency is exceptionally high. Ensuring the transparency of financial reporting of joint-stock companies through the integration of the Due Diligence procedure requires not only an appropriate regulatory framework but also institutional readiness of market participants. In practice, the implementation of Due Diligence within corporate reporting systems faces a number

of challenges, ranging from the lack of unified methodologies and digital platforms to weak legal accountability for unreliable disclosures. Nevertheless, international experience confirms that a structured introduction of this procedure can significantly improve the quality of information provided to investors, auditors, and regulators. Of particular importance is the modularity and adaptability of the model: depending on their industry, size, and ownership structure, companies may vary the depth of review by prioritizing specific areas (for example, legal risks in real estate development or environmental risks in industrial enterprises). Moreover, practical experience demonstrates that visualizing the results of Due Diligence reviews and developing digital dashboards enhances the accessibility of information for a broad group of shareholders, including minority investors. Below is a comparative overview of traditional financial reporting and reporting enhanced through the integration of Due Diligence across several key parameters.

Table 2. Comparative Analysis of Traditional Financial Reporting and Reporting with Integrated Due Diligence

Parameters	**Traditional reporting**	**Reporting with Due Diligence**
Misstatement verification	External audit only	Multi-level: audit plus internal review
Transparency of liabilities	Limited	Extended disclosure of hidden risks
Risk forecasting	Almost absent	Use of scenarios and stress testing
Data visualization	Tabular format	Infographics and interactive dashboards
Involvement of external experts	Auditor only	Lawyers, valuers, tax consultants
Non-financial (ESG) reporting	Voluntary or absent	Included in review and disclosure
Impact on investment decisions	Moderate	High due to comprehensive information

The integration of Due Diligence transforms the reporting process from a formal regulatory obligation into a strategic management and communication tool for stakeholders. It is important to emphasize that the implementation of such an approach requires legislative initiatives, professional training, standardization of reporting formats, and the development of digital infrastructure.

CONCLUSION AND SUGGESTIONS

Transparency of financial reporting of joint-stock companies represents a cornerstone of effective corporate governance, investment attractiveness, and resilience to external risks. The conducted research demonstrates that integrating the Due Diligence procedure into the process of preparing and disclosing financial statements significantly enhances their reliability, completeness, and analytical value. Unlike traditional auditing, Due Diligence encompasses not only accounting indicators but also legal, operational, tax, and ESG aspects, thereby providing a comprehensive view of a company's overall condition.

The application of visual tools and digital platforms in the preparation of Due Diligence reports improves the accessibility and understanding of information for stakeholders, including minority shareholders and potential investors. Moreover, comparative analysis shows that companies implementing Due Diligence within corporate reporting practices enjoy higher levels of market trust, attract investment more easily, and adapt more rapidly to regulatory changes. For the widespread adoption of this approach in Uzbekistan, it is necessary to establish regulatory standards for Due Diligence, enhance professional competencies, and develop digital infrastructure. Consequently, the use of Due Diligence as a tool for ensuring transparency in financial reporting becomes an integral element of modern corporate practice.

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