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REGIONAL INNOVATION DEVELOPMENT INDICATORS AND THEIR EVALUATION SYSTEM

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Abstract: The study analyzed the methodology for assessing indicators of regional innovation development. The research applied a composite index approach to measure regional innovation systems. The Regional Innovation Development Composite Index (RIDCI) was constructed using four structural blocks: innovation capacity, entrepreneurial ecosystem, digital infrastructure, and innovation outcomes. Indicators were selected based on theoretical relevance and statistical availability. All indicators were normalized using the min–max method. Weighting coefficients were determined through the Delphi expert method and principal component analysis. Block values were aggregated into a single index using linear aggregation. Methodologies of international innovation indices were comparatively examined. An adapted assessment model for the regions of Uzbekistan was developed. The results demonstrated the feasibility of systematic measurement of regional innovation development.

Key words: regional innovation system, composite index, innovation capacity, digital infrastructure, assessment methodology, entrepreneurial ecosystem.

INTRODUCTION

In the context of the modern economy, disparities in innovative development among regions are increasingly becoming one of the key determinants of national competitiveness and economic convergence [1]. The acceleration of technological change and the transition toward a digital economy require regional policymakers to develop methodological approaches that enable the systematic measurement, analysis, and effective management of innovation activities. This necessity has made the development of regional innovation development indicators one of the important directions of contemporary scientific research.

Integrating various aspects of innovation activity—from input factors (such as R&D investments and education levels) to output results (such as patents and technological exports)—within a single measurement system represents a complex methodological challenge. Existing international frameworks, including the Global Innovation Index (GII), the European Innovation Scoreboard (EIS), and the OECD innovation indicator system, are primarily designed at the national level and have relatively limited capacity to fully reflect regional specificities [2], [3]. As a result, these systems do not always adequately capture structural differences within regions, which complicates the development of targeted and territorially oriented policy measures.

In the context of Uzbekistan, the assessment of regional innovation potential is of particular importance. The economic reforms implemented in the country, the modernization of the education system, and government programs aimed at developing the digital economy are creating an important institutional foundation for innovation-driven growth. At the same time, differences in the level of innovative development among regions still persist [25]. The high concentration of industrial and intellectual resources in the city of Tashkent, compared with the development opportunities of other regions, further strengthens the need to develop an effective system for measuring regional innovation development.

The main objective of this article is to systematize the methodological foundations for assessing regional innovation development, analyze international experience, and propose a composite index structure adapted to

the conditions of Uzbekistan. The research is conducted at the intersection of several scientific fields, including innovation systems theory [7], [13], regional economics [18], [19], and evaluation methodology [1], [22].

The article has the following logical structure: the literature review section analyzes existing theoretical approaches and empirical studies; the methodology section describes the process of constructing the composite index and determining weighting coefficients; the analysis and results section presents a comparative analysis of international experience and innovation indicators; and the conclusion and recommendations section provides practical proposals aimed at improving regional innovation policy.

LITERATURE REVIEW

The concept of Regional Innovation Systems (RIS) was first developed in the early 1990s by Philip Cooke [7], who interpreted the region as an independent unit of the innovation process. This approach extends the paradigm of National Innovation Systems (NIS) [13], [15] to the territorial level and provides an important analytical framework for examining interactions among institutions, firms, and knowledge organizations. Bjørn T. Asheim and Lars Coenen [6] proposed a typology of regional knowledge bases—analytical, synthetic, and symbolic—which allows the development of differentiated innovation policies for various industrial clusters.

David Doloreux and Saeed Parto [8] analyzed the evolution of the RIS concept and identified several methodological challenges in its empirical application, including the conceptual ambiguity of the term, the flexible nature of geographical boundaries, and measurement issues. Franz Tödting and Michaela Trippel [9] distinguished three types of regional innovation systems: industrialized core regions, old industrial regions undergoing transformation, and peripheral regions. This typology theoretically justifies the need to develop specific policy measures tailored to each regional context.

Ron Boschma [18], in his proximity theory, analyzes the complex interaction among geographical, cognitive, organizational, social, and institutional proximities in the innovation process. This approach demonstrates that geographical proximity alone is not sufficient to stimulate innovation activities. Therefore, applying a multidimensional approach in constructing regional innovation indicator systems is considered essential.

The methodology for measuring innovation has been standardized through two key international documents: the Frascati Manual developed by the Organisation for Economic Co-operation and Development (OECD), which provides guidelines for measuring R&D activities [1], and the Oslo Manual, which establishes principles for identifying and measuring innovation indicators. These methodological frameworks have served as a scientific foundation for numerous empirical studies. However, they are primarily based on aggregated national-level data and therefore have limited capacity to fully reflect regional characteristics [3].

The Global Innovation Index (GII) developed by the World Intellectual Property Organization [2] evaluates 132 countries using more than 80 indicators and includes seven thematic pillars: institutions, human capital, infrastructure, market sophistication, business sophistication, knowledge and technology outputs, and creative outputs. One of the key advantages of the GII methodology is its integration of multiple data sources and the transparency of its weighting procedures. Nevertheless, the index is largely based on national-level aggregation, which restricts its ability to capture regional disparities.

The European Innovation Scoreboard (EIS) [3], [22], developed by the European Commission, also calculates a Regional Innovation Scoreboard (RIS) for European Union regions, representing one of the most advanced practices in regional innovation assessment. Hugo Hollanders and co-authors [22] emphasize that one of the main limitations of RIS implementation is the shortage of regional statistical data. This issue is particularly typical for developing economies and is closely related to the level of development of statistical infrastructure [11].

Christopher Freeman [14], through his study of Japan's technological policy, demonstrated that cooperation between the state and industry is a key institutional factor driving innovation-led growth. Charles Edquist [17] further expanded the analysis of innovation systems by identifying interactions among institutions and organizations as the central element of the analytical framework. Richard R. Nelson [15], by conducting a comparative study of innovation systems in 15 countries, highlighted the diversity of national innovation systems, emphasizing the need for context-sensitive approaches in developing universal indicator systems.

Richard Florida [19], within the concept of learning regions, identified social capital, knowledge exchange networks, and the presence of the creative class as key drivers of innovative development. Michael Storper [20], in the "territorial worlds" model, explains the formation of regional competitiveness through interdependencies in production processes and economic coordination. Meanwhile, Michael E. Porter [16] developed the theory

of cluster-based competitive advantage, which further confirms the functional relationship between innovation systems and industrial clusters.

Dominique Foray [21] highlights the central role of knowledge assets in the process of innovation-driven development within the knowledge economy framework. The concept of smart specialization, proposed by Philip McCann and Raquel Ortega-Argilés [23], emphasizes the importance of identifying regional strengths and strategic priorities in innovation policy and has become a key element of the European Union's cohesion policy.

Finally, Roberta Capello and Peter Nijkamp [24] analyzed regional economic growth theories and explained the complex dynamic relationship between innovation, economic growth, and territorial development through various theoretical approaches. The synthesis of these academic sources suggests that indicators for assessing innovation development should capture not only technological outputs but also the institutional and economic dynamics of innovation systems.

RESEARCH METHODOLOGY

In this study, a composite index methodology was applied to assess regional innovation development. The process of constructing the index was based on the methodological guidelines for composite indicators developed by the Organisation for Economic Co-operation and Development (OECD) and the Joint Research Centre of the European Commission (JRC). The methodology consisted of five sequential stages: theoretical justification, indicator selection, normalization, determination of weighting coefficients, and aggregation.

As a theoretical foundation, the study integrates innovation systems theory, the regional economics approach, and the methodologies used in international innovation indices. During the indicator selection process, several scientific criteria were applied: theoretical relevance, availability of statistical data, absence of high multicollinearity among indicators ($VIF < 5$), the ability to reflect regional disparities, and sensitivity to policy changes. Based on these criteria, 16 key indicators were selected and grouped into four main blocks: innovation capacity, entrepreneurial ecosystem, digital infrastructure, and innovation outputs.

To bring indicators expressed in different measurement units to a unified scale, the min–max normalization method was applied. The normalization was:

$$I_{\text{norm}} = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

Here, X represents the original value of the indicator for a given region, while X_{\min} and X_{\max} denote the minimum and maximum values within the dataset, respectively.

To determine the weighting coefficients of the indicators, a two-stage approach was applied. In the first stage, preliminary weights were determined using the Delphi expert evaluation method. In the second stage, the statistical significance of the indicators was examined using Principal Component Analysis (PCA). When no significant differences were observed between the expert assessments obtained through the Delphi method and the PCA results, the expert evaluations were adopted as the final weighting coefficients.

At the final stage, the normalized indicators within each block were combined into a single composite index using the linear aggregation method:

$$\text{MIRKI} = 0.25B_1 + 0.25B_2 + 0.25B_3 + 0.25B_4$$

Here, B_1 – B_4 represent the average values of the normalized indicators within each respective block. The use of equal-weight aggregation ensures the methodological transparency of the index structure and enables comparative analysis across regions.

The empirical calculations were conducted using data obtained from the open databases of the Statistics Agency of the Republic of Uzbekistan, UNESCO, the World Bank, and the World Intellectual Property Organization (WIPO).

ANALYSIS AND RESULTS

The conceptual MIRKI model proposed for assessing regional innovation development is illustrated in Figure 1. This model consists of four main structural blocks, each of which covers a specific functional segment of the innovation system and contributes significantly to the formation of the final composite result (Figure 1).

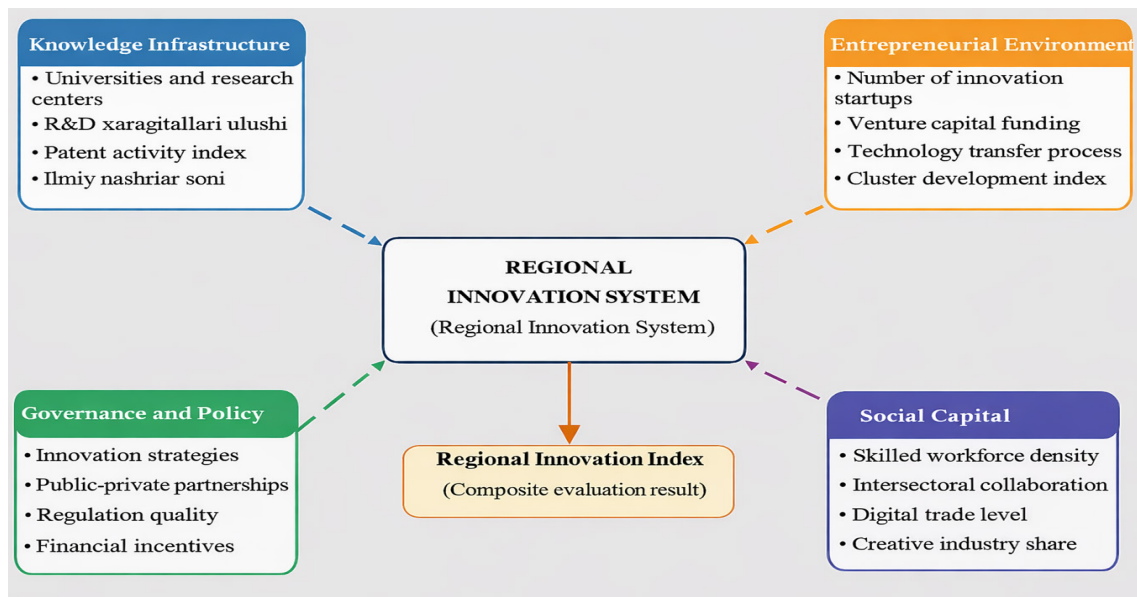


Figure 1. Conceptual Model of the Regional Innovation System¹

As illustrated in Figure 1, the MIRKI model includes four blocks that function not only as input components of the central index but also interact with each other through functional linkages. The knowledge infrastructure (Block I) provides knowledge flows to the entrepreneurial environment; the governance system (Block III) creates an institutional framework that supports both knowledge generation and entrepreneurial activities; while social capital (Block IV) enhances the effectiveness of all blocks through human resources and inter-network linkages.

Figure 2 presents the complete hierarchy of MIRKI indicators, including the structural elements of each block and their aggregation scheme. This structure was developed in accordance with international methodological standards, particularly the Oslo Manual of the Organisation for Economic Co-operation and Development [1] and the methodology of the Global Innovation Index (GII) developed by the World Intellectual Property Organization [2].

In order to compare international practices of innovation index construction, the main methodological differences among three leading systems—Global Innovation Index (GII) [2], European Innovation Scoreboard (EIS) [3], and the Regional Innovation Scoreboard (RIS)—were identified. The results of this comparative assessment are presented in Table 1.

Table 1. Comparative Analysis of International Innovation Indexing Systems²

Indicator	GII (WIPO, 2023)	EIS (European Commission, 2023)	Regional Innovation Scoreboard (RIS, 2023)
Coverage level	National level (132 countries)	National level (European Union countries)	Regional level (EU regions)
Number of indicators	80 indicators	32 indicators	18 indicators
Normalization method	Min–max and Z-score methods	Recoding to a 0–1 scale	Min–max normalization (0–1 scale)
Weighting system	Equal weighting of indicators	Equal weighting of indicators	Equal weighting of indicators
Aggregation method	Geometric mean	Arithmetic mean	Arithmetic mean
Update frequency	Annual updates	Annual updates	Biennial updates
Data sources	Multiple open data sources	Eurostat and complementary statistical sources	Eurostat and complementary statistical sources

Analysis of Table 1 shows that among the existing international systems there is no single comprehensive approach fully designed for the regional level. The Global Innovation Index (GII) and the European Innovation Scoreboard (EIS) are primarily based on national-level aggregation and therefore do not fully capture structural differences within regions. Meanwhile, the Regional Innovation Scoreboard (RIS) has been specifically

1 Author’s elaboration based on the referenced sources.
 2 Author’s elaboration based on the referenced sources.

developed for the regions of the European Union and cannot be directly applied to the context of Central Asian countries. This situation further confirms the relevance and methodological necessity of the MIRKI concept proposed in this study.

Table 2 presents the 16 key indicators of MIRKI, grouped into four structural blocks, along with their measurement units and corresponding international data sources. The use of internationally recognized data sources enhances the methodological reliability and analytical robustness of the selected indicators (Table 2).

Table 2. Classification of MIRKI Indicators by Structural Blocks³

Block	Indicator	Unit of Measurement	Source
I. Innovation Capacity	Share of R&D expenditure in GDP	Percentage (%)	Organisation for Economic Co-operation and Development [1]; UNESCO
I. Innovation Capacity	Higher education enrollment rate	Percentage (%)	UNESCO; World Bank [10]
I. Innovation Capacity	Number of researchers per 1,000 people	Persons per thousand	Organisation for Economic Co-operation and Development; UNESCO
I. Innovation Capacity	Scientific publications (Scopus / WoS)	Number per year	Scopus; Web of Science
II. Entrepreneurial Ecosystem	Density of newly established startups	Per 1,000 people	World Bank [10]
II. Entrepreneurial Ecosystem	Venture capital investment volume	Percentage of GDP	Crunchbase; Organisation for Economic Co-operation and Development
II. Entrepreneurial Ecosystem	Cluster development index	Index (0–1)	World Economic Forum Global Competitiveness Index; Organisation for Economic Co-operation and Development
II. Entrepreneurial Ecosystem	Technology transfer agreements	Number per year	World Intellectual Property Organization [2]
III. Digital Infrastructure	Internet penetration rate	Percentage (%)	International Telecommunication Union; World Bank [10]
III. Digital Infrastructure	Digital literacy index	Index (0–1)	United Nations Development Programme [12]; International Telecommunication Union
III. Digital Infrastructure	E-government development index	Index (0–1)	United Nations E-Government Development Index; United Nations Development Programme [12]
III. Digital Infrastructure	Broadband internet penetration	Subscribers per 100 inhabitants	International Telecommunication Union
IV. Innovation Outputs	Number of patents (per 1 million people)	Number	World Intellectual Property Organization [2]
IV. Innovation Outputs	Share of high-technology exports	Percentage of merchandise exports	World Bank [10]
IV. Innovation Outputs	Share of creative industries output	Percentage of GDP	United Nations Conference on Trade and Development; Eurostat
IV. Innovation Outputs	Share of new products in total sales	Percentage (%)	European Commission EIS [3]; Organisation for Economic Co-operation and Development

A key characteristic of the indicators presented in Table 2 is that they are calculated on the basis of open data sources, which ensures transparency and enables international comparative analysis. However, for the

³ Author's elaboration based on the referenced sources.

regions of Uzbekistan, some indicators (such as venture capital investment and the cluster development index) are currently not available at the regional level. In such cases, they can be substituted with two proxy indicators: (1) the share of the regional GDP attributable to innovation-oriented sectors; and (2) an index reflecting the presence of technoparks and innovation zones within the region.

An analysis based on data from the Statistics Agency of the Republic of Uzbekistan [25] and international innovation indices indicates that there are notable differences in innovation development across the regions of Uzbekistan. The city of Tashkent and Tashkent region account for a substantial share of the country's overall research and innovation capacity. More than 60 percent of higher education institutions are located in Tashkent, which represents a typical example of the geographical concentration of intellectual capital.

Uzbekistan's position in the Global Innovation Index (GII) has improved in recent years. According to the 2023 Global Innovation Index report prepared by the World Intellectual Property Organization, Uzbekistan ranked 84th among 132 countries [2]. Nevertheless, national-level aggregate indicators may conceal important regional disparities. Innovation activity demonstrates noticeable asymmetry across regions, particularly between the industrial clusters of the Fergana Valley, the technopark ecosystem of Tashkent, and other territories. At the same time, the level of innovation infrastructure development in regions such as Navoi, Khorezm, and Syrdarya remains relatively modest [25].

For the practical application of the MIRKI framework, a comprehensive dataset covering the 14 administrative regions of Uzbekistan is required. These data should include: education statistics (National Center for Educational Assessment), industrial and innovation statistics (Statistics Agency and the Ministry of Innovative Development), digital development indicators (Ministry for the Development of Information Technologies and Communications), and patent and intellectual property statistics (Intellectual Property Agency of the Republic of Uzbekistan). To ensure the effective integration of these datasets, the establishment of a unified regional innovation monitoring system is considered essential.

International experience in applying regional innovation indices demonstrates that such indices serve as an effective tool for monitoring the effectiveness of regional policy measures. Within the European Union's regional development policy, data from the Regional Innovation Scoreboard (RIS) are widely used as a key analytical input for designing territorial development programs and allocating financial resources to less-developed regions [11], [23]. Similarly, under the conditions of Uzbekistan, integrating MIRKI into the monitoring and evaluation framework of regional development programs could provide significant practical value for evidence-based policymaking and balanced regional innovation development.

CONCLUSION AND RECOMMENDATIONS

This study developed the methodological foundations for constructing a system of regional innovation development indicators and proposed the concept of the Regional Innovation Development Composite Index (MIRKI) adapted to the conditions of Uzbekistan. The literature review demonstrates that the measurement of innovation development requires an integrated approach situated at the intersection of innovation systems theory and regional economics. The methodology section describes a weighting system based on the combined application of the Delphi expert evaluation method and Principal Component Analysis (PCA), confirming its consistency with internationally recognized analytical practices.

The analytical results indicate that existing international indices—such as the Global Innovation Index (GII) developed by the World Intellectual Property Organization, the European Innovation Scoreboard (EIS) prepared by the European Commission, and the Regional Innovation Scoreboard (RIS)—do not fully capture regional-level dynamics and therefore cannot be directly applied in many developing economies. The four structural blocks of MIRKI—innovation capacity, entrepreneurial ecosystem, digital infrastructure, and innovation outputs—provide a comprehensive framework that can serve as a diagnostic tool for regional policymakers. In the context of Uzbekistan, the observed asymmetry among regions further confirms the importance of adopting differentiated regional innovation policies.

Based on the results of the research, the following theoretical and practical recommendations are proposed:

First recommendation. To ensure the systematic calculation of MIRKI for 14 regions and 2 major cities of Uzbekistan on an annual basis, a unified regional innovation monitoring platform should be established through cooperation among the Ministry of Innovative Development, the national statistical authorities, and higher education institutions. Such a platform would directly contribute to the implementation of the objectives defined in the innovation policy framework of the Republic of Uzbekistan adopted in 2020.

Second recommendation. For regions where statistical information is limited, specialized proxy indicators should be developed. In particular, indicators reflecting the activities of technoparks, business incubators, and innovation zones should be incorporated into standardized reporting formats. This approach aligns with the open-data practices promoted by the World Bank and with modern data governance standards widely applied in European statistical systems.

Third recommendation. When designing regional innovation policies, it is advisable to apply the regional classification proposed by Franz Tödtling and Michaela Trippl, which divides regions into three categories: innovation leaders, transition regions, and potential regions. Based on this classification, differentiated policy guidelines can be developed for each group of regions.

Fourth recommendation. The MIRKI methodology could be harmonized with analytical frameworks used in other Central Asian countries in order to enable cross-regional comparative analysis. Such an initiative may contribute to strengthening regional cooperation and competitiveness in the field of innovation, in line with the concept of cross-border knowledge spillovers described in the knowledge economy theory of Dominique Foray.

Fifth recommendation. The results of MIRKI should be institutionally integrated into the process of determining funding priorities for regional development programs. Experience from the European Union's smart specialization strategies and regional innovation policies demonstrates that innovation index data can significantly influence the geographic allocation of public investment and the effectiveness of targeted regional development initiatives.

Overall, the proposed MIRKI framework provides a methodologically transparent and analytically robust tool for assessing regional innovation development and may serve as a practical instrument for strengthening evidence-based regional innovation policy in Uzbekistan and comparable emerging economies.

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