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INTERNATIONAL TRENDS OF DIGITALIZATION IN CUSTOMS MANAGEMENT

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Abstract. This article analyzes contemporary international trends in the digitalization of customs management, including artificial intelligence (AI), blockchain technology, big data analytics, the Internet of Things (IoT), and Single Window systems. The study is based on empirical evidence from the World Customs Organization (WCO), the World Trade Organization (WTO), and the World Bank Group. The findings indicate that, since the implementation of the WTO Trade Facilitation Agreement (TFA), global trade has increased by more than USD 230 billion, while average trade costs have decreased by 1–4%. Customs processing time at the Kenya–Tanzania border was reduced by 87%. The article examines the economic efficiency of digital customs, key technological development areas, successful country experiences, including China, South Korea, Singapore, and the United Arab Emirates, and provides practical recommendations for developing economies.

Keywords: digital customs, artificial intelligence, blockchain, Single Window system, trade facilitation, WCO, WTO TFA, big data, Authorized Economic Operator, international trade.

Annotatsiya. Ushbu maqolada bojxona boshqaruvini raqamlashtirishning zamonaviy xalqaro tendensiyalari, jumladan, sun'iy intellekt (AI), blokcheyn texnologiyasi, katta hajmdagi ma'lumotlar tahlili (big data), Buyumlar interneti (IoT) hamda "Yagona darcha" tizimlari tahlil qilingan. Tadqiqot Jahon bojxona tashkiloti (WCO), Jahon savdo tashkiloti (WTO) va Jahon banki guruhi ma'lumotlari asosida olib borilgan. Tadqiqot natijalari shuni ko'rsatadiki, JSTning Savdoni yengillashtirish to'g'risidagi bitimi (TFA) joriy etilgandan so'ng global savdo hajmi 230 milliard AQSH dollaridan ortiqqa oshgan, savdo xarajatlari esa o'rtacha 1–4 foizga qisqargan. Keniya–Tanzaniya chegarasida bojxona rasmiylashtiruv vaqti 87 foizga qisqartirilgan. Maqolada raqamli bojxona tizimining iqtisodiy samaradorligi, asosiy texnologik rivojlanish yo'nalishlari, Xitoy, Janubiy Koreya, Singapur va BAA tajribasi hamda rivojlanayotgan davlatlar uchun amaliy tavsiyalar yoritilgan.

Kalit so'zlar: raqamli bojxona, sun'iy intellekt, blokcheyn, "Yagona darcha" tizimi, savdoni yengillashtirish, WCO, WTO TFA, katta hajmdagi ma'lumotlar, Vakolatli iqtisodiy operator, xalqaro savdo.

Аннотация. В данной статье анализируются современные международные тенденции цифровизации таможенного управления, включая искусственный интеллект (AI), технологию блокчейн, аналитику больших данных, Интернет вещей (IoT) и системы «Единого окна». Исследование основано на эмпирических данных Всемирной таможенной организации (WCO), Всемирной торговой организации (WTO) и Группы Всемирного банка. Результаты исследования показывают, что после внедрения Соглашения ВТО об упрощении процедур торговли (TFA) объем мировой торговли увеличился более чем на 230 млрд долларов США, а средние торговые издержки сократились на 1–4%. Время таможенного оформления на границе Кении и Танзании сократилось на 87%. В статье рассматриваются экономическая эффективность цифровой таможни, ключевые направления технологического развития, успешный опыт Китая, Южной Кореи, Сингапура и ОАЭ, а также представлены практические рекомендации для развивающихся стран.

Ключевые слова: цифровая таможня, искусственный интеллект, блокчейн, система «Единое окно», упрощение торговли, WCO, WTO TFA, большие данные, Уполномоченный экономический оператор, международная торговля.

INTRODUCTION

In the second quarter of the 21st century, the development of international trade is taking place against the background of increasingly complex global supply chains and the rapid expansion of the digital economy. According to the World Trade Organization (WTO), transit delays may account for up to 44% of transport costs [1]. Under these conditions, traditional paper-based customs procedures are gradually losing their effectiveness

and are being replaced by digital ecosystems based on artificial intelligence, blockchain technology, big data analytics, the Internet of Things (IoT), and “Single Window” systems.

According to the World Customs Organization (WCO), digital customs refers to the use of digital systems for collecting customs duties, controlling the flow of goods, people, vehicles, and money, and protecting cross-border trade from illegal activities [2]. This trend serves not only as a means of improving operational efficiency, but also as an important tool for increasing state budget revenues, strengthening trade security, and stimulating economic growth.

The aim of this research is to analyze the most relevant international trends in the digitalization of customs management based on empirical data, assess their economic effectiveness, and develop strategic conclusions for developing countries.

LITERATURE REVIEW

The issue of digitalization in customs management has been extensively studied in international scientific literature, mainly across three major directions. The first direction focuses on institutional research. In particular, the “Digital Customs” concept proposed by the World Customs Organization (WCO) and developed by Kunio Mikuriya established the conceptual and regulatory foundations of digital customs administration. Furthermore, the Organisation for Economic Co-operation and Development (OECD) report *“Going Paperless”* (2025) quantitatively demonstrated the direct impact of border process automation on reducing trade costs. Based on data from the WTO Trade Facilitation Agreement (TFA) database, Cadot and Zaki (2025) concluded that the implementation of digital trade facilitation measures reduced import processing time by approximately 3.7 days.

The second direction is technology-oriented research. Ganne (2018), in studies conducted under the framework of the World Trade Organization (WTO), theoretically substantiated the potential applications of blockchain technology in cross-border trade operations. In addition, a comprehensive review published by ScienceDirect (2024) systematized more than 200 academic articles related to blockchain and digital customs technologies. The WCO’s *AI/ML Adoption Report* (2025), which summarized the experience of 108 countries, highlighted that the implementation of artificial intelligence and machine learning technologies in customs administration remains at an early stage of development [8].

The third direction concerns comparative analyses of country experiences. Peterson (USITC), while examining Singapore’s TradeNet system, demonstrated that the introduction of digital customs procedures reduced document-related expenses for users by nearly 30%. Similarly, Sarker (2025), in a master’s thesis prepared at JAMK University of Applied Sciences, empirically identified infrastructure limitations and the digital divide as major barriers to customs digitalization in developing economies.

Nevertheless, two major research gaps remain in the existing literature. First, the customs systems of Central Asian countries, particularly Uzbekistan, have received very limited attention in international academic research. Second, practical models for integrating blockchain technology with “Single Window” systems still lack a sufficiently developed empirical foundation. Therefore, this study aims to contribute to the literature by addressing these gaps through a comprehensive analysis of data and analytical materials provided by the WTO, WCO, OECD, and the World Bank.

RESEARCH METHODOLOGY

This research is based on a descriptive-analytical approach. Official documents, statistical data, and scientific publications of international organizations covering the period from 2017 to 2025 were examined, and conclusions were formulated on the basis of the collected materials. The primary sources used in the study include official reports of the World Trade Organization (WTO), the World Customs Organization (WCO), the United Nations Conference on Trade and Development (UNCTAD), the Organisation for Economic Co-operation and Development (OECD), and the World Bank Trade Facilitation Support Program (TFSP). In addition, peer-reviewed scientific articles published in reputable academic platforms and journals such as Oxford Academic, ScienceDirect, and Springer were analyzed. In total, 29 scientific and analytical sources were reviewed [4].

The following research methods were employed in the study:

Document analysis — examination of the content, recommendations, and regulatory guidelines presented in the reports of international organizations;

Comparative analysis — comparison of the experiences and digital customs practices of China, South Korea, Singapore, the United Arab Emirates, and several developing countries;

Statistical analysis — assessment of the economic impact of digitalization indicators based on data from the WTO Trade Facilitation Agreement (TFA) Database and the OECD Trade Facilitation Indicators.

Since the research relies primarily on secondary data sources, certain national and institutional

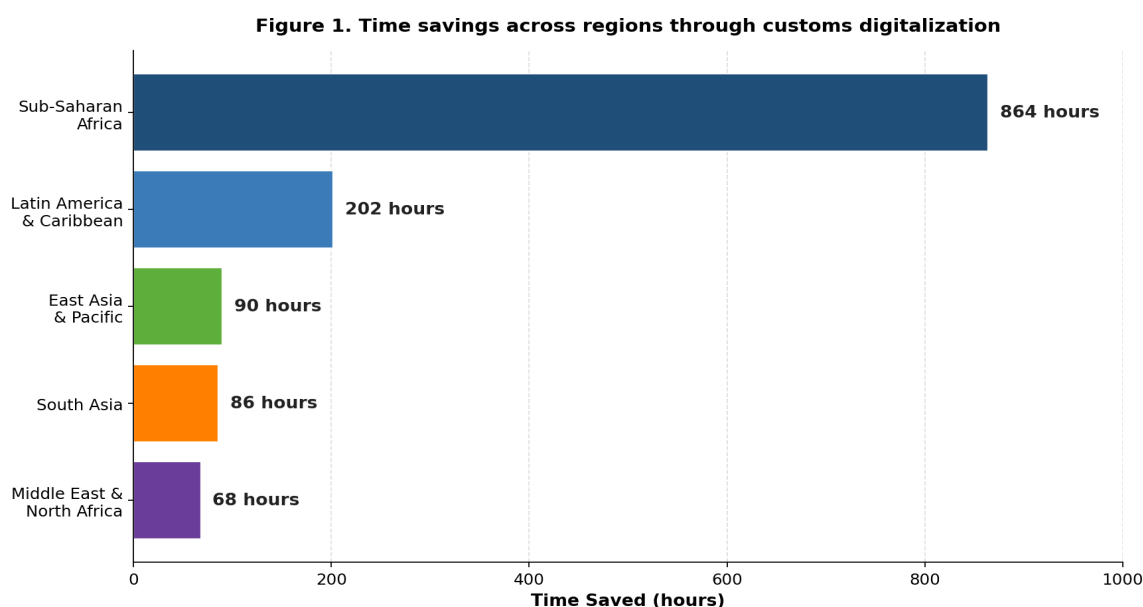
characteristics of individual countries may not be fully reflected in the analysis. Furthermore, the rapid pace of technological change in the field of digitalization requires the continuous updating of statistical indicators and analytical assessments.

RESULTS AND DISCUSSION

According to data published by the World Trade Organization (WTO) in February 2025, since the entry into force of the Trade Facilitation Agreement (TFA) in 2017, the volume of international trade has increased by approximately USD 230 billion [1]. At the same time, average global trade costs have decreased by 1–4%, while the most significant positive effects have been observed in the agricultural sector, where cost reductions reached up to 17%.

The results of the World Bank's Trade Facilitation Support Program (TFSP) indicate that, across 58 participating countries, the average time required for import-export clearance procedures decreased by 21%, generating approximately USD 109 million in savings for the private sector [5]. The most substantial improvements were recorded in Sub-Saharan Africa, where digitalization initiatives contributed to saving nearly 864 hours in customs and border processing procedures.

These findings demonstrate that the digitalization of customs administration not only improves operational efficiency, but also contributes significantly to reducing logistics costs, accelerating cross-border trade, and strengthening the competitiveness of national economies. In particular, the transition to digital customs systems has enhanced transparency, optimized document processing procedures, and improved coordination among border control agencies. As a result, countries implementing advanced digital customs solutions are achieving higher levels of trade facilitation and economic integration within global supply chains (Figure 1).



Source: World Bank Group, Trade Facilitation Support Program (2025)

Figure 1. Time savings across regions through customs digitalization (2016/17–2024)

The most significant results of customs digitalization can be observed at border crossing points. According to WTO data, customs clearance time and queue delays were reduced by 62% at the Kenya–Uganda border and by 87% at the Kenya–Tanzania border [1]. These achievements were made possible through the combined implementation of several modern digital instruments, including the “Single Window” system, Authorized Economic Operator (AEO) mechanisms, advance electronic declaration procedures, and artificial intelligence-based risk management analysis.

The integration of these technologies has substantially improved the efficiency of border operations by accelerating document verification, reducing human intervention, and strengthening coordination among customs and border control agencies. In addition, AI-driven risk assessment systems have enabled customs authorities to focus inspections on high-risk shipments while facilitating faster clearance for low-risk traders. As a result, border crossing procedures have become more transparent, predictable, and cost-efficient, contributing to the expansion of international trade and regional economic integration (Figure 1).

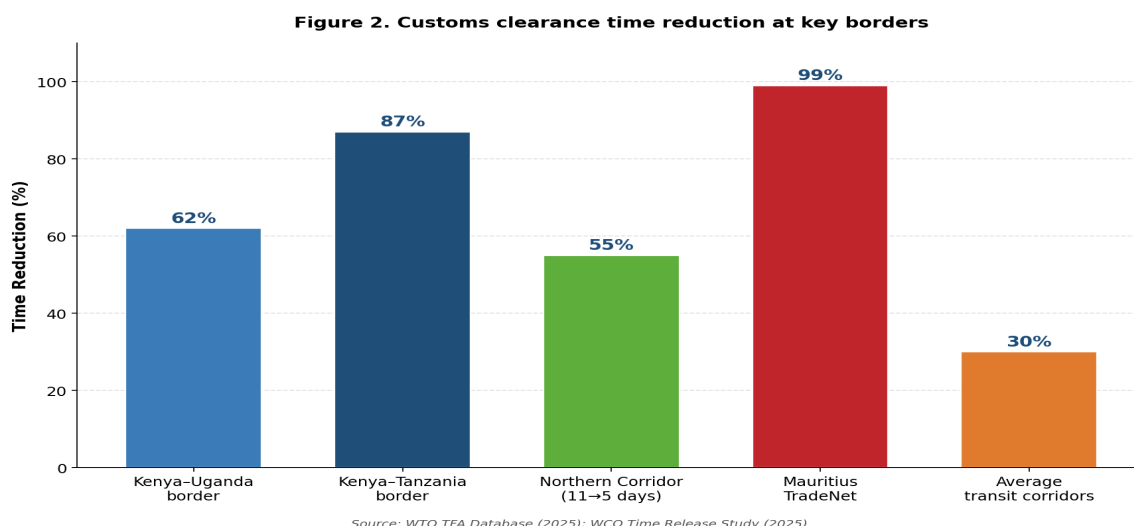


Figure 2. Customs clearance time reduction at key borders

Taking the Mauritius TradeNet platform as an example, the customs clearance process that previously took 4 hours is now completed in just 15 minutes — a vivid illustration of time savings [6]. The Korea Customs Service (KCS) has automated 93% of its business processes [7]. These results demonstrate the growing effectiveness of digital customs technologies in improving operational efficiency, reducing administrative procedures, and accelerating cross-border trade processes. The table below summarizes the key statistical indicators (Table 1).

Table 1

Empirical effectiveness indicators of digital customs¹

Indicator	Description and source	Value
Global trade growth	After TFA implementation (2017–2024) [WTO]	\$230+ billion
Kenya–Tanzania border	Reduction of customs processing time [WTO]	87%
Kenya–Uganda border	Reduction of queues and delays [WTO]	62%
Mauritius TradeNet	Clearance: from 4 hours to 15 minutes [WBG]	99%
Northern Corridor	Transit time: from 11 days to 5 days [WTO]	–6 days
Sub-Saharan Africa	Time saved through digitalization [WBG]	864 hours
Time spent on imports	Average reduction following TFA implementation	–3.7 days
Time spent on exports	Average reduction following TFA implementation	–1.9 days
Trade costs	Global reduction rate due to TFA [WTO]	1–4%
Transit delays	Share in transport costs [WTO]	up to 44%
China Customs	Value of smuggling detected by algorithmic models	¥16+ billion
South Korea KCS	Share of automated business processes	93%
Global TFA rating	Average level of TFA implementation (2024)	79.4%

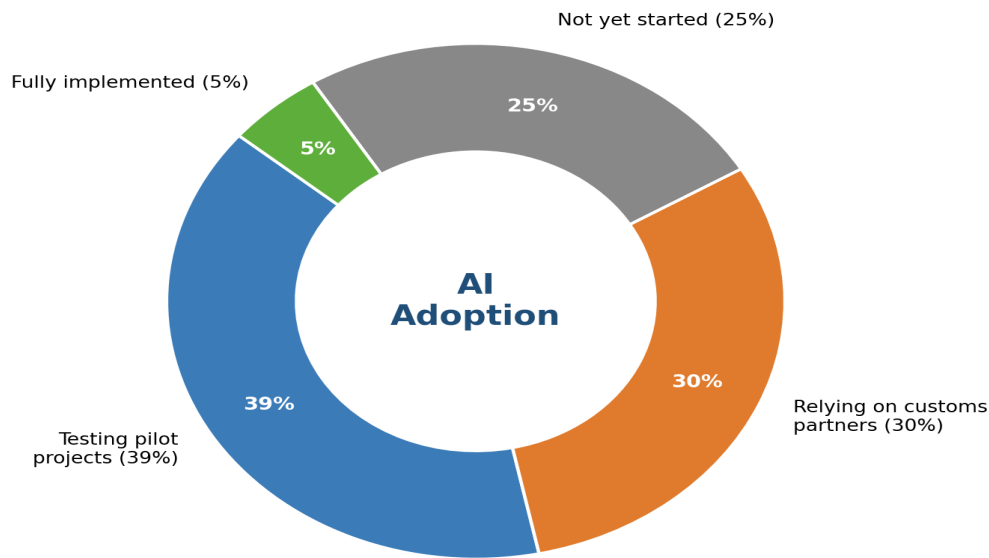
According to the results of the “Global Smart Customs Survey” conducted by the WCO from April to June 2024, AI/ML, blockchain, and cloud computing were identified as the three highest-priority technologies for customs administrations [8]. The “Adoption of AI/ML in Customs” report, published in 2025, provides an in-depth analysis of the technical foundations, governance mechanisms, risk management approaches, business processes, and capacity-building measures related to AI/ML.

However, the level of adoption remains at an early stage. According to the results of the 2025 Customs Forum survey conducted in the Netherlands with the participation of more than 100 specialists, only 5% of respondents had fully implemented AI, while 39% were testing pilot projects, 25% had not yet started

¹ author's development

implementation, and 30% relied on customs partners [9] (Figure 3).

Figure 3. AI adoption stages in customs management (2025)



Source: Customs Forum 2025 — Survey of 100+ industry professionals

Figure 3. AI adoption stages in customs management (2025)

AI is being effectively applied in customs services in the following areas: (1) risk management and the automatic identification of high-risk cargo consignments; (2) intelligent document verification; (3) automatic classification of goods according to HS codes; (4) scanner image analysis (NII Image Analysis); and (5) predictive analytics.

China Customs is considered one of the leading examples in the implementation of AI technologies. The “Tianji Knowledge Graph” system identifies high-risk enterprises through a visualized network of relationships. Its Big Data platform integrates expert analysis with machine intelligence: thousands of successful operational cases have been transformed into algorithmic models, contributing to the detection of smuggling activities valued at more than 16 billion yuan [10]. In addition, China Customs has introduced real-time video monitoring systems at more than 1,900 customs operation sites.

The decentralized and immutable ledger structure of blockchain technology is generating significant improvements in the security of customs documentation and supply chain management [11]. Smart contracts facilitate the automation of verification and payment procedures, thereby reducing the need for intermediaries and increasing transaction transparency.

One of the most important trends of 2025 is the concept of digital “passports for goods.” In 2025, the WCO published Model Clauses for the use of TradeTrust Electronic Bills of Lading [12]. Furthermore, the Inter-American Development Bank (IADB) is supporting a blockchain-based solution for the automated exchange of information related to Authorized Economic Operators (AEOs) among the customs administrations of Mexico, Peru, and Chile.

The Korea Customs Service (KCS) applies blockchain, artificial intelligence, and big data technologies in an integrated manner to monitor goods imported through e-commerce channels. KCS has pursued a long-term digital transformation strategy since the 1970s, and currently approximately 93% of its business processes are automated [7].

The “Single Window” system has become one of the core foundations of digital customs modernization. According to the analysis presented in UNCTAD’s *UN Trade Digitalization Index*, such systems are recognized as one of the key indicators of digital trade facilitation [4]. The system allows traders to submit all required documents — including customs declarations, permits, licenses, and certificates — through a unified electronic platform.

At the WTO TFA Committee meeting held in June 2025, the results of an analysis covering 19 transit corridors across Africa, Asia, Eurasia, and South America were presented. The findings showed that the implementation of digital tools and coordination mechanisms reduced transit time by 20–40% [13]. One of the

most notable examples is the Northern Corridor (Mombasa – Kenya – Uganda – Rwanda – Burundi – DRC – South Sudan), where transit time was reduced from 11 days to 5 days (Figure 5).

Figure 5. Digital customs ecosystem architecture

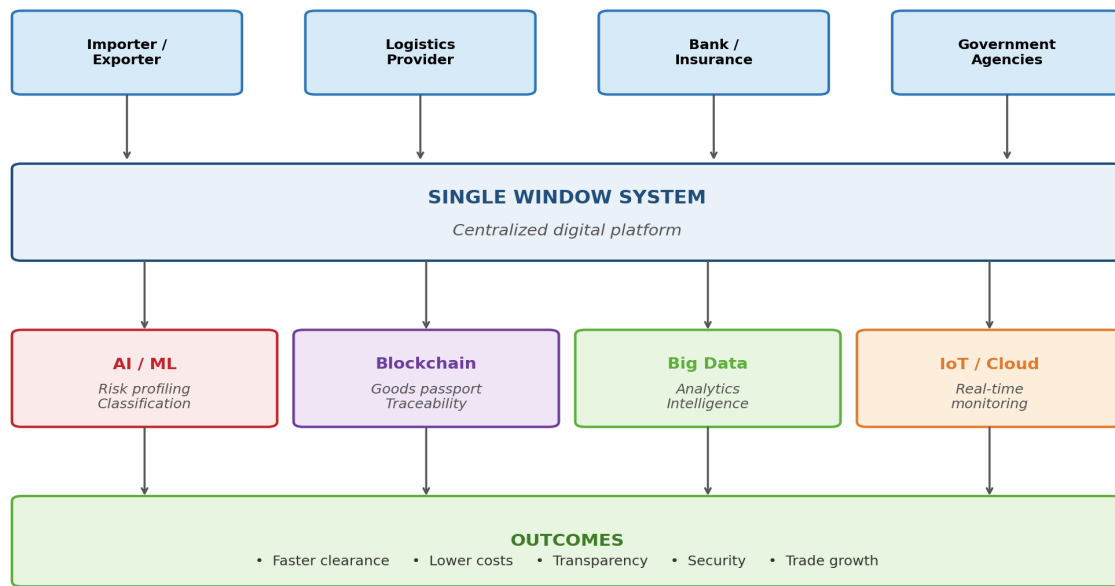


Figure 5. Digital customs ecosystem architecture²

In a scientific article published in *Journal of African Economies* by Oxford Academic in 2025, it was estimated that the effective implementation of TFA measures can reduce customs clearance time by 3.7 days for imports and 1.9 days for exports [14]. This reduction is equivalent to an ad valorem tariff reduction of 3.5–7% for imports and may contribute to an additional 8% increase in exports.

According to UNCTAD estimates, the economic value of this time reduction amounts to USD 210 billion per year, expressed as the “Estimated Willingness-to-Pay for Time Reductions” [5]. The figure below illustrates the impact of the TFA across different sectors (Figure 6)

Figure 4. Economic impact of the WTO Trade Facilitation Agreement

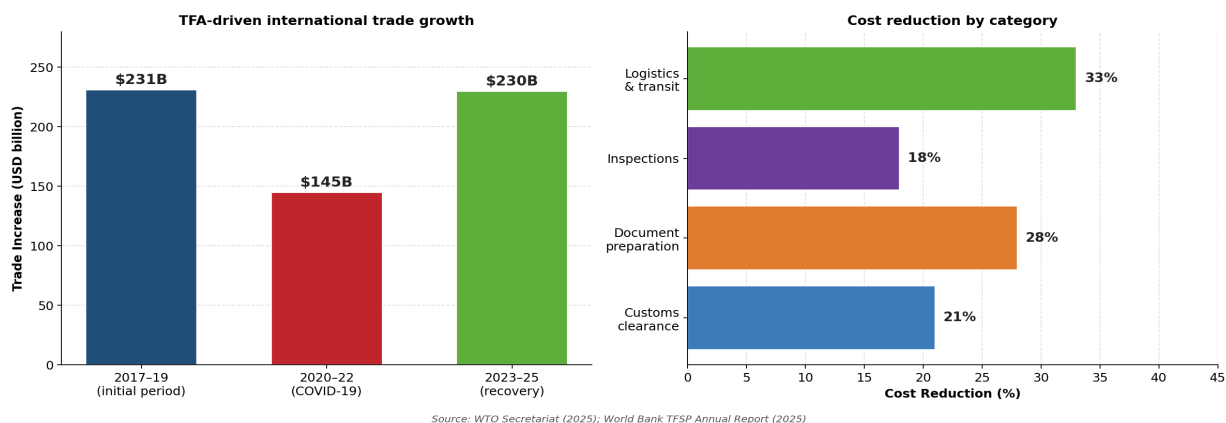


Figure 6. Economic impact of the WTO Trade Facilitation Agreement

Singapore’s TradeNet system is considered one of the most advanced Single Window platforms in the world. According to UNCTAD’s *UN Trade Digitalization Index*, Singapore has achieved a 100% score in paperless trade [4].

The Korea Customs Service (KCS) began its digitalization process in the 1970s, and currently 93% of its business processes are automated. KCS is among the first national customs administrations to integrate

blockchain, AI, and big data technologies in the control of e-commerce [7].

Since July 2025, Dubai Customs has introduced the possibility of inspecting goods directly at exporters' warehouses or distribution centers under the "Seamless Inspections" initiative [12]. This approach is based on IoT technologies and continuous digital monitoring.

The first domestic study mission organized in China in November 2024 under the WCO Smart Customs Project confirmed the effectiveness of the "Tianji Knowledge Graph," "Smart NII Image Analysis," "Intelligent Document Examination," and "Smart Port Development" systems [15].

Although the advantages of digital customs are evident, several important challenges also remain. According to UNCTAD's 2024 analysis, the digital divide between developed and developing countries is still significant. First, differences among international standards and the lack of interoperability remain pressing issues. Second, vulnerability to cyberattacks is increasing: in 2024, global container shipping costs rose by 122%, partly due to disruptions related to cybersecurity [4]. Third, the need for staff retraining and the existing skills gap remain relevant, and the WCO IT Guide pays particular attention to these issues [2]. Fourth, developing countries continue to require substantial infrastructure investment.

In a joint report published by Maersk and the World Economic Forum (WEF) at the end of 2025, the following customs trends for 2026 were identified [16]:

The use of customs as a strategic instrument ("Customs as a strategy");

AI-based screening and management tools;

The full implementation of the European Union's Carbon Border Adjustment Mechanism (CBAM) from 2026;

The entry into force of the EU Digital Battery Passport from 2027;

The expansion of AEO certificates and the concept of "trust packages";

The integration of green trade and ESG requirements with customs platforms [17].

CONCLUSION AND RECOMMENDATIONS

The results of the analysis show that digitalization in customs management is no longer a matter of the future, but a necessity that has already become a reality today. The empirical evidence — more than USD 230 billion in trade growth due to the WTO TFA, an 87% reduction in clearance time at the Kenya–Tanzania border, and the reduction of customs clearance time from 4 hours to 15 minutes through Mauritius TradeNet — confirms the economic effectiveness of digital customs.

The integration of artificial intelligence, blockchain, IoT, big data, and Single Window systems is fundamentally transforming customs services. However, this transformation requires a comprehensive approach that covers technology, legislation, personnel training, and international cooperation.

For Uzbekistan and other developing countries, studying and adopting these trends is an important condition for effective integration into global supply chains, enhancing national competitiveness, and fulfilling the requirements of the WTO TFA.

The recommended priority directions are as follows: (1) full implementation of the Single Window system; (2) alignment of the AEO program with international standards; (3) phased introduction of an AI/ML-based risk management system; (4) launch of blockchain pilot projects; and (5) regular improvement of the digital competencies of customs personnel.

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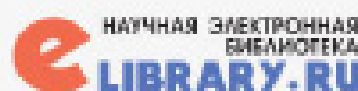
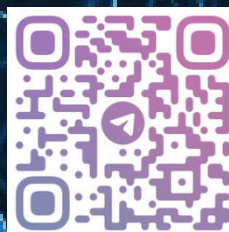
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