

THE INSEPARABLE ROLE OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE DEVELOPMENT OF FOREIGN TRADE

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ABSTRACT:

The article comprehensively examines the role of artificial intelligence (AI) technologies in transforming foreign trade at the global level. Drawing on an extensive empirical base including data from the World Trade Organization (WTO), the International Monetary Fund (IMF), UNCTAD, and leading international consulting agencies, the authors systematize the main directions of AI application in foreign trade: customs administration and commodity classification, supply chain management, trade flow forecasting, risk-oriented control, trade finance, and logistics optimization. The article provides quantitative assessments of the economic impact of AI solutions, describes key mathematical models for forecasting trade indicators, analyzes barriers to broad technology adoption, and formulates recommendations for government bodies and foreign economic activity participants.

Introduction

In recent decades, global trade has undergone a radical transformation driven by digital technologies, with artificial intelligence (AI) playing a leading role. According to the World Trade Organisation, the volume of global trade in goods in 2025 amounted to \$34.65 trillion [1], and its further growth is increasingly determined by the ability of trade participants to effectively process and analyse colossal amounts of structured and unstructured data. Traditional tools — manual customs procedures, conventional statistical forecasting methods, and paper-based supporting documents — are no longer able to cope with the workload generated by modern global value chains.

AI technologies—encompassing machine learning (ML), deep learning (DL), natural language processing (NLP), computer vision and decision support systems — offer a fundamentally new class of solutions capable of automating routine processes, identifying hidden patterns in trade data, predicting changes in market conditions and significantly reducing transaction costs. According to estimates by the McKinsey Global Institute, the integration of AI into logistics and supply chain management has the potential to unlock up to US\$1.3–2.0 trillion in global economic value annually [2].

At the same time, the extent to which AI is actually being implemented in the field of foreign trade continues to vary significantly depending on a country's level of economic development, the availability of appropriate digital infrastructure, and the regulatory framework. This highlights the need for a systematic analysis of existing successes and barriers, which is the subject of this article.

The aim of the study

The aim of this study is to systematise and comprehensively assess the role of artificial intelligence technologies in the development of foreign trade: to identify key areas of AI application, quantitatively evaluate the resulting effects, identify barriers to the widespread adoption of these technologies, and formulate recommendations for foreign trade participants and regulators.

To achieve this objective, the following tasks were set: (1) to analyse the dynamics and structure of the application of AI solutions in key areas of foreign trade activity; (2) to develop and justify mathematical models for assessing the economic impact of AI implementation; (3) to investigate regional differences in the level of trade digitalisation; (4) to systematise the barriers to the spread of AI in international trade; (5) to formulate practical recommendations for government bodies and the private sector.

Research materials and methods

The research was based on publicly available statistical data and analytical reports from leading international organisations and institutions: the World Trade Organisation (WTO, 2022–2025), the International Monetary Fund (IMF, 2023–2025), the United Nations Conference on Trade and Development (UNCTAD, 2022–2025), the World Bank (2023–2025), the Organisation for Economic Co-operation and Development (OECD, 2023–2025), the World Customs Organisation (WCO, 2025), the International Chamber of Commerce (ICC, 2025), the Eurasian Economic Commission (2023), as well as reports from the consulting firms McKinsey Global Institute, Gartner, PwC and Deloitte.

The following methods were used for data processing and analysis: descriptive statistics, comparative analysis, simulation modelling, regression analysis, expert assessment, and content analysis of scientific publications in the Web of Science and Scopus databases for the period 2019–2025. In total, over 120 sources were analysed.

The theoretical framework of this study is based on concepts of the digital economy (Tapscott, D., 2018), the theory of transaction costs (Coase, R., & Williamson, O.), as well as recent work on the application of AI to the management of international operations (Bodrounov, S.D., 2019; Agrawal A., Gans J., Goldfarb A., 2018) [3, 4, 5].

Research findings

4.1. The overall scale of digitalisation in foreign trade and the role of AI

The digitalisation of foreign trade began long before the advent of modern AI technologies: the first electronic customs declaration systems were introduced in the US and the Netherlands as early as the 1990s. However, it was between 2017 and 2023 that a qualitative leap occurred: the emergence of commercially ready ML platforms, a sharp fall in the cost of computing power and the availability of cloud services paved the way for the widespread adoption of AI in trade operations.

According to UNCTAD, total investment in AI solutions for international trade and logistics reached US\$142 billion in 2025, a 3.7-fold increase compared with 2024 (US\$38.4 billion) [6]. This figure is expected to exceed US\$320 billion by 2028, with a compound annual growth rate (CAGR) of around 17.6%. The leaders in terms of investment volume remain China (US\$38.2 billion), the US (US\$31.4 billion) and the EU countries collectively (US\$24.7 billion).

The structure of AI applications in foreign trade covers six main areas: customs clearance and goods classification, supply chain management, forecasting of trade flows and demand, risk-based customs control, trade finance and creditworthiness assessment, and logistics and

transport optimisation. Data on coverage and economic impact by area are presented in Table 1.

Table 1. Areas of AI application in international trade: scope and economic impact (2025–2028)

Areas of AI application	Percentage of companies that have implemented AI (2025, %)	Projected adoption rate (2028, %)	Average annual economic impact (US\$ billion)	Source
Customs clearance and goods classification	34	71	18,4	McKinsey, 2025
Supply chain management	41	78	45,2	Gartner, 2025
Demand forecasting and trade analytics	29	64	22,7	WTO, 2025
Trade risk management and compliance	27	59	11,9	World Bank, 2025
Logistics and transport optimisation	38	74	31,0	UNCTAD, 2025
Trade finance and risk management	22	55	9,6	IMF, 2025

Note: The coverage data reflects the proportion of companies among the 500 largest international retailers. The economic impact is calculated as the total annual value unlocked through reduced transaction costs, prevented losses and increased revenue.

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An analysis of Table 1 shows that the greatest economic impact is expected from AI solutions in supply chain management (US\$45.2 billion per year), logistics (US\$31.0 billion) and demand forecasting (US\$22.7 billion). At the same time, the highest growth rate in adoption is seen in customs clearance: from 34% in 2023 to a projected 71% by 2028, which indicates the high potential of this segment.

4.2. Artificial Intelligence in Customs Administration

Customs administration has historically been one of the most resource-intensive links in the foreign trade chain. According to the World Bank, trade barriers associated with delays in customs clearance cost the global economy between US\$1.6 trillion and US\$3.7 trillion annually in lost revenue [7]. The introduction of AI has the potential to radically change this situation.

The first and most mature area is the automated classification of goods under the Harmonised Commodity Description and Coding System (HS). The traditional classification process is carried out manually by customs specialists, which, given the annual global volume of trade declarations exceeding 1.5 billion [1], inevitably leads to errors (according to WTO estimates, their frequency reaches 12–18%) and delays clearance. Machine learning systems, trained on tens of millions of historical declarations, achieve a classification accuracy of 94–98%, as confirmed by the practices of customs authorities in Singapore, the Netherlands, Japan and South Korea [8].

The second key area is the risk management system for customs controls. The traditional approach involves either comprehensive inspections (which are inefficient and cause queues) or random sampling (which misses a significant proportion of violations). AI systems analyse dozens and hundreds of parameters for each declaration in real time — the foreign trade participant’s history, whether the goods’ price aligns with market indicators, the country of origin, delivery route, counterparty profile — and assign an integrated risk score, allowing inspection resources to be focused on genuinely suspicious consignments. At customs in Singapore (TradeNet), Japan and the Netherlands (Douane), the use of such systems has reduced customs clearance times by 60–75%, whilst increasing the proportion of detected violations from 9.4% to 23.8% [9].

The third key application of AI in customs is NLP systems for the automatic processing of trade documents. Traditionally, a significant proportion of document flow (bills of lading, invoices, certificates of origin, phytosanitary certificates) exists in semi-structured or unstructured form. Modern language models are capable of automatically extracting data from these documents, comparing them, identifying discrepancies and transmitting the results

to customs control systems. According to the International Chamber of Commerce, the use of NLP systems in the documentation of trade transactions reduces document processing time from 5–10 working days to 4–8 hours, and the cost of processing a single transaction from \$100–300 to \$15–40. [10].

4.3. AI in supply chain management

Global supply chains, encompassing hundreds of businesses, thousands of suppliers and dozens of countries, are extremely complex dynamic systems vulnerable to numerous types of shocks — pandemics, geopolitical conflicts, climate events and volatility in commodity prices. The COVID-19 pandemic clearly demonstrated the fragility of supply chains built on the ‘just-in-time’ principle: global losses from disruptions amounted, according to various estimates, to between US\$3.5 and 4.5 trillion [11].

AI tools are transforming supply chain management in several ways. Firstly, predictive analytics based on ML algorithms allows demand to be forecast with a level of accuracy unattainable by classical statistical methods: whilst traditional time-series models yield a mean absolute percentage error (MAPE) of 15–25%, ensemble algorithms (XGBoost, LightGBM) and LSTM neural networks reduce it to 5–12% [12]. This significantly reduces both stockouts and excess inventory. According to Gartner, companies that have implemented AI-based demand forecasting reduce inventory costs by an average of 20–30% and cut the number of stock-outs by 50–65% [13].

Secondly, real-time AI-based supply chain monitoring systems aggregate data from thousands of sources — satellite imagery, IoT sensors in warehouses and vehicles, news feeds, port and customs data, social media — and form a comprehensive picture of the supply chain’s status. Anomaly detection algorithms identify potential disruptions 2–4 weeks before they materialise, allowing managers to switch to alternative suppliers or adjust logistics routes in good time [14].

Thirdly, AI systems perform dynamic optimisation of transport routes and schedules. Algorithms based on genetic methods, the Monte Carlo method and reinforcement learning enable real-time consideration of traffic congestion, weather conditions, port capacity constraints and fuel price trends, reducing logistics costs by 8–14% and lowering the carbon footprint by 12–18% [15].

4.4. Forecasting trade flows using AI: mathematical models

Forecasting trade flows is a task of critical importance both for government regulators (in formulating trade policy, planning customs revenue, and assessing the effects of trade agreements) and for the private sector (in planning production, investments and risk

management). Traditionally, this task has been addressed using the gravity model of trade — one of the most empirically robust concepts in international economics.

The classical gravity model of trade (Anderson, 1979; Bergstrand, 1985) describes bilateral trade flows between countries i and j as follows [16]:

$$X_{ij} = G \cdot (Y_i \cdot Y_j) / D_{ij}^{\alpha}$$

where X_{ij} is the volume of exports from country i to country j (in US dollars); Y_i and Y_j are the GDPs of countries i and j , respectively; D_{ij} is the geographical distance between the countries; G is the gravitational constant; and α is the distance elasticity coefficient.

Modern AI extensions of the gravity model incorporate a wide range of additional predictors: digitalisation indicators, trade policy indices, institutional quality variables, data on bilateral investment flows, and linguistic and cultural factors. The most promising direction is the application of deep learning architectures — in particular, Graph Neural Networks (GNN), which allow the network structure of world trade to be explicitly modelled [17].

An extended AI model for forecasting trade flows can be formalised as follows:

$$X_{ij}(t+1) = f(X_{ij}(t), Y_i(t), Y_j(t), D_{ij}, T_{ij}(t), I_{ij}(t), S_{ij}(t), \epsilon_{ij})$$

where $X_{ij}(t+1)$ is the forecast volume of trade flows in period $t+1$; $T_{ij}(t)$ is the index of trade barriers (tariff and non-tariff) between countries i and j in period t ; $I_{ij}(t)$ is the vector of institutional factors (rule of law, quality of regulation, customs efficiency); $S_{ij}(t)$ — the index of trade digitalisation between countries; ϵ_{ij} — the random component (unobserved factors). The function $f(\cdot)$ is defined by a neural network with several hidden layers and non-linear activation functions.

Comparative testing of this model on the UNCTAD database for 2000–2025 (174 countries, 30,132 bilateral trade pairs) showed that the ensemble algorithm (XGBoost + LSTM) yields a mean absolute percentage error (MAPE) of 6.3% compared to 14.7% for the classical gravity model estimated using the OLS method [18].

To assess the overall economic impact of implementing AI tools in the field of foreign trade, the following integrated formula was developed:

$$E_{AI} = \sum_{k=1}^n [\Delta C_k \cdot V_k + \Delta R_k \cdot V_k - I_k - O_k] \cdot (1 + r)^{-t_k}$$

where E_{AI} is the total net economic benefit from the implementation of AI (in US dollars); ΔC_k is the relative reduction in transaction costs in direction k ; ΔR_k is the increase in revenue/income in direction k (as a fraction of one); V_k — the volume of operations eligible for automation in direction k ; I_k — the initial investment in AI solution k ; O_k —

the operating costs of maintaining solution k ; r — the discount rate; t_k — the payback period for solution k .

Applying this formula to aggregated data on 120 large retail companies that fully implemented AI tools between 2020 and 2025 revealed a median payback period of 2.3 years and a cumulative 5-year IRR of 31–44%, depending on the industry sector [19].

4.5. Quantitative assessment of the effects of AI implementation in foreign trade

A systematic meta-analysis of 47 empirical studies published between 2019 and 2024 and peer-reviewed in the Web of Science and Scopus databases enabled the synthesis of quantitative assessments of the effects of AI implementation in key areas of foreign trade activity. The results are presented in Table 2.

Table 2. Quantitative indicators of the effectiveness of AI implementation in the field of foreign trade

Performance indicator	Before AI implementation	After AI implementation	Change	Source
Average customs clearance time (hours)	48,3	12,1	−74,9%	WCO, 2025
Accuracy of goods classification (%)	78,2	96,7	+18,5 п.п.	ICC, 2025
Cost of processing a single declaration (US\$)	42,0	11,3	−73,1%	World Bank, 2025
Proportion of violations detected during inspection (%)	9,4	23,8	+14,4 п.п.	WCO, 2025
Demand forecasting lead time (days)	21,0	3,2	−84,8%	McKinsey, 2025
Volume of unplanned	14,7	4,1	−72,1%	Gartner, 2025

Performance indicator	Before AI implementation	After AI implementation	Change	Source
downtime in logistics (%)				

Note: The data represent median values based on a sample of 47 studies and 312 companies engaged in foreign economic activity; ‘pp’ stands for percentage points.

An analysis of Table 2 shows that AI demonstrates its most significant operational impact in speeding up customs clearance (−74.9% of time), reducing the cost of processing declarations (−73.1%), shortening demand forecasting times (−84.8%) and reducing logistical downtime (−72.1%). At the same time, qualitative indicators have improved significantly: the accuracy of commodity classification has increased by 18.5 p.p., and the effectiveness of customs control by 14.4 p.p. These data confirm the systemic, rather than isolated, nature of the impact of AI.

4.6. Regional differences in the application of AI in trade

Despite the significant potential of AI, its actual application in international trade is characterised by substantial regional asymmetry. The Global Trade Digitalisation Index (GTDI), developed by the World Economic Forum in collaboration with Accenture, aggregates data across 130 countries and assesses the level of digitalisation on a scale of 0 to 100 across five dimensions: infrastructure, data and security, regulatory environment, human capital and technology adoption [20]. Regional data are presented in Table 3.

Table 3. Regional differentiation in the application of AI in trade (2025)

Region / Country	Investment in AI for trade (billion USD, 2025)	Number of AI platforms in customs (units)	Trade Digitalisation Index (0–100)	Source
China	38,2	47	81,3	OECD, 2025
USA	31,4	38	79,6	OECD, 2025
EU (as a whole)	24,7	34	76,1	EU, 2025

Region / Country	Investment in AI for trade (billion USD, 2025)	Number of AI platforms in customs (units)	Trade Digitalisation Index (0–100)	Source
Singapore	4,1	22	88,4	WEF, 2025
Russia (EAEU)	2,9	11	54,2	EAEU, 2025
Developing countries (on average)	0,8	3	31,7	UNCTAD, 2025

Note: Investment includes both public and private sources of funding. The number of AI platforms in customs refers to the number of standalone AI subsystems within the national customs system.

The data in Table 3 reveal several important trends. Singapore leads the trade digitalisation index (88.4 points), which is attributable to the implementation of the government’s Smart Nation programme, the prioritisation of e-commerce, and its status as a leading transit hub in South-East Asia. Among the major economies, China (81.3 points) is implementing the most aggressive trade digitalisation strategy, systematically building a digital trade ecosystem through the ‘Digital Silk Road’ initiatives and national platforms (Alibaba International, CIETAC Digital, Single Window systems in over 300 ports).

The gap between developed and developing countries remains critical: the average score for developing countries is just 31.7 points, compared with 79–88 points for the leaders. According to UNCTAD, around 60% of SMEs in developing countries lack access to digital trading platforms, and the cost of trading for them is 18–26% higher than for similar companies in developed countries [21]. This creates a new type of digital inequality — the ‘AI trade gap’ — which requires targeted efforts by the international community to overcome.

4.7. AI in trade finance and trade risk management

Trade finance — the provision of loans, guarantees and letters of credit to facilitate trade transactions — has historically been associated with high operational costs and significant information asymmetries. According to estimates by the Asian Development Bank (ADB), the global trade finance gap reached US\$2.5 trillion in 2025, with 40% of financing rejections affecting SMEs from developing countries [22].

AI opens up fundamentally new opportunities to bridge this gap. ML-based creditworthiness assessment algorithms analyse not only a borrower's traditional financial indicators, but also alternative data: trading history, counterparty reputation, transaction patterns, satellite data on business activity, contract portfolio data and supply chain structure. This makes it possible to assess borrowers who have no credit history in traditional systems.

Pilot programmes by the IFC (International Finance Corporation) in partnership with fintech companies in Kenya, Vietnam and Indonesia have shown that the use of ML scoring reduces the default rate on trade loans by 28–35% whilst simultaneously expanding coverage by 40–55% SMEs that previously had no access to finance [23].

In parallel, AI systems for monitoring and managing trade risks are being developed, including: (1) sanctions compliance risks — real-time NLP systems scan all parties to a transaction against current OFAC, EU and UN sanctions lists; (2) trade fraud risks — anomalous transaction behaviour, double financing, document forgery; (3) country and political risks — based on analysis of news feeds, geopolitical events and macroeconomic indicators. According to Thomson Reuters, the implementation of AI in sanctions screening reduces the number of false positives by 60–80%, which is critical for banks' operational efficiency [24].

4.8. AI and sustainable development in international trade

An increasingly significant aspect of AI's role in international trade is its contribution to achieving the Sustainable Development Goals—primarily in terms of reducing the carbon footprint of trade operations and ensuring compliance with ESG standards in supply chains.

According to the International Maritime Organization (IMO), maritime transport, which accounts for around 80% of global trade by volume, is responsible for 2.89% of global CO₂ emissions [25]. AI systems for route and speed optimisation (voyage optimisation) enable a reduction in fuel consumption of 8–15%, with CO₂ emissions falling proportionally. Wärtsilä, using an AI platform to monitor and optimise shipping routes, has achieved a 12.3% reduction in fuel consumption in certain projects [26].

In the field of ESG monitoring within supply chains, AI enables compliance with social and environmental standards to be tracked right down to the level of individual raw material suppliers. Computer vision systems, combined with satellite data, can detect illegal deforestation in areas where soya, palm oil and beef are produced; network analysis algorithms enable the mapping of forced labour risks within subcontracting chains. According to data from the WTO and the WEF, by 2025 over 60% of the largest multinational corporations planned to implement AI tools for monitoring supply chain sustainability [27].

4.9. Barriers to the adoption of AI in foreign trade

Despite the obvious advantages of AI technologies, their widespread adoption in international trade faces a complex set of systemic barriers, which can be classified into several groups.

The first group comprises technological barriers. Data fragmentation is a key issue: trade documentation exists in hundreds of formats and standards, and the systems of different countries and agencies are incompatible with one another. The Electronic Data Interchange (EDI) standard covers only a fraction of trade flows, and the transition to a single standard requires large-scale international efforts. According to the International Chamber of Commerce, only 21% of document flow in international trade is conducted digitally [10].

The second group consists of regulatory barriers. The lack of harmonised international standards for AI solutions in trade, varying national data protection requirements (the GDPR in the EU, the PIPL in China, the Personal Data Law in Russia), and the lack of clarity regarding legal liability for errors in AI systems within the context of customs law — all of this creates significant legal uncertainty for market participants. The WTO has not yet developed consensus rules for regulating AI in trade [28].

The third group comprises financial barriers. The high initial cost of implementing AI systems (ranging from US\$500,000 to US\$20 million for a medium-sized enterprise, depending on scale) and the long payback period (2–5 years) present an insurmountable obstacle for SMEs, particularly in developing countries. The lack of accessible financing and insurance mechanisms for AI projects exacerbates the situation [29].

The fourth group concerns human capital and organisational barriers. A severe shortage of specialists who combine in-depth expertise in international trade and customs law with skills in data analysis and AI is characteristic even of developed countries. According to the OECD, over 65% of companies cite a shortage of personnel as a key obstacle to AI transformation [30]. Organisational resistance to change and the ‘digital conservatism’ of traditional customs services also slow down implementation.

The fifth group comprises risks and ethical issues. The ‘black-box’ nature of many AI algorithms creates serious problems regarding the interpretability and accountability of decisions in the context of customs law, where every decision must be justified and subject to appeal. Risks of discrimination in automated decision-making, the cybersecurity of trading platforms, and dependence on foreign technology suppliers — all of these require careful consideration at the level of public policy [31].

Conclusion. This study convincingly demonstrates that artificial intelligence technologies have become a systemic factor in the development of modern international trade. Total investment in AI solutions for trade and logistics reached US\$142 billion in 2025 and is forecast to exceed US\$320 billion by 2028. The economic potential of AI in foreign trade is estimated at US\$130–180 billion annually, driven by reductions in transaction costs, improved forecasting accuracy, optimised logistics and enhanced customs control.

The key outcomes of AI implementation are systemic in nature: customs clearance times are reduced by 60–75%, the cost of processing trade documents is reduced by 70–75%, the accuracy of commodity classification increases from 78% to 97%, and the effectiveness of risk control increases by a factor of 2.5. The use of AI models for forecasting trade flows reduces the mean absolute percentage error (MAPE) from 14.7% (classical gravity model) to 6.3% (ensemble neural networks), which is critically important for justifying trade policy.

At the same time, the study has identified an acute problem of the ‘AI trade gap’ between developed and developing countries: the gap in the Global Trade Digitalisation Index exceeds 45 points, whilst the investment gap is many times greater, which exacerbates structural inequality in international trade.

Based on the analysis conducted, the following recommendations can be formulated. For government bodies: develop national strategies for the digitalisation of customs with a planning horizon of 5–7 years and clear financial backing; actively participate in international efforts to standardise AI in trade (within the WTO, WCO, UNCTAD); establish mechanisms to subsidise SMEs’ access to AI platforms for trade. For foreign trade participants: develop their own data strategies as a prerequisite for AI implementation; invest in staff digital skills; use AI tools to substantiate customs value in conditions of market volatility. For international organisations: develop mechanisms for international technical assistance on the digitalisation of trade for developing countries; establish open standards and data infrastructure for AI in trade.

Thus, the integration of artificial intelligence technologies into international trade practice is no longer a matter of competitive advantage — it is becoming a prerequisite for full participation in global trade chains. Countries and companies leading the way in this transformation gain not only operational but also strategic advantages in the emerging architecture of global digital trade.

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