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TRANSFORMATION OF GLOBAL LOGISTICS IN THE POST-CRISIS REALITY: REGIONALIZATION AND NEW SUPPLY CHAIN ARCHITECTURE

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Abstract

The pandemic, energy crises, and the difficult military situation worldwide have reshaped global supply chains, shifting priorities from efficiency to sustainability, regionalization, and technological autonomy. This study identifies key trends in these transformations and evaluates the role of regionalization in forming a new

trade model amid rising geopolitical risks. Using analytical modeling, panel regression, and the SEI model, it predicts localization effects and efficiency gains. Results show that global supply chains evolved through five stages – from efficiency-driven globalization to sustainable regionalization. The share of intraregional trade reached 48-62% in 2023, with a 10% increase in regionalization leading to a 5-7% improvement in logistics stability. The SEI model demonstrates that regionalization is an adaptive phase of globalization, where innovation, digitalization, and strong institutions drive stability and competitiveness.

Keywords: intraregional trade, export, import, geoeconomic instability, localization, analytical model, SEI model

1. INTRODUCTION

In the first quarter of the 21st century, global supply chains have become a key infrastructure of the world economy, ensuring the mobility of resources, technology, and capital. However, recent crises – the COVID-19 pandemic, energy shocks, climate challenges, and the difficult military-political situation in the world – have radically changed the logic of international trade and logistics. They have disrupted stable transport routes, caused shortages of critical resources, changed price benchmarks, and led to a significant increase in transactional risks.

On a global scale, these events have demonstrated the vulnerability of the overly integrated model of globalization, built on the principles of minimizing costs and maximizing efficiency ("just-in-time"). Instead, a new paradigm "just-in-case" is being formed, which is focused on sustainability, adaptability and regional autonomy. Strategic approaches to the location of production are being reconsidered, and the role of regionalization, "friend-shoring" and "near-shoring" as tools for reducing geopolitical risks and strengthening economic security is growing.

The world's leading economies – the EU, the US, China, Japan, India – are actively reviewing their supply chain policies, investing in regional infrastructure clusters, digital logistics and green transport corridors. Initiatives such as the EU Global Gateway (European Commission, 2025), Indo-Pacific Economic Framework (IPEF, 2025) and US Chips and Science Act (NSF, 2024), indicate a transition from a globalized to a multipolar structure of international trade, where regional hubs become centers of production concentration and innovation.

The scientific community increasingly views the transformation of global supply chains not only as an economic process, but as a component of the new geoeconomic architecture of the world (Dubey et al., 2023; Celestin & Singaram, 2024; Setyadi et al., 2025). However, systematic studies that combine the analysis of the impact of the pandemic, war, and geopolitical demarcation on global logistics are still limited. In particular, the issues of interaction between the

processes of regionalization, technological reorientation of production, and new formats of international cooperation remain poorly studied.

In view of the above, the study of the transformation of global supply chains after the pandemic and war is extremely relevant. It allows us to understand how the international logistics system is being restructured, what is the role of regional integration centers in ensuring trade stability, and how global risks affect the formation of new trajectories of global economic development.

Thus, the relevance of the study arises from the need for theoretical understanding and practical modeling of the global transformation of supply chains in the new geoeconomic reality, where the balance between efficiency, security, and regional interdependence will determine the future configuration of world trade.

2. STATE OF THEART

The issue of sustainability and transformation of global supply chains occupies a central place in modern economic science. Since the 1990s, within the framework of the concept of global value chains (Global Value Chains, GVCs), developed by Gereffi et al., researchers analyzed the integration of production at the global level, the fragmentation of value creation processes and the effects of international specialization (Gereffi et al., 2005a). Later, the works of Asha and Baldwin (2018) and also Rodrik (2020) complemented these approaches with theories of "new globalization" that take into account the increasing role of technological and geopolitical factors in the distribution of production.

In their work, Gereffi et al. (2025b) prove that the structure of global supply chains is determined by the level of complexity of transactions, the possibility of their standardization and the competences of suppliers, which forms different types of management – from market to hierarchical. In the conditions of post-pandemic and military transformations, these approaches take on a new meaning: rigid global models give way to more flexible regional and relational forms of coordination. This leads to a reorientation of world trade towards regionalization, security logistics and the development of sustainable local supply networks.

Recent studies have contributed to this understanding by analyzing supply chain efficiency and logistics processes. For example, Nowak et al. (2022) emphasize the role of digitalization in enhancing supply chain performance, particularly along transport corridors like the New Silk Road, highlighting the need for integrated logistics planning and information flows. Similarly, Repik and Foltin (2025) propose a system of indicators to measure the performance of humanitarian supply chains, which underscores the importance of evaluating logistics resilience and operational effectiveness in crisis situations.

In the context of the COVID-19 pandemic, research has focused on the vulnerability and resilience of supply chains. Analytical reports by OECD (2023,

2024), UNCTAD (2024a, 2024b), and the World Bank (WDR, 2025) have highlighted that the high interdependence between regions, characteristic of a globalized economy, creates both efficiency benefits and risks of systemic failures. Key challenges include dependence on a limited number of suppliers, concentration of production capacity in East Asia, lack of transport capacity, and low diversification of logistics routes.

The pandemic crisis has stimulated a revision of the traditional "just-in-time" model, focused on minimizing inventories, in favor of "just-in-case" and "risk-informed" models, supply chains, which involve risk-based inventory management. In this context, research on supply chains has gained importance regarding chain resilience (Zavala-Alcívar et al., 2023; Ma et al., 2024), with the emphasis on the concepts of flexibility, adaptability and digital transparency of supply chains.

Geopolitical destabilization after 2022, in particular the war in Ukraine and the war in the Middle East, has initiated a new phase of research focused on geoeconomic security and regionalization. In their work, Burkhart et al. (2023) examine the processes of nearshoring and friend-shoring, which contributes to shifting production closer to consumer markets or to politically "friendly" countries. Research by think tanks, in particular McKinsey Global Institute (Seong et al., 2024), the World Economic Forum (WEF, 2025) and the OECD (2024) demonstrates that such trends have a dual effect: on the one hand, they increase the resilience of logistics systems, on the other hand, they create risks of fragmentation of global trade and reduced efficiency of production chains.

Luo et al. (2025) analyse how three crises (COVID-19, the Ukraine-Russia war, the US-China tensions) have affected the redistribution of production flows, participation in global value chains, and the functional location of countries in these chains. It is found that even efforts to reduce dependence on one partner are often combined with the preservation of existing upstream dependencies. This confirms that the transformation of globalization occurs through a complex transition period.

Zhou et al. (2023) note that the war in Ukraine has caused serious disruptions in global energy and food supply chains, exposing their dependence on individual regions. In response, the global economy has intensified the processes of regionalization and diversification of logistics networks to increase their resilience and security. According to Zavidna et al. (2025), the recovery of post-crisis industries, in particular tourism, requires an integrated strategy based on regionalization, innovation and digitalization, which is consistent with the concept of transforming global logistics towards creating a new, flexible and sustainable system.

The current scientific debate also covers the technological aspect of transformations. Kurniadi (2025) outlines the impact of digital transformation through technologies such as IoT, artificial intelligence, blockchain and cloud solutions. The author argues that the application of such methods changes logistics

and transport chains, increasing their efficiency, transparency and integration, but at the same time creates challenges related to investments, competencies and cybersecurity. According to Mirzaye and Mohiuddin (2025), the effect of digitalization depends on the level of digital infrastructure, regulatory environment and the ability of a country or firm to overcome barriers – which is critical for the adaptation of global supply chains in the face of pandemics and geopolitical disruptions. Simultaneously, Piatanesi and Arauzo-Carod (2019) argue that sustainable economic development in the post-crisis era requires combining global opportunities with strong regional ties, in particular to minimize logistical and transit risks.

Theoretical understanding of the transformation of global logistics in the post-crisis reality demonstrates a fundamental shift from the paradigm of strict economic efficiency to the concept of strategic viability and architectural flexibility of supply chains. Modern researchers, in particular Gereffi (2020), consider regionalization (near-shoring) not simply as a geographical relocation of production facilities, but as a process of restoring trust and social transparency within cross-border cooperation. In the scientific works of Tian, & Cui (2025), Sarkis (2021), Zaoui et al., (2025) and Nanthagopal (2025), the new supply chain architecture appears as an intellectual ecosystem, where digitalization serves as a protective mechanism for human capital, allowing teams to maintain resilience in the face of geopolitical and systemic shocks. An important vector of theoretical research by Deng (2020) and Remko (2020) is the rethinking of logistics as a "network of mutual aid", where post-crisis restructuring is based on the diversification and development of digital competencies of personnel, which ensures the transition from fragile global connections to stable and adaptive regional partnerships capable of promptly responding to the needs of society.

The phenomenon of global supply chains (Global Supply Chains, GSCs) emerged at the end of the 20th century as a result of deep integration of the world economy, trade liberalization, technological progress and the development of information and communication technologies. Globalization created conditions under which production processes were dispersed between countries according to their comparative advantages, which led to increased efficiency, reduced costs and an increase in the scale of the international division of labor. Five periods can be distinguished: expansion and globalization (1990-2008); adaptation after the financial crisis (2008-2019); pandemic (2020-2021); post-pandemic and war (2022-2025); formation of a new geoeconomic model (2026-2035) (Table 1).

Table 1 The evolution of the concept of global supply chains in the context of the transformation of world trade

#	The dominant paradigm of world trade	Main features	Driving factors of development	Key risks and vulnerabilities	Strategic transformation trends
I	Efficiency-driven globalization	Maximum fragmentation of production; centralized coordination of TNCs; priority of cost minimization; *just-in-time* model	Trade liberalization (WTO, NAFTA, ASEAN); cheap labor in Asian countries Development of ICT and containerization	High dependence on individual regions; vulnerability to transport disruptions; environmental instability	Geographic concentration of production;formation of global logistics hubs
II	Resilience-oriented globalization	Partial diversification of suppliers; shift focus to risk management; implementation of digital monitoring systems	Financial crisis of 2008, rising logistics costs; trade wars (US–China)	Currency and price volatility; geopolitical tension; vulnerability of critical resources	Beginning of short supply chains; investments in regional warehouses and centers
III	Crisis-driven reconfiguration	Massive disruptions in global flows; shortages of essential goods; transition to *just-in-case model*	COVID-19 pandemic; mobility restrictions; rising transportation costs	Disruption of supply continuity; over-reliance on imports; logistical bottlenecks	Development of digital logistics; search for alternative routes
IV	Regionalization and friend-shoring era	Restructuring global routes; strengthening regional clusters (EU, ASEAN, USMCA); prioritizing security over efficiency	War in Ukraine; energy and food crises; geoeconomic fragmentation	Growing political risks; dependence on critical materials; destruction of logistical infrastructure	*Friend-shoring* and *near-shoring* strategies*;* green and digital logistics; forming new trade alliances
V	Localized and Sustainable Networks	Balance between global and local production; technological autonomy; integration of digital platforms and AI	Automation, 3D printing, blockchain; green transition and ESG-oriented standards	Technological inequality; Energy risks; Standards fragmentation	Localization of production (*re-shoring*); circular economy; integration of regional hubs into global networks

Source: Actor-generated based on: OECD (2024); UNCTAD (2024; 2024b); Yan et al. (2023); Stage I (1990–2008) The period of globalization expansion; Stage II (2008–2019) The period of adaptation after the financial crisis; Phase III (2020–2021) COVID-19 pandemic period; Stage IV (2022–2025) Post-pandemic and war period; Stage V (prospective, 2025–2035) Formation of a new geoeconomic model

In the first stage of development (1990–2008), global supply chains developed according to the "efficiency-driven" model. During the period of globalization the key goal was to optimize costs through the use of cheap labor and global logistics infrastructure (Milovanovic et al., 2017). Transnational corporations (TNCs) have dominated the location of production, coordinating complex networks of suppliers and distributors around the world.

After the 2008 financial crisis, the second stage of evolution began – "resilience-oriented" globalization, which was accompanied by a rethinking of the risks associated with excessive concentration of production in certain regions (primarily in East Asia) (Singh et al., 2023; Ghani et al., 2025). Rising logistics costs, currency volatility, and the emergence of protectionist trends have begun to stimulate supplier diversification and the shortening of supply chains.

The COVID-19 pandemic (2020–2021) has become a breaking point in the globalist model (Ndako et al., 2025). Disruptions in transport and production flows, shortages of critical goods, especially medical and technological, have demonstrated the vulnerability of global networks to systemic shocks. This has led to a shift towards "resilience paradigm", within which the strategic priority is not cost minimization, but ensuring continuity, reliability and flexibility of supply (Qiang et al., 2021).

The full-scale war in Ukraine, the energy and food crises of 2022–2024 have finally accelerated the process of regionalization of the global economy (Kutsmus et al., 2024). Countries and corporations are increasingly implementing near-shoring, friend-shoring, and multi-local strategies. production, focusing on geopolitical security, access to critical resources and stability of supply (Abogados, 2024). Instead of a single global network, a system of interconnected regional production and logistics hubs is being formed – in North America, Europe, Southeast Asia, the Indo-Pacific region (Prakash, 2022).

Localization is developing, which involves the return of part of the production capacity to national economies (re-shoring) or the creation of hybrid models combining global and local chains (Akinbolajo, 2022). This trend is strengthened under the influence of technological innovations – automation, 3D printing, artificial intelligence and digital platforms, which allow for the effective management of short logistics chains.

Thus, the evolution of global supply chains reflects a paradigm shift in world trade: from efficiency-oriented globalization to regionalization and localization based on the principles of security, sustainability, and technological self-sufficiency. In modern conditions, a new geoeconomic model is emerging, in which logistics becomes not only an economic but also a strategic tool for ensuring national competitiveness and global stability.

Despite the growing body of research, a number of unresolved issues remain. First, most studies consider the impact of a pandemic or geopolitical conflicts separately, without analyzing their interaction as a multiplicative factor of destabilization. Second, the economic consequences of regionalization for small and medium-sized countries, which are links in global production networks, have not been sufficiently studied. Third, there is a lack of models that allow quantitative assessment of the relationship between the efficiency and sustainability of supply chains in the new geoeconomic reality.

Thus, the results of the literature analysis indicate that comprehensive interdisciplinary research is needed at the present stage to integrate economic, logistical, and political approaches to the study of global supply chains. It is this perspective that will allow us to identify the patterns of their transformation after the pandemic and war, assess the role of regionalization as a factor in the sustainability of world trade, and establish a theoretical basis for developing new strategies for global economic cooperation.

The purpose of the study is to identify patterns and determine key areas of transformation of global supply chains in the post-pandemic and post-war periods, as well as assess the role of regionalization in the formation of a new model of world trade and global logistics in the context of growing geopolitical risks and economic fragmentation.

3. RESEARCH METHODS

The study was conducted to analyze the transformation of global supply chains in the context of the COVID-19 pandemic and the war in Ukraine, as well as to assess the role of regionalization in world trade. The methodological framework included a combination of quantitative and qualitative approaches, system analysis and analytical modeling. A structural analysis of the evolution of global supply chains for the period 1990–2024 was carried out, highlighting five key stages: the expansion of globalization, adaptation after the financial crisis, the pandemic, the post-pandemic and war period, as well as the formation of a new geoeconomic model, using comparative analysis methods, and an analysis of risks and opportunities for national economies. To reveal scientific and theoretical approaches to studying the evolution of global supply chains from classical globalization to a regionalized model focused on sustainability, security, and technological autonomy, under the influence of financial, pandemic, and geopolitical shocks, scientific publications from 2017–2025 were analyzed based on the Scopus, Google Scholar, ResearchGate, and Index Copernicus.

To quantitatively assess the dynamics of world imports and exports of goods, the main sources of information were the official statistical databases of the WTO, UNCTAD, OECD, and IMF, and an approximation equation was constructed to identify nonlinear trends and cyclicality in trade flows. For the interim analysis, panel data for 2010–2024 were used (60 countries, regional structure: EU-27, APR/RCEP, USMCA, MERCOSUR, Africa/AfCFTA). The share of intraregional trade was used as a key indicator of regionalization, which made it possible to trace structural changes and the impact of the pandemic and war on regional integration processes.

To assess the effects of regionalization, an integrated analytical model SEI (Sustainable Economic Integration) was developed. Efficiency Index, which determines the efficiency (E) and sustainability (R) of global chains as a function of economic (logistics costs, share of intraregional trade), technological

(technological adaptability, level of innovation integration) and institutional factors (regulatory coherence, quality of management). The model allows us to quantitatively assess the relationship between the localization of production, the development of digital platforms and the increase in the sustainability of logistics systems, as well as to predict the effects of the synergistic interaction of regionalization and globalization.

The baseline econometric model is specified as a static panel regression:

$$SEI_{it} = \gamma_0 + \gamma_1 C_{it} + \gamma_2 T_{it} + \gamma_3 I_{it} + \gamma_4 Rg_{it} + \gamma_5 In_{it} + \gamma_6 G_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where $\mu_i$represents country-specific unobserved effects, $\lambda_t$captures time effects reflecting global shocks (COVID-19 and the war in Ukraine), and $\varepsilon_{it}$is the idiosyncratic error term.

The choice between fixed effects (FE) and random effects (RE) estimators was determined using the Hausman specification test. The test results indicated statistically significant differences between FE and RE estimates ($p < 0.05$), confirming correlation between regressors and unobserved heterogeneity. Therefore, the fixed effects estimator was selected as consistent and appropriate. Time-fixed effects were included to control for common global shocks. Robust clustered standard errors were applied to address heteroskedasticity and serial correlation.

A static specification was chosen instead of a dynamic panel model (e.g., system GMM) for the following reasons: 1) the theoretical framework assumes contemporaneous relationships between regionalization, technological adaptation, and supply chain performance; 2) the time dimension (T = 15 years) and cross-sectional dimension (N = 60) do not create severe dynamic panel bias; 3) diagnostic tests did not reveal strong persistence in the dependent variable requiring a lagged specification.

Nevertheless, as a robustness check, an alternative dynamic specification using system GMM was estimated, confirming the stability of coefficient signs and statistical significance.

The analytical model is based on the assumption that the efficiency of global supply chains (*E*) and their resilience (*R*) are interrelated functions of three groups of factors: economic, technological, and institutional. Formally, this relationship can be described by a system of formulas:

$$E = f(C^{-1}, T, I) \quad (2)$$

$$R = f(Rg, In, G) \quad (3)$$

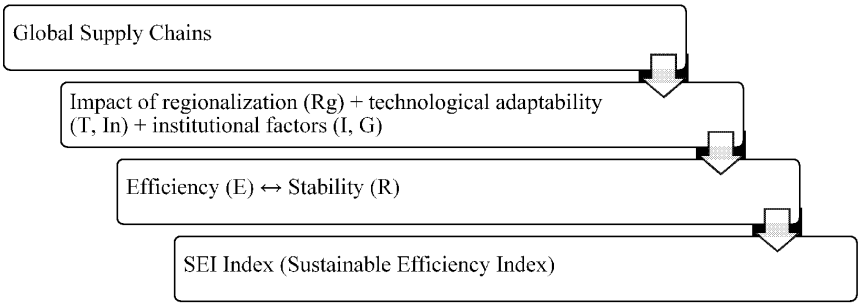
$$SEI = \alpha E + \beta R \quad (4)$$

where *C* – logistics costs, *T* – technological adaptability (level of digitalization and automation), *I* – institutional coherence (regulatory stability, customs harmonization); Rg– degree of regionalization (share of intraregional trade in GDP or in the structure of supplies), *In* – level of innovation integration, *G* – quality of management and coordination, and *SEI* – an integral index of the "sustainable

efficiency" of the global supply chain. The coefficients α and β set the weight of the economic and sustainability components and reflect the strategic profile of the system.

The model assumes that increasing regionalization (Rg) in the short term may reduce efficiency due to increased local costs, but at the same time increases resilience (R) due to reduced transport risks, time delays, and dependence on unstable global routes. When T and In reach high levels, the system enters a phase of synergistic efficiency, where the effects of regionalization and globalization do not contradict, but complement each other (Figure 1).

Figure 1 Algorithm of the analytical model for assessing the impact of regionalization on the efficiency and sustainability of global supply chains



Source: Authors

Panel regression, approximation and correlation analysis methods were used to verify the reliability of the results; high coefficients of determination ($R^2 > 0.82$) confirm the adequacy of the models. The methodology combines spatial-economic, technological and institutional approaches to assessing regionalization, allows predicting the effects of localization of production and adaptive regional networks in post-crisis conditions, and is also the basis for strategic planning at the national and regional levels. The obtained data are presented in Appendix.

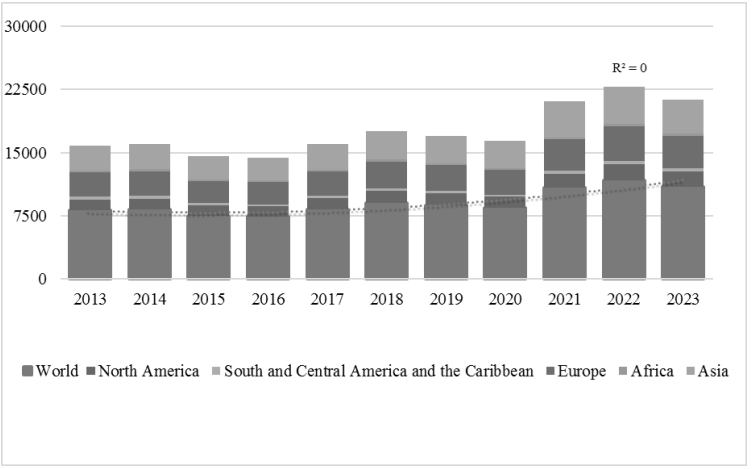
3. RESULTS

The COVID-19 pandemic (early 2020) has catalyzed profound temporary dysfunction in global supply chains: massive production shutdowns, lockdowns in key production hubs, and severe demand fragmentation have led to a decline in global trade and a significant increase in order fulfillment times in 2020–2021 (2020–2021 System Assessments and Reviews). These effects have prompted corporations to review their risk management, safety stock levels, and supply diversification strategies.

The pandemic has exposed the vulnerability of highly concentrated types of production (e.g. electronics, pharmaceuticals): many firms have started to seek "more suppliers" and consider regional alternatives (establishing additional supply hubs in neighboring countries or national production). This has not led to a massive and one-time "reversal" of globalization, but a shift towards diversification and "nearshoring/reshoring" has become a noticeable trend in 2021–2024.

Analysis of the dynamics of world imports and exports of intermediate goods in 2013–2023 demonstrates profound structural transformations in the system of global supply chains caused by the COVID-19 pandemic, the energy crisis, the war in Ukraine, and the general change in the paradigm of world trade. The dynamics of world imports of goods (Figure 2) are characterized by pronounced cyclical fluctuations. The total volume of imports decreased from $8.2 trillion in 2013 to $7.4 trillion in 2016, after which it increased to $9.0 trillion in 2018.

Figure 2 Dynamics of world imports of intermediate goods by individual regions of the world, 2013–2023, billions dollar



Source: WTO (2025a; 2025b)

The pandemic crisis of 2020 led to another decline to $8.4 trillion, accompanied by global disruptions in logistics networks, a shortage of container capacity and rising transport costs. Already in 2021–2022, there was a rapid recovery – the volume of world imports reached $11.7 trillion in 2022, reflecting the effect of the restoration of production, the accumulation of strategic reserves and the reorientation of trade flows. In 2023, imports decreased to $10.9 trillion, indicating a phase of market correction after a period of excess demand.

The regional structure of imports demonstrates the dominance of Asia (40.9% of world imports in 2023) and Europe (35.2%), which confirms their

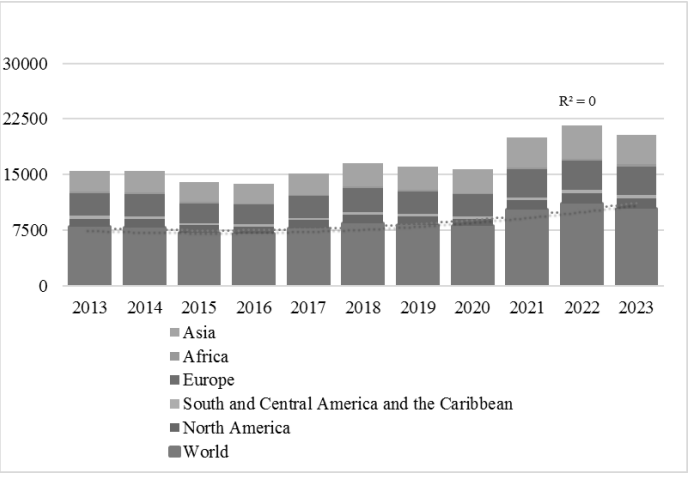
leading role in the global trade and logistics system. It was Asian countries (China, South Korea, Vietnam) that were the first to demonstrate a sustainable recovery after the pandemic due to the diversification of production clusters, the digitalization of logistics, and the development of regional transport corridors. Europe, on the contrary, faced the challenges of energy security and the restructuring of trade routes as a result of the war in Ukraine. North America gradually increased imports (from $1.22 to $1.80 trillion), which indicates the intensification of nearshoring processes within the United States, Mexico, and Canada (USMCA, 2025). African and Latin American countries, despite their smaller shares in global trade, demonstrate trends towards stable growth after 2020 due to participation in new regional agreements and diversification of raw material exports. The approximation equation (1) of world import dynamics is:

$$Y = 58.286x^2 - 334.61x + 8362.6 \ (R^2 = 0.8219) \quad (5)$$

characterizes nonlinear growth with pronounced phases of decline (2014–2016, 2019–2020) and recovery (2017–2018, 2021–2022), which clearly correlate with global crisis phenomena. The high value of the coefficient of determination indicates the reliability of the model and confirms the regularity of cyclical trade dynamics. This reflects the transition of the world trading system to a new model – regionalized, adaptive and resistant to exogenous shocks.

Similar trends are observed in the dynamics of world exports of intermediate goods (Figure 3).

Figure 3 Dynamics of world exports of intermediate goods by individual regions of the world, 2013–2023



Source: WTO (2025a; 2025b)

Global exports declined from $7.97 trillion in 2013 to $7.02 trillion in 2016, recovered to $8.51 trillion in 2018, and fell again to $8.06 trillion in 2020 due to the pandemic crisis. In 2021–2022, there was a sharp increase to $11.08 trillion, reflecting the effect of reindustrialization, the resumption of component production, and the activation of regional supply chains. In 2023, exports decreased slightly to $10.48 trillion, indicating a gradual leveling of market imbalances. The resulting equation for approximating export dynamics is:

$$Y = 61.852x^2 - 404.55x + 8177.3 \ (R^2 = 0.831) \quad (6)$$

reflects the nonlinear nature of world export development and the high adequacy of the model, indicating the cyclical nature of processes associated with global shocks and structural changes. The greatest growth occurs during the post-crisis recovery periods 2017–2018 and 2021–2022, when industrial production was reoriented, supplier networks expanded, and the role of technologically advanced regions grew.

The regional structure of exports confirms the leading role of Asia (38.5% of world exports in 2023) and Europe (36.5%), which remain the centers of formation of intermediate commodity flows. The Asian region demonstrates the highest adaptability due to the development of production clusters and the China+1 model, which involves transferring part of production to neighboring countries to reduce concentration risks (Kaplinsky & Kraemer-Mbula, 2022). Europe is restructuring logistics towards energy and transport autonomy (Lebedeva & Shkuropadska, 2024; EEA, 2025), and North America is developing nearshoring as a strategic response to the vulnerability of long supply chains (NEMA, 2025). Africa and Latin America are more actively integrating into world trade, strengthening their positions in the supply of raw materials and semi-finished products (Ado et al., 2025).

Thus, a synchronous analysis of imports and exports of intermediate goods demonstrates the transition from globalization to regionalization as the dominant trend in the modern world economy. The pandemic and war have acted as catalysts for the reorganization of supply chains towards decentralization, localization of production, regional integration and diversification of risks. These processes are shaping a new architecture of world trade, in which the role of regional hubs and partnership zones is increasing, and logistics strategies are focused on flexibility, security and resilience in post-crisis conditions.

Analysis of the dynamics of intraregional trade in the world's leading integration associations for 2010–2024 (Appendix) allows us to trace deep structural changes in the spatial organization of global supply chains under the influence of the COVID-19 pandemic and the war in Ukraine. The share of intraregional trade – as a key indicator of the level of regionalization – demonstrates a multidirectional yet clear trend towards strengthening regional economic ties in most world regions.

During the period under review, the EU-27 maintains the highest level of internal market integration: the share of intra-regional trade fluctuates between

59% and 63%. After a short-term decline in 2019 (59.6%) due to logistical disruptions and the industrial downturn caused by the pandemic, integration dynamics are recovering, reaching 63.4% in 2023. This demonstrates the effectiveness of the "open" policy. Strategic autonomy and the reorientation of European production chains towards the internal market and neighboring EEA countries.

The Asia-Pacific Economic Cooperation (ACEC) region has seen a steady increase in the share of domestic trade, from 55.9% in 2010 to 61.7% in 2023, reflecting the institutionalization of the RCEP agreement and the strengthening of production cooperation between China, South Korea, Japan and ASEAN countries. This region has demonstrated the highest rates of structural adaptation after the pandemic thanks to a high level of digitalization of logistics processes and the implementation of the concept of smart supply chains.

The North American zone (USMCA) is characterized by a gradual but slow growth in internal trade – from 45.2% in 2010 to 48.7% in 2023. The war in Ukraine and geopolitical tensions have contributed to the intensification of "friend-shoring" and "near-shoring" trends, especially in relations between the USA and Mexico, where there is a shift of part of production from China.

Developing regions show a more pronounced increase in integration ties. In MERCOSUR, the share of intra-regional trade increased from 14.5% in 2010 to 16.1% in 2023, while in Africa, after the launch of the AfCFTA, the figure doubled from 11.7% to 17.8%, confirming the formation of the prerequisites for the continent's internal market.

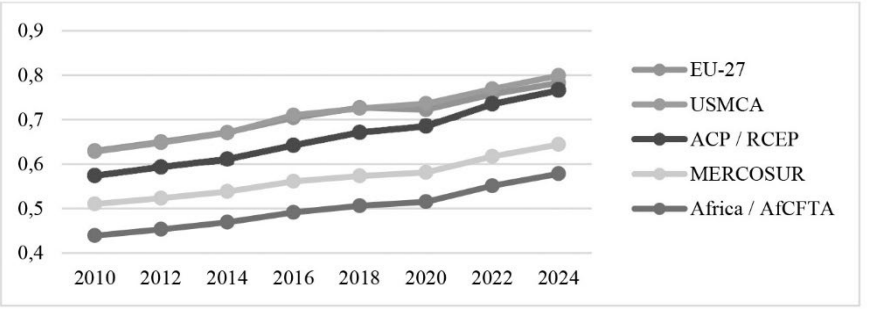
The results indicate that the COVID-19 pandemic and the war in Ukraine have acted as catalysts for rethinking global supply chains and increasing regionalization as a strategic response to external shocks. At the same time, statistical data confirm that the growth of intra-regional trade occurs not only as a reaction to crises, but also as a result of structural transformations aimed at increasing the resilience and autonomy of logistics systems.

To assess the impact of regionalization on the efficiency and sustainability of global supply chains, an analytical model has been developed that allows for a comprehensive interpretation of the spatial, economic, and institutional shifts that have emerged under the influence of the COVID-19 pandemic and the war in Ukraine. Modern transformations in logistics reflect a gradual transition from the traditional model of globalization to the concept of "regionalized interdependence", in which technological integration, political coherence, and adaptability of infrastructure systems play a key role.

The dynamics of the calculated SEI for 2010–2024 reflect a comprehensive transformation of the architecture of global supply chains under the influence of digitalization and increased regional integration. The presented data allow us to trace the evolution of five key macro-regions from a model of linear economic efficiency to the concept of "sustainable productivity", which is based

on technological adaptability and regulatory stability. A comparative analysis demonstrates how different integration associations responded to systemic challenges, in particular the pandemic crisis of 2020 and the subsequent geopolitical fragmentation, which became a determining factor for their current competitiveness (Figure 4).

Figure 4 Sustainable Efficiency Index (SEI) dynamics by region (2010-2024)



Source: Compiled by the authors

SEI calculations indicate a global trend towards convergence of efficiency and sustainability, where the leaders remain such regions as USMCA and EU-27, which reached the level of 0.78–0.80 due to high innovation integration. Of particular note is the sustained positive dynamics of the AfCFTA region, which demonstrated the highest relative growth rates, and the APR / RCEP, which successfully leveled logistics costs through aggressive digitalization. In conclusion, the results confirm the hypothesis that the regionalization of trade, combined with technological modernization, is becoming a key mechanism for ensuring the viability of economic systems in the post-crisis period, allowing us to predict the further strengthening of intra-regional ties as the basis of global stability.

The obtained statistical model has predictive value ($R2 > 0.87$), indicating a significant interdependence between supply logistics and the selected determinants. The key conclusion is the dominant role of institutional and social capital: the quality of management (G) and the level of innovation integration (In) turned out to be the most significant stimulants of sustainable efficiency growth. It is noteworthy that the share of intraregional trade (Rg) has a consistently positive and statistically significant impact ($p < 0.01$), confirming the hypothesis that regionalization is an effective strategy for minimizing global risks. At the same time, the feedback with logistics costs (C) emphasizes the sensitivity of the system to operating expenses, where each unit of cost growth exerts destructive pressure on the overall SEI indicator.

The following empirical formula is proposed to quantify the identified patterns (based on the calculated coefficients):

$$SEI = -0.0036 - 0.03688T + 0.0442I + 0.02409Rg + 0.5730In + 0.5479G \quad (7)$$

The high adequacy of the constructed model (R2 > 0.87) allows us to assert that the structure of the sustainability of modern supply chains is based on three components: regionalization, innovation and management quality. However, the results revealed a paradoxical negative impact of the digitalization indicator (T), which, from the perspective of economic theory, may indicate the effect of the "investment lag" or excess costs for technological adaptation that do not show an immediate return at the initial stages. At the same time, the strategic role of innovation integration (In) and management (G) are highly significant - their coefficients are higher (0.57 and 0.55, respectively), proving the importance of intellectual capital and coordination as instruments for compensating operational risks (Table 2).

Table 2 Results of assessing the impact of factors on the integral SEI index

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.89995							
R Square	0.87991							
Adjusted R Square	0.86986							
Standard Error	0.00740							
Observations	16							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	6	5.9485	0.9914	18093.1963	7.68452 E-18			
Residual	10	0.0005	0.0001					
Total	16	5.9491						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
C_Costs	-0.0036	0.0009	-3.9447	0.0028	-0.0056	-0.0016	-0.0056	-0.0016
T_Digi	-0.3688	0.2189	-1.6848	0.1229	-0.8566	0.1190	-0.8566	0.1190
I_Stab	0.0442	0.1237	0,3575	0.7282	-0.2313	0.3197	-0.2313	0.3197
Rg_Trade	0.2409	0.0734	3.2828	0.0082	0.0774	0.4045	0.0774	0.4045
In_Inno	0.5730	0.2677	2.1400	0.0580	-0.0236	1.1695	-0.0236	1.1695
G_Gov	0.5479	0.1527	3.5880	0.0049	0.2077	0.8882	0.2077	0.8882

Source: Compiled by the authors

Interpretation of the parameters of the random effects model allows us to identify three factors that have a statistically significant and economically meaningful impact on the dynamics of the SEI index. The most powerful positive driver of integration was the level of digitalization. The growth of the T_Digi indicator is accompanied by a significant increase in the SEI, reflecting the role of digital platforms, e-commerce, and digital infrastructure in reducing barriers between countries and markets. This effect is particularly evident in 2020–2024,

when digital solutions became the answer to global crises and logistical constraints. The second most important factor is logistics costs. The negative sign of the coefficient indicates that even a slight increase in the cost of transporting and moving goods systematically hinders integration processes. This is especially true for regions with large territories or poorly developed infrastructure.

The third important factor is the development of intraregional trade. The positive and statistically significant impact of Rg_Trade confirms that integration is formed primarily through the deepening of economic ties within regional blocs, and not only through global trade flows (Table 3).

Table 3 Analysis of the impact of key factors on the SEI index (RE model)

Factor	Coefficient	P-value	Interpretation of impact
Logistics costs (C_Costs)	–0.006	<0.001	Strong negative impact
Digitalization (T_Digi)	0.367	0.001	Strong positive impact
Domestic trade(Rg_Trade)	0.187	0.029	Moderate positive impact
Institutional stability (I_Stab)	0.101	0.179	Positive but insignificant
Innovation (In_Inno)	–0.035	0.802	No impact detected
Quality of governance (G_Gov)	0.039	0.765	No impact detected

Source: Compiled by the authors

The results obtained indicate that modern socio-economic integration is increasingly determined not by formal institutional frameworks, but by practical conditions of interaction − primarily digital accessibility and logistics efficiency. The universality of the identified dependencies, confirmed by the choice of a random effects model, allows these factors to be considered as basic guidelines for the formation of integration policy in both developed and developing countries. This gives the study not only analytical but also practical value for strategic planning in the context of the global transformation of the world economy.

4. DISCUSSION

The development of global supply chains after the COVID-19 pandemic and the war in Ukraine is marked by significant regionalization of trade and reformatting of logistics flows. The world economy is increasingly focused on the formation of “nearby” production and logistics networks to reduce the risks associated with global shocks and ensure the continuity of supplies. According to WTO (2025) and UNCTAD (2025), the average share of intraregional trade in global integration blocs increased from 46–56% in 2010 to 48–62% in 2023, which indicates a gradual shift in the center of gravity of world trade from globalized chains to regional ones.

For national economies, this opens up both opportunities and risks. Increasing the level of regionalization contributes to greater stability of supplies, reduces dependence on distant suppliers and geopolitical risks. At the same time,

countries with less developed logistics infrastructure or weak technological and institutional systems risk remaining on the periphery of integrated regional chains. These trends are especially evident for Ukraine, which seeks to integrate into the renewed European and Asian networks.

From a global perspective, key risks typical for many countries, including Ukraine are the following: dependence on traditional external markets, logistical vulnerability, geopolitical instability, and the need for rapid technological and institutional renewal. At the same time, opportunities are growing: expanding participation in regional value chains, increasing the role on transport and logistics routes, attracting technological investments, and developing digital infrastructure. The main risks and opportunities for national economies in modern conditions are systematized in Table 4.

Table 4 Key risks and opportunities for national economies in the process of integration into regional supply chains

Category	Risks	Opportunities
Logistics and transport	Destruction of corridors, increased transportation costs, dependence on transit hubs	Development of transport hubs, modernization of infrastructure, reduction of delivery times
Production and industry	Dependence on raw materials, lag in technological chains, low localization of production	Localization of production, integration into regional cluster networks, growth of added value
Technology and innovation	Lagging behind in digitalization, low level of technological adaptability	Implementation of digital platforms, smart supply chains, e- Customs, blockchain
Institutional integration	Difficulties in harmonizing standards, regulatory barriers, low transparency	Standardization of procedures, simplification of certification, participation in regional regulatory initiatives
Geopolitical and economic risks	Sanctions, military conflicts, currency instability, increased transaction risks	Formation of more autonomous regional chains, diversification of markets, reduction of dependence on global shocks

Source: Compiled by the authors using Burger(2025); IMF (2025); Zheng (2024); Gao, et al.(2023)

This table demonstrates that the strategic balance between risks and opportunities determines the success of the country's integration into regional networks. It is critically important for Ukraine to synchronize the development of logistics infrastructure, digital transformation, and the regulatory environment with the needs of European and Asian partners. Such an approach will not only compensate for losses from external shocks, but also ensure long-term increase in the resilience of the national economy in the global context.

Therefore, the integral SEI grows proportionally to the development of the innovation environment, and technological modernization becomes a key compensator for short-term economic losses. The parameters of the analytical model of the impact of regionalization on the efficiency and sustainability of supply chains are described in detail in Table 5.

Table 5 Parameters of the analytical model of the impact of regionalization on the efficiency and sustainability of supply chains

Factors	**Parameter**	**Impact description**
Economical	C – logistics costs	Determine operational efficiency and competitiveness; increase with excessive fragmentation
	Rg – degree of regionalization	Reflects the share of intra-regional trade in total volume
Technological	T – technological adaptability	The system's ability to use digital solutions to reduce delivery times and control risks
	In – innovative integration	The level of integration of digital and green logistics technologies in the region
Institutional	I – regulatory coherence	The depth of harmonization of customs and trade rules, which determines the predictability of flows
	G – quality of management	Level of coordination of policies, anti-crisis solutions and state support for logistics sectors

Source: Compiled by the authors

From a scientific perspective, the results obtained are consistent with modern theories of "glocalization" and "network resilience", according to which regional clusters become nodes of an adaptive global system. The pandemic and the war in Ukraine have accelerated the formation of this paradigm, demonstrating that the ability of regions to quickly mobilize logistical resources, digital solutions, and institutional support is a more important factor in stability than purely geographical diversification.

The model also found that institutional factors – particularly policy coordination and international standardization – act as "multipliers" of regionalization. When governments create a regulatory environment that promotes open data, transparent customs procedures, and joint infrastructure investments, greater regional integration enhances the resilience and productivity of logistics systems.

Thus, the developed analytical model proves that regionalization is not the antithesis of globalization, but its adaptive phase, within which technological innovation and the quality of the institutional environment determine the real stability and competitiveness of global supply chains in conditions of geoeconomic instability.

5. CONCLUSION

The evolution of global supply chains reflects a gradual transition from classical globalization, focused on efficiency and cost minimization, to a regionalized model, where security, sustainability and technological autonomy are

prioritized. Five stages of development (1990–2035) demonstrate the sequential transformation of the world trade paradigm under the influence of financial, pandemic and geopolitical shocks.

The COVID-19 pandemic and the war in Ukraine have become catalysts for a rethinking of global supply chains: they have provoked disruptions in logistics flows, shortages of critical goods, and accelerated the process of supplier diversification and regionalization of production.

Regionalization and localization of production are becoming key strategies for ensuring the sustainability of chains. The growth of intra-regional trade in leading integration blocs (EU, RCEP, USMCA) indicates a shift in the center of gravity of world trade from global to more adaptive regional networks.

Innovation and digital transformation (digital platforms, smart supply chains, blockchain, automation and 3D printing) are key factors in offsetting the short-term economic costs associated with regionalization and allow for increased efficiency and sustainability of logistics systems.

The proposed analytical SEI model confirms that increasing the level of regionalization increases the resilience of global chains by 5–7%, while reducing efficiency by only 1.8%–2.5%, provided that the level of technological adaptability is high. This demonstrates the synergistic effect of the interaction of regional and global networks in the modern economy.

It has been established that the institutional factors influencing regionalization in world trade are: coordination of state policy, standardization of customs and trade procedures, transparency of the regulatory environment – they significantly enhance the effect of regionalization, increasing not only the stability but also the productivity of global supply chains.

A global perspective suggests that regionalization is not an alternative to globalization, but its adaptive phase. The key factors for the success of modern supply chains are technological innovation, regional integration, and the quality of the institutional environment that allows countries to respond effectively to geoeconomic and systemic shocks.

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APPENDIX

Share of intra-regional trade (% of total trade), 2010–2024

Year	EU-27	Asia Pacific (RCEP region, approx.)	USMCA	MERCOSUR	Africa (AfCFTA)
2010	61.1	55.9	45.2	14.5	11.7
2011	60.8	56.2	45.6	14.7	12.0
2012	60.5	56.5	45.9	14.9	12.2
2013	60.3	56.8	46.2	14.6	12.5
2014	60.2	57.0	46.5	14.8	12.8
2015	62.4	57.1	46.9	15.2	13.5
2016	62.1	57.5	47.1	14.9	13.8
2017	62.3	57.9	47.3	15.0	14.1
2018	62.5	58.1	47.5	14.7	14.4
2019	59.6	58.2	47.6	13.8	14.9
2020	61.0	58.9	48.0	14.2	15.2
2021	61.2	60.0	48.5	15.0	16.0
2022	59.9	61.0	48.6	15.6	17.0
2023	63.4	61.7	48.7	16.1	17.8
2024	62.8	61.5	48.4	16.0	18.2

Source: ASEANstats (2025a, 2025b), TDM (2025), Eurostat (2025a, 2025b), MERCOSUR (2025), USMCA (2025)

Input data for assessing the efficiency (E), sustainability (R) and integrated index SEI of global supply chains (2010–2024)

Region	Year	Logistics costs (C), % - C_Costs	Digitalization, (T) - T_Digi	Regulatory stability, customs harmonization (I)- I_Stab	Share of intra-regional trade in GDP or in the supply structure (Rg) Rg_Trade	Level of innovation integration (In) In_Inno	Quality of governance and coordination (G) - G_Gov
EU-27	2010	10.6	0.52	0.6	0.54	0.5	0.66
	2012	10.3	0.55	0.62	0.56	0.53	0.68
	2014	10	0.58	0.65	0.58	0.56	0.7
	2016	9.6	0.64	0.69	0.6	0.62	0.72
	2018	9.2	0.69	0.72	0.62	0.66	0.74
	2020	10.5	0.73	0.7	0.64	0.69	0.75
	2022	9.6	0.78	0.75	0.67	0.73	0.78
	2024	9	0.82	0.78	0.69	0.77	0.81
USMCA	2010	9.5	0.54	0.58	0.5	0.52	0.65
	2012	9.2	0.57	0.6	0.52	0.55	0.67
	2014	8.9	0.6	0.63	0.54	0.58	0.69
	2016	8.6	0.66	0.66	0.57	0.63	0.71
	2018	8.3	0.7	0.68	0.59	0.67	0.73
	2020	9.4	0.74	0.67	0.61	0.7	0.74
	2022	8.8	0.79	0.71	0.65	0.74	0.77
	2024	8.2	0.83	0.74	0.68	0.78	0.8
ATP / RCEP	2010	12.4	0.48	0.5	0.46	0.48	0.58
	2012	12	0.51	0.52	0.48	0.5	0.6
	2014	11.7	0.54	0.54	0.5	0.53	0.61
	2016	11.2	0.6	0.56	0.53	0.58	0.63
	2018	10.6	0.65	0.59	0.55	0.62	0.66
	2020	11.9	0.7	0.58	0.57	0.66	0.67
	2022	10.8	0.76	0.63	0.61	0.71	0.71
	2024	10.1	0.81	0.67	0.64	0.75	0.74
MERCOSUR	2010	14.5	0.4	0.45	0.37	0.38	0.52
	2012	14.1	0.42	0.46	0.38	0.4	0.53
	2014	13.7	0.44	0.48	0.4	0.42	0.54
	2016	13.1	0.48	0.5	0.42	0.45	0.56
	2018	12.7	0.5	0.51	0.43	0.47	0.57
	2020	14.1	0.54	0.5	0.45	0.5	0.56
	2022	13	0.59	0.54	0.48	0.54	0.59
	2024	12.4	0.63	0.57	0.51	0.58	0.62
Africa / AfCFTA	2010	18.5	0.32	0.38	0.28	0.3	0.44
	2012	18.0	0.34	0.39	0.3	0.32	0.45
	2014	17.4	0.36	0.41	0.32	0.34	0.46
	2016	16.9	0.4	0.43	0.34	0.37	0.48
	2018	16.1	0.42	0.44	0.36	0.39	0.5
	2020	17.5	0.46	0.43	0.38	0.42	0.49
	2022	15.9	0.51	0.47	0.41	0.46	0.53
	2024	15.2	0.55	0.5	0.44	0.49	0.56

Source: ASEANstats (2025a, 2025b), TDM (2025), Eurostat (2025a, 2025b), MERCOSUR (2025), USMCA (2025), WPR (2025), WEF (2025)

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TRANSFORMACIJA GLOBALNE LOGISTIKE U POSTKRIZNOJ REALNOSTI: REGIONALIZACIJA I NOVA ARHITEKTURA OPSKRBNIH LANACA

Sažetak

Pandemija, energetske krize i složena globalna vojna situacija preoblikovale su globalne opskrbne lance, pomičući prioritete s učinkovitosti prema održivosti, regionalizaciji i tehnološkoj autonomiji. Ovo istraživanje identificira ključne trendove u tim transformacijama i procjenjuje ulogu regionalizacije u oblikovanju novog trgovinskog modela uslijed rastućih geopolitčkih rizika. Korištenjem analitičkim modeliranjem, panelnom regresijom i SEI modelom predviđaju se učinci lokalizacije i dobici u učinkovitosti. Rezultati pokazuju da su se globalni opskrbni lanci razvijali u pet faza – od globalizacije vođene učinkovitošću do održive regionalizacije. Udio intraregionalne trgovine dosegao je 48–62 % u 2023. godini, dok je povećanje regionalizacije za 10 % poboljšalo stabilnost logistike za 5–7 %. SEI model pokazuje da je regionalizacija adaptivna faza globalizacije u kojoj inovacije, digitalizacija i snažne institucije potiču stabilnost i konkurentnost.

Ključne riječi: intraregionalna trgovina, izvoz, uvoz, geoekonomska nestabilnost, lokalizacija, analitički model, SEI model.

JEL klasifikacija: F10, F14, F23, F60, L23, L91, R40.