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INFORMATION SYSTEMS AS A DRIVER OF INTERNATIONAL TRADE DEVELOPMENT AND VALUE CHAIN FORMATION IN CONDITIONS OF GLOBAL INSTABILITY

Abstract. *Introduction.* Global instability has significantly altered the architecture and functioning of international logistics and trade systems. Multiple overlapping shocks - pandemics, geopolitical conflicts, sanctions, and supply disruptions - have exposed the fragility of global value chains (GVCs). At the same time, the rapid expansion of digital technologies has created new opportunities to strengthen the resilience, transparency, and adaptability of global trade networks through the deployment of information systems (IS). These systems have evolved from operational tools into strategic infrastructures that synchronize material, financial, and informational flows.

Problem Statement. The current stage of globalization reveals growing asymmetries between efficiency-oriented and resilience-oriented GVC models. Existing studies insufficiently integrate the role of IS into the analysis of structural GVC transformations, particularly regarding financial-flow resilience, visibility, and coordination mechanisms under instability. Limited empirical evidence exists for developing or war-affected economies such as Ukraine. There is a need for a comprehensive framework that links digital transformation, GVC reconfiguration, and resilience outcomes, supported by institutional and empirical data.

The *purpose* of the article is to conceptualize and assess the role of information systems as a driver of resilience in international logistics and trade chains, focusing on their transformative impact on global value chains under global instability and formulating practical recommendations for economies undergoing systemic shocks.

Methods. The study applies systemic and comparative analysis, risk taxonomy evaluation, synthesis of institutional frameworks (OECD, WTO, World Bank, UNCTAD), and conceptual modeling of IS-resilience linkages. Empirical verification is based on cross-referencing leading scientific publications and international reports (McKinsey, DHL, UNCTAD, IMF). The analytical approach integrates three flows of GVCs - material, financial, and informational - into a single IS-based governance model.

Results. The findings confirm that IS synchronize global production and trade processes by ensuring traceability, financial integrity, and real-time visibility. AI, big data, and blockchain enhance predictability and automation, while digital customs and e-trade platforms reduce transaction costs by 14–18% and accelerate settlements. The WTO (2024) demonstrates that digitalization is the core driver of “re-globalization,” lowering trade costs and fostering inclusiveness. DHL (2025) proves that economies with high digital openness maintain greater trade stability during crises, while Maersk and Flexport (2023) show that digital twins and analytics enable nearshoring and friend-shoring flexibility. For Ukraine, integration into the EU’s digital trade infrastructure (eFTI, eIDAS, e-CMR) is critical for reconstruction and GVC participation.

Conclusions. Information systems have become a structural and functional foundation for global trade resilience. Their implementation reduces logistical and financial risks, enhances adaptability, and supports diversification of trade networks. The scientific

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novelty lies in developing an integrated IS-GVC-resilience framework that unites digital transformation theory with supply chain governance. The theoretical and practical significance is expressed through evidence-based recommendations for policymakers and firms to enhance resilience via IS-enabled tools. The socio-economic effect includes reduced volatility, higher competitiveness, and improved macroeconomic stability in post-crisis and developing economies. Further research should quantify IS-resilience pathways and assess the long-term economic impacts of digital trade integration.

Keywords: global value chains, information systems, supply chain resilience, digital trade, logistics, blockchain, financial flows.

JEL classification: F13, F14, M15, O33.

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ІНФОРМАЦІЙНІ СИСТЕМИ ЯК ДРАЙВЕР РОЗВИТКУ МІЖНАРОДНОЇ ТОРГІВЛІ ТА ФОРМУВАННЯ ЛАНЦЮГІВ ДОДАНОЇ ВАРТОСТІ В УМОВАХ ГЛОБАЛЬНОЇ НЕСТАБІЛЬНОСТІ

Анотація. *Вступ.* Глобальна нестабільність суттєво змінила архітектуру та функціонування міжнародних логістичних і торговельних систем. Накладання численних шоків – пандемії, геополітичних конфліктів, санкцій і розривів поставок – виявило вразливість глобальних ланцюгів створення вартості (Global Value Chains, GVCs). Водночас стрімке поширення цифрових технологій створило нові можливості для підвищення стійкості, прозорості й адаптивності світових торговельних мереж через упровадження інформаційних систем (ІС). Ці системи еволюціонували від операційних інструментів до стратегічної інфраструктури, що синхронізує матеріальні, фінансові та інформаційні потоки.

Проблематика. Сучасний етап глобалізації засвідчує наростання асиметрій між ефективністю та стійкістю у глобальних ланцюгах створення вартості. У наукових працях недостатньо інтегровано роль ІС у структурних трансформаціях GVC, зокрема в забезпеченні стійкості фінансових потоків, прозорості та координації в умовах нестабільності. Обмежено досліджено досвід країн, що розвиваються або перебувають у стані війни, зокрема України. Необхідно розробити комплексну аналітичну рамку, яка поєднує цифрову трансформацію, переконфігурацію GVC і результати підвищення резиліентності на основі емпіричних та інституційних даних. *Мета* – концептуалізація та оцінка ролі інформаційних систем як рушійної сили стійкості міжнародних логістичних і торговельних ланцюгів, дослідження їхнього трансформаційного впливу на глобальні ланцюги створення вартості в умовах світової нестабільності та розроблення практичних рекомендацій для країн, що зазнають системних шоків.

Методи. Використано системний і порівняльний аналіз, таксономію ризиків, синтез інституційних рамок та концептуальне моделювання взаємозв'язків між ІС і стійкістю. Емпірична перевірка ґрунтується на аналізі наукових публікацій та звітів міжнародних організацій. Методологія передбачає інтеграцію трьох потоків GVC – матеріального, фінансового та інформаційного – в єдину ІС-орієнтовану модель управління.

Результати. Встановлено, що ІС синхронізують виробничо-торговельні процеси, забезпечуючи простежуваність, фінансову цілісність і прозорість у реальному часі.

Технології штучного інтелекту, аналітика великих даних і блокчейн підвищують передбачуваність та автоматизацію, тоді як цифрові митні системи та платформи електронної торгівлі зменшують транзакційні витрати і пришвидшують розрахунки. Згідно зі звітом Світової організації торгівлі (2024), цифровізація є ключовим драйвером “реглобалізації”, знижує торговельні витрати та розширює інклюзивність. Звіт DHL (2025) підтверджує, що країни з високим рівнем цифрової відкритості зберігають стійкість торгівлі під час криз, а аналітика Maersk і Flexport (2023) демонструє, що цифрові двійники та великі дані підсилюють можливості нішорингу, френдшорингу та мультимодальної гнучкості. Для України критично важливо інтегруватися в цифрову інфраструктуру ЄС (eFTI, eIDAS, e-CMR) для відновлення та участі в GVC.

Висновки. Інформаційні системи стали структурною та функціональною основою стійкості глобальної торгівлі. Їх упровадження знижує логістичні й фінансові ризики, підвищує адаптивність і сприяє диверсифікації торговельних мереж. Наукова новизна полягає у створенні інтегрованої моделі IS-GVC-resilience, що поєднує теорію цифрової трансформації та управління ланцюгами постачання. Теоретичне та практичне значення пов'язане з формуванням доказових рекомендацій для політиків і бізнесу щодо підвищення стійкості на основі ІС. Соціально-економічний ефект втілюється у зниженні волатильності, зміцненні конкурентоспроможності та макростабільності економік, що відновлюються. Перспективи подальших досліджень охоплюють кількісну оцінку зв'язку між цифровими технологіями та резилієнтністю й вивчення довгострокового впливу цифрової торгівлі на економічне зростання.

Ключові слова: міжнародні ланцюги поставок, GVC, інформаційні системи, ризики, resilience, цифровізація торгівлі, блокчейн, міжнародна логістика.

Рис. 2. Табл. 2. Літ. 24.

Introduction. Over the past decade, global value chains (GVCs) have been exposed to overlapping systemic shocks: the COVID-19 pandemic, geopolitical conflicts, port congestions, sanctions, energy volatility, and the fragmentation of global governance institutions. According to the WTO World Trade Report (2023), these shocks have accelerated a shift from hyper-globalization toward “re-globalization” - a model emphasizing resilience, digital integration, and sustainable connectivity.

As Sheffi (2021) [1] argues, modern logistics systems must prioritize resilience capabilities - visibility, flexibility, and rapid recovery - over pure cost minimization. At the same time, digital transformation has intensified: cloud platforms, big data analytics, AI-based forecasting, blockchain, IoT sensing, and digital trade procedures have become strategic drivers of network survivability.

Information systems (IS) are now the core infrastructure enabling firms and states to manage logistics disruptions, coordinate cross-border operations, and maintain continuity of financial and material flows. Empirical studies (Wamba et al., 2020 [2]; Ivanov & Dolgui, 2021 [3]) show that IS-enabled visibility reduces operational volatility, shortens lead times, accelerates customs processes, strengthens trade finance integrity, and improves adaptability.

Despite growing academic attention, several aspects remain understudied:

(1) How IS interact with structural properties of GVCs (modularity, complexity, dependency).

(2) How IS redesign both logistical and financial flows under instability.

(3) How digital trade systems (UNCTAD, 2023 [4]; OECD, 2022 [5]; World Bank, 2022 [6]) reshape resilience at firm and national levels.

Research analysis and problem statement. The theoretical foundations of GVCs were formed by Gereffi (2019), who conceptualized global production networks around governance structures, upgrading trajectories, and inter-firm coordination. Recent studies highlight the increasing vulnerability of GVCs due to tighter interdependencies (UNCTAD, 2023 [4]) and the growing exposure to geopolitical and financial shocks (IMF, 2023 [7]; DHL, 2023 [8]).

A growing body of literature recognizes digitalization as the core driver of modern supply chain transformation. ScienceDirect-indexed studies (Spieske & Birkel, 2021 [9]; Kumar & Choubey, 2022 [10]; Huang et al., 2023 [11]) confirm that AI, data analytics, and Industry 4.0 technologies significantly increase supply chain agility, robustness, and recovery capacity. Blockchain-based systems improve trade integrity and reduce information asymmetry (Saber et al., 2019 [12]). Digital platforms and e-customs systems reduce administrative time, documentation errors, and transaction costs (OECD, 2022 [3]; WTO, 2022 [13]).

However, several key gaps persist in the literature:

- insufficient integration of three-flow GVC analysis (material, financial, information) with IS functions;
- limited empirical evidence linking IS-enabled visibility with macroeconomic stability in developing and war-affected economies;
- insufficient analysis of IS as a driver of financial-flow resilience - payments, guarantees, and trade finance;
- lack of Ukraine-focused studies aligned with EU digital trade requirements.

The **purpose** of this article is to conceptualize and evaluate the role of information systems as a driver of resilience in international logistics and trade chains, focusing on their transformative impact on global value chains under conditions of global instability, and to develop policy and managerial recommendations for improving resilience, particularly for countries undergoing structural shocks.

Research methods. The research is based on a combination of qualitative and analytical approaches:

1. Systemic analysis of GVC architecture - decomposition into material, financial, and information flows (Gereffi, 2019 [14]; UNCTAD, 2023 [15]).
2. Comparative analysis of IS-enabled resilience mechanisms using empirical studies from Google Scholar and ScienceDirect (Wamba et al. [2], 2020; Kumar & Choubey, 2025 [10]; Huang et al., 2023 [11]).
3. Risk taxonomy analysis based on global risk reports (McKinsey, 2022 [16]; DHL, 2023 [8]; UNCTAD, 2022 [17]).
4. Synthesis of institutional frameworks for digital trade and customs (OECD, 2022 [5]; World Bank, 2022 [6]; WTO, 2023 [18]).
5. Conceptual modeling of IS-to-resilience relationships (visibility, predictability, modularity, financial integrity).

Main results of the research include GVC architecture and the structural role of IS, IS capabilities as foundations of resilience, IS impact on financial flows in GVCs, Digital transformation and global trade reconfiguration, Risk mapping and IS mitigation mechanisms and Implications for Ukraine.

GVC architecture and the structural role of IS. Modern GVCs function through three interconnected flows - material, financial, and information - as highlighted in structural GVC literature (Gereffi [14, pp. 34–36]; UNCTAD [4]; OECD [5]). Their integration through IS tools is summarized in Table 1.

Table 1. **The structure of global value chains and the role of information systems**

Flow	Core activities	IS enablers	Expected effect
Material	Sourcing, production, transport, warehousing	IoT, digital twins, TMS/WMS	Traceability, reduced volatility
Financial	Payments, guarantees, invoicing, trade finance	Blockchain, e-invoicing, Open Banking APIs	Faster settlements, fraud reduction
Information	Forecasting, orders, documentation, customs	ERP/SCM, analytics, e-customs	Visibility, lower transaction costs

Compiled by the authors based on Gereffi [14, pp. 34–36]; UNCTAD [4, pp. 10–16]; OECD [5, pp. 22–25]; Ivanov & Dolgui [3, pp. 3–7].

IS synchronize these flows, enabling a shift from efficiency-only networks toward resilient, risk-sensitive architectures. Gereffi (2019) emphasizes that informational coordination defines the ability of economies to “upgrade” their GVC participation.

IS capabilities as foundations of resilience. Empirical studies from ScienceDirect and Google Scholar (Wamba et al. [2]; Kumar & Choubey [10]; Spieske & Birkel [9]) confirm that IS capabilities directly reinforce resilience mechanisms. These mechanisms are systematized in Table 2.

Table 2. **Information systems as drivers of sustainability of global logistics chains**

IS capability	Resilience mechanism	Evidence
AI & big data analytics	Predictive demand, anomaly detection, network optimization	Wamba et al. [2, pp. 4–6]; Kumar & Choubey [10]
Industry 4.0 technologies	Sensorization, cyber-physical control, dynamic reconfiguration	Spieske & Birkel [9, pp. 121–125]
Blockchain & smart contracts	Immutable traceability, reduced counterparty risk	Saberi et al. [12, pp. 2120–2125]
Digital platforms (eFTI, e-customs, PCS)	End-to-end visibility, lead-time reduction, documentation efficiency	OECD [5, pp. 18–22]; WTO [13, pp. 30–32]

Compiled by the authors based on the “visibility-predictability-flexibility-recovery” chain described in Ivanov & Dolgui [3, pp. 4–11] and institutional reports OECD [5] and WTO [13].

IS impact on financial flows in GVCs. Financial resilience is increasingly recognized as a key dimension of supply chain stability, since disruptions in

payments, invoicing, certification, and liquidity directly propagate across borders. Studies in ScienceDirect (Huang et al., 2023 [11]; Kumar & Choubey, 2025 [10]) show that digitalization substantially reduces cash-conversion cycles, improves invoice verification speed, lowers banking and administrative costs, and decreases counterparty risk via blockchain-based authentication mechanisms.

UNCTAD’s analysis of global e-commerce trends reinforces these findings. According to UNCTAD’s analysis of ICT usage in business, participation in e-commerce has become a key determinant of firms’ ability to maintain continuity of financial and material flows. Comparative data demonstrate that in many advanced economies more than 70–90% of businesses engage in online purchasing, whereas international e-commerce sales remain below 20% for most economies (Figure 1). This asymmetry between domestic and cross-border digital transactions indicates that information systems enabling online contracting, e-invoicing, and digital customs procedures are now a structural driver of financial-flow resilience in global value chains. UNCTAD concludes that the expansion of digital trade systems and e-commerce reduces transaction costs, accelerates settlements, and strengthens firms’ ability to diversify suppliers and markets during shocks [15, pp. 10–13].

UNCTAD’s interpretation of these trends underscores that digital transactions restructure financial flows by reducing reliance on manual documentation, lowering operational and compliance costs, accelerating payment cycles, and increasing transparency in cross-border settlements. When businesses engage in e-commerce, financial flows are increasingly governed by automated transaction systems, integrated payment gateways, and electronic trade documentation (e-invoicing, e-receipts, digital purchase orders). This automation minimizes

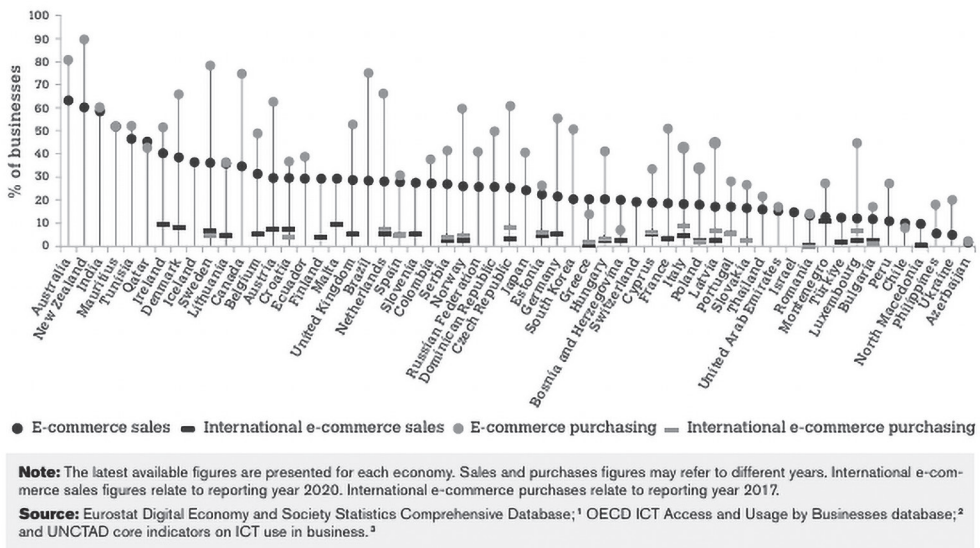


Figure 1. UNCTAD: Business participation in e-commerce, % of firms

Source: [15].

errors, reduces fraud exposure, and improves the accuracy and timeliness of financial information shared among GVC partners.

The cumulative effect of these changes is a system-wide reduction of trade frictions. While UNCTAD does not assign one uniform global percentage value across all economies, its measurement initiatives consistently show that digital trade systems significantly lower transaction costs, especially for developing economies with previously low levels of digitization. This aligns with broader institutional findings (OECD, 2022 [5]; World Bank, 2022 [6]) that digital trade integration reduces the cost and duration of cross-border financial procedures and mitigates liquidity risks during crises.

Thus, the integration of IS into e-commerce ecosystems delivers measurable improvements in the predictability, efficiency, and security of financial flows in GVCs, reinforcing overall supply chain resilience in conditions of global instability.

Digital transformation and global trade reconfiguration. The World Bank (2022) [6] and OECD (2022) [5] emphasize that digital trade integration - cross-border data flows, e-certification systems, interoperable digital standards, and paperless trade - has become a prerequisite for participation in reconfigured global value chains. Digital transformation enables firms to synchronize logistics operations, reduce documentation time, and enhance predictive capabilities, thus increasing resilience when facing geopolitical or financial shocks. The WTO World Trade Report (2024) [18] confirms that digitalization is now a core driver of “re-globalization”, facilitating the reintegration of fragmented trade networks by lowering informational barriers, improving transparency, and strengthening coordination across GVCs.

The findings of the *WTO World Trade Report 2024* substantially reinforce the argument that digitalization is a central driver of the ongoing reconfiguration of global trade, including the emerging paradigm of *re-globalization*. According to the report, digital technologies reshape inclusiveness, reduce trade costs, diversify global value chains (GVCs), and enable new forms of participation, particularly for low- and middle-income economies.

The WTO (2024) [18] emphasizes that digitalization-driven reductions in trade costs—including streamlined customs, better logistics, automated compliance, online sales, e-commerce, and digital documentation - have a powerful impact on trade expansion. Quantitative analysis using the *WTO Global Trade Model* shows that lower trade costs due to digitalization can significantly increase annual trade growth, especially for low-income economies.

Digital technologies (e-customs, online platforms, language tools, AI logistics optimization) directly reduce frictions in cross-border transactions, lowering the need for physical interaction and documentation. These effects are amplified in digitally deliverable services, which face fewer transport constraints.

The WTO (2024) [18] explicitly links digitalization with a strategic shift toward re-globalization—a model that seeks *greater inclusiveness* and integrates underrepresented economies into global markets. The Director-General’s foreword stresses that digital trade lowers barriers to market entry, enabling MSMEs,

women, and small economies to enter global markets more easily, which helps bring “more economies and communities from the margins to the mainstream of the global economy”.

Digital tools help diversify GVCs toward new regions by reducing dependency on traditional hubs, thus contributing to resilience and inclusivity. Digitalization is essential for diversifying supply chains, improving visibility, and reducing dependence on a narrow set of suppliers or routes. Digital technologies such as blockchain, IoT, AI-based logistics forecasting, and platform-based routing contribute to:

- smoother cross-border data flows,
- improved traceability and monitoring,
- reduced transaction uncertainty,
- enhanced risk management and recovery capability.

The WTO (2024) [18] notes that diversifying global supply chains toward underrepresented economies is part of building global resilience and that digitalization is a key enabler of this process.

The WTO (2024) [18] stresses that the benefits of digitalization cannot be fully realized without international cooperation on digital infrastructure, cross-border data governance, digital skills, and regulatory standards. Effective digital trade depends on predictable rules for:

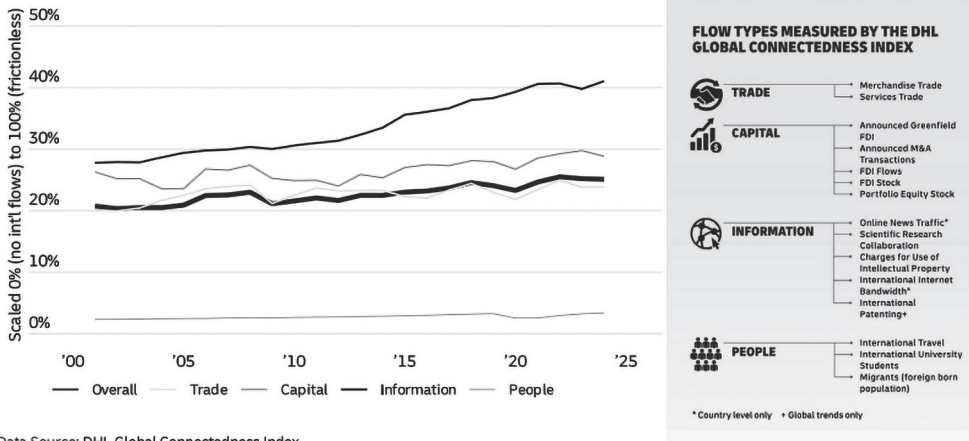
- cross-border data flows,
- e-signatures,
- cybersecurity,
- privacy,
- interoperable digital IDs,
- online consumer protection.

The Joint Initiative on E-commerce and other multilateral negotiations aim to create a global framework for digital trade, enabling economies to fully participate in a data-driven GVC environment.

According to DHL (2023/24) [8; 19], high levels of cross-border information and trade connectivity — i.e., digital openness - are associated with greater resilience of trade flows under shocks. The report notes that despite pandemic, war, and supply-chain disruptions, global connectedness remained near all-time highs, demonstrating the stabilising effect of strong digital and informational linkages.

Evidence from the *DHL Global Connectedness Index* demonstrates that information flows have become the fastest-rising component of global connectedness, growing from $\approx 22\%$ in 2000 to over 35% by 2025, significantly outpacing trade and capital flows (Figure 2) [8, p. 8]. This long-term upward trend indicates that digital openness - measured through global internet bandwidth, cross-border data exchange, online collaboration, and digital information transfer - correlates strongly with trade resilience during global shocks. Countries with higher levels of digital openness experienced smaller declines in trade volumes and faster recovery after disruptions, as digital systems allowed rerouting, remote

coordination, and data-driven reallocation of production and transport capacities [8, pp. 7–8].



Data Source: DHL Global Connectedness Index

Note: Scaled from 0% (no flows cross national borders) to 100% (no border or distance effects).

Figure 2. DHL Global Connectedness Index depth trends (2000–2025)

Source: [8].

Moreover, DHL (2025) [19] shows that countries with stronger digital infrastructures experienced greater trade stability, while economies with limited digital integration were more exposed to supply chain fragmentation. Global trade volumes in early 2025 reached their fastest non-pandemic growth since 2010, highlighting that digital connectivity mitigates the impact of shocks by enabling rapid adjustment, end-to-end visibility, and data-driven logistics coordination. The report also indicates that average trade distances increased to a record 4,990 km, suggesting that firms continued to rely on global suppliers and partners, facilitated by digitally coordinated operations rather than reverting to regional or domestic networks.

These findings confirm that digital transformation is not only reshaping logistics processes but also driving a structural reconfiguration of international trade, enabling GVCs to remain viable, interconnected, and adaptive under global instability.

Analysis of the *Reuters Events & Maersk (2023) white paper* [20] demonstrates that digitalization is becoming a foundational enabler of nearshoring and regional restructuring of electronics and technology supply chains. The report highlights that firms increasingly rely on big data analytics, real-time monitoring and digital twin simulations to model supply-chain webs, evaluate vulnerability clusters, and dynamically reconfigure sourcing footprints when shifting production closer to end markets. According to the white paper, digital twins allow companies to “map multi-tier supplier networks, stress-test them under alternative sourcing scenarios, and identify optimal near-shore nodes before relocations occur,” enabling faster and more accurate decisions under geopolitical and logistical uncertainty.

This digital capability substantially reduces the traditional lead time and risk associated with relocations, transforming nearshoring from a linear, cost-driven process into an iterative data-driven orchestration model. Firms apply continuous data feeds from logistics partners, supplier OT systems, and financial/market indicators to generate updated scenarios, which “unlock capacity, enhance resilience and allow production to be redistributed without compromising service levels”.

As a result, digital transformation does not simply accompany shifts in global trade geography—it actively accelerates them. Companies can now evaluate alternative manufacturing hubs (e.g., Poland, Romania, Vietnam, India) using high-resolution digital models and dynamically reroute production in response to shocks. Thus, digital tools serve as a catalyst for trade reconfiguration by enabling:

- Predictive nearshoring: Pre-emptive identification of optimal regional production nodes;
- Resilience-by-design: Capacity modelling across multiple tiers, rather than reactive risk mitigation;
- Faster transition cycles: Digital twins shorten the time required to switch suppliers or locations;
- Enhanced transparency: Big data and real-time analytics reduce informational frictions across borders.

Consequently, the white paper confirms that digital infrastructures now form the backbone of regionalization strategies. Nearshoring decisions increasingly depend not only on labour or cost factors, but on the availability of digital tooling for scenario modelling, making digital transformation a structural driver of global value chain reconfiguration.

Risk mapping and IS mitigation mechanisms. Global supply chains continue to face a growing spectrum of systemic and operational risks, which have intensified in frequency and severity since 2020. Recent risk assessments from leading international institutions offer convergent evidence that logistics disruptions have become structurally embedded in global trade (McKinsey, 2022 [16]; UNCTAD, 2022 [17]; DHL, 2023 [8]; IMF, 2023 [7]). Synthesizing these analyses reveals eight dominant risk categories shaping contemporary GVC resilience:

1. Geopolitical risks - armed conflicts, sanctions regimes, shifts in trade alliances, export controls, and political instability that fragment logistics corridors and introduce regulatory volatility. Diplomatic tensions increasingly shape routing and availability of transport capacities, as evidenced in McKinsey’s *Resilience Imperative* (2022) [16], which underscores that geopolitical disruptions are now the single largest driver of supply-chain redesign.

2. Transport and maritime risks - port congestions, canal blockages, container shortages, maritime incidents, airspace restrictions, and unstable transit times. UNCTAD (*Global Supply Chain Report*, 2022 [17]) documents that maritime reliability remains below pre-pandemic levels, amplifying the need for predictive capacity planning and rerouting technologies.

3. Customs and regulatory risks - inconsistencies in documentation, non-harmonized digital standards, certification bottlenecks, evolving trade compliance requirements, and cross-border administrative delays. OECD (2022) [5] shows that regulatory heterogeneity remains one of the strongest inhibitors of digital trade.

4. Financial and foreign-exchange risks - currency volatility, liquidity shortages, rising capital costs, and destabilized trade-finance channels. IMF (2023) [7] highlights that FX volatility directly affects import/export cost structures and undermines resilience for developing and transition economies.

5. Cybersecurity risks - attacks on logistics IT systems, ransomware, manipulation of transport documentation, and breaches of digital platforms. DHL (2023) [8] reports that cyber risks now rank among the top three threats to global logistics operations.

6. Supplier insolvency and counterparty risks - financial distress among upstream partners, contract breaches, and opacity of multi-tier supplier networks. McKinsey (2022) [16] estimates that tier-2 and tier-3 insolvencies account for more than half of cascading disruptions.

7. Raw material and component scarcity - shortages in semiconductors, critical minerals, agricultural inputs, or industrial chemicals. UNCTAD (2022) [17] shows that resource scarcity is increasingly structural due to geopolitical contestation and shifts in energy transition pathways.

8. Energy and infrastructure risks - power grid failures, rising energy prices, infrastructure degradation, or damage to logistics nodes. IMF (2023) [7] notes that energy-price volatility has become a long-term factor rather than a temporary shock.

According to recent analyses, information systems function as systemic stabilizers, enabling early detection, dynamic response, and continuous adaptation to the above risks. The following digital mechanisms are central to contemporary logistics resilience:

- Predictive route analytics, powered by big data and real-time geospatial information, allow companies to anticipate congestion, political disruptions, or weather-related incidents and dynamically reroute cargo. This directly mitigates transport and geopolitical risks (UNCTAD, 2022 [17]; DHL, 2023 [8]).
- Automated compliance and regulatory intelligence systems support verification of sanctions lists, certificates of origin, customs documentation, and trade-policy changes. These tools reduce customs/regulatory disruptions (OECD, 2022 [5]; WTO, 2023 [18]).
- Cyber-protected data environments - including encrypted platforms, zero-trust architectures, and blockchain-based audit trails - protect logistics operations from cyberattacks and ensure data integrity across borders. Cyber risk ranked as the fastest-growing logistics threat in DHL (2023) [8].
- Supplier-scoring and multi-tier visibility models use historic performance, financial indicators, ESG metrics, and early-warning analytics to detect insolvency risks and strengthen procurement resilience. McKinsey (2022) [16] finds that firms with multi-tier visibility have up to 40% fewer disruption-days.

- E-customs, e-certification, and digital origin systems integrate API-based workflows, digital identity verification, and standardized electronic documentation. UNCTAD (2023) [8] emphasises that digital trade systems reduce border-processing times and mitigate administrative delays by 30–50%.

Together, these IS-enabled mechanisms shift supply chains from reactive crisis response to proactive resilience management, allowing global networks to absorb shocks more effectively and maintain continuity of trade flows.

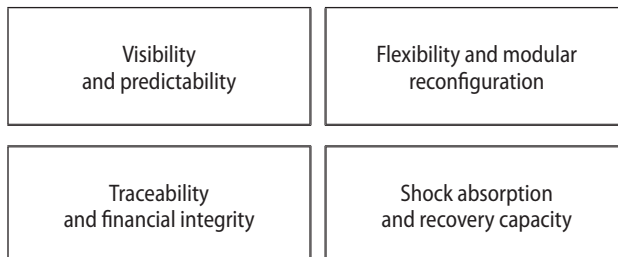
Implications for Ukraine. Ukraine's integration into EU and global production networks requires building digital trade corridors aligned with EU frameworks (eFTI, e-CMR, eIDAS). Key priorities:

1. Digitalization of customs and border agencies.
2. Blockchain pilots for agricultural and industrial traceability.
3. Cyber-resilience of critical logistics hubs.
4. Development of national IS standards compatible with EU digital single market tools.
5. Adoption of risk analytics for export diversification strategies.

Conclusions. The results of this study confirm that information systems have become a structural and functional cornerstone of resilience in international logistics and trade chains under conditions of global instability. Empirical evidence from UNCTAD (2023) [4; 15], WTO (2024) [18], DHL (2023–2025) [8; 19], McKinsey (2022) [16], and leading industry reports demonstrates that GVC disruptions are no longer episodic but systemic, requiring the transformation of supply-chain architecture through digital tools and data-driven coordination.

Scientific Novelty. The scientific contribution of the article lies in the development of an integrated IS-GVC-resilience framework that unifies three traditionally separate analytical fields: (1) GVC structural analysis (material, financial, and information flows); (2) digital capability theory (AI, analytics, blockchain, platforms, digital trade systems); (3) resilience and risk-governance research.

The framework identifies the specific channels through which IS enhance:



This multidimensional model contributes to the scientific literature by demonstrating that IS are not merely operational tools but system-wide enablers of GVC viability, capable of restructuring both micro-level (firms) and macro-level (countries) trade performance.

Theoretical Significance. The article deepens the theoretical understanding of how digitalization reshapes global trade by

- showing that digital trade systems reduce costs (UNCTAD, 2023 [4; 15]), thus reconciling resilience with efficiency;
- demonstrating how WTO's concept of "re-globalization" arises from digital integration, flexible sourcing, and reduced barriers to data exchange;
- incorporating DHL (2023–2025) [8; 19] evidence that digital openness strengthens resilience during global shocks, correlating with faster recovery of trade flows;
- integrating insights from Maersk (2023) [21; 22], Flexport (2023), and European industrial reports showing the rise of nearshoring, friend-shoring, and platform-based orchestration enabled by real-time analytics and digital twins.

This expands classical GVC theory (Gereffi, 2019) [14] by adding a digital-resilience dimension, positioning IS as core governance mechanisms in reconfigured production networks.

Practical Significance. Practical implications follow directly from the empirical results:

- Firms that invest in IS—particularly predictive analytics, blockchain-based verification, digital customs integration, and multi-tier supplier visibility - achieve measurable improvements in delivery reliability, working-capital cycles, and financial-flow security.
- Digital tools significantly mitigate key risks identified by McKinsey (2022) [16], UNCTAD (2022) [17], DHL (2023) [19], and IMF (2023) [7], including geopolitical, transport, regulatory, cyber, financial, and supplier-insolvency risks.
- Digital platforms and e-trade systems accelerate goods movement, reduce administrative barriers, and expand participation in global markets, especially for developing economies.

For Ukraine, practical significance is especially high: IS adoption in customs, border management, transport corridors, and sector-specific supply chains can act as a catalyst for EU integration, post-war reconstruction, and participation in diversified, friend-shored GVCs.

Socio-Economic Effect. Implementation of IS-driven resilience strategies yields the following socio-economic impacts:

- lower trade and logistics costs;
- improved macroeconomic stability through reduced volatility in supply of critical imports;
- strengthened export competitiveness due to higher reliability and compliance;
- enhanced energy and infrastructure security through predictive monitoring;
- reduced vulnerability of businesses and households to shocks in food, medical, and industrial supply chains.

These outcomes directly support sustainable economic recovery, inclusive growth, and long-term integration into European and global markets.

Prospects for further research. Future research should address:

1. Quantitative modeling of IS-to-resilience pathways (e.g., how analytics, blockchain, or digital twins statistically influence agility, lead time, or cash-to-cash cycles).
2. Sector-specific resilience studies for agriculture, defense-industrial production, pharmaceuticals, and energy.
3. Digital trade governance and interoperability between Ukraine and the EU (eFTI, e-CMR, NCTS, eIDAS).
4. Assessment of friend-shoring and nearshoring opportunities for Ukraine using real-time economic complexity and network analytics.
5. Macroeconomic simulations of digital trade integration on Ukraine's GDP, export structure, and post-war reconstruction scenarios.

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