

Digital Logistics Infrastructure and Sustainable Trade Performance: A Proposed Conceptual Framework

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Abstract

Global trade systems are becoming increasingly complex and data-intensive. This transformation is also changing the nature of logistics infrastructure and increasing the role of digital systems in trade processes. This section seeks to develop a conceptual framework explaining the impact of digital logistics infrastructure on sustainable trade performance. In this context, the study investigates how digital components such as digital customs systems, single window applications, data platforms, and traceability technologies strengthen data visibility and coordination in logistics processes. The developed framework shows that digital infrastructure creates operational efficiency and that this efficient infrastructure provides the data infrastructure necessary for carbon tracking and environmental performance management. In this context, it is proposed that digital logistics infrastructure creates a multi-stage mechanism that influences sustainable trade performance through data visibility, operational coordination, and carbon integration. The findings reveal that digital logistics infrastructure is not merely a set of technologies that accelerate trade processes, but also creates an institutional capacity that supports the development of sustainable and resilient trade systems.

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1. Introduction and Theoretical Foundations

The spread of production processes across different geographical regions has made global trade more complex. The deepening of global value chains has shifted trade towards a structure that relies more on data and documentation. In trade by container, a single shipment requires an intense flow of documents and data between numerous public and private institutions. This indicates that logistics is not limited to physical transportation activities, but also functions as an infrastructure that manages information flow and facilitates corporate coordination (Balci & Surucu-Balci, 2021). The speed and quality of data sharing in maritime supply chains directly affect coordination and process continuity. Uncertainty management also depends on this capacity. Therefore, trade performance is related to information integration capacity as much as physical capacity (Barratt, 2004). In this context, the effectiveness of logistics systems is determined not only by infrastructure capacity but also by the extent to which inter-organizational information flow is integrated.

Infrastructure is one of the key catalysts for economic progress. It provides the necessary physical and institutional framework for the stable continuation of economic activity. This role influences both national prosperity and societal quality of life (Yeo et al., 2020). The quality and nature of transportation infrastructure are crucial factors in determining competitiveness. Efficient infrastructure systems optimize production operations by reducing transportation costs, which in turn positively impacts commercial operations. Improvements in road and port facilities facilitate cross-border trade and strengthen exports (Nguyen et al., 2025). The efficiency of trade systems depends on the physical capacity of the infrastructure and its ability to operate in an integrated and coordinated manner. The increase in trade volumes and the complexity of value chains necessitate a holistic strategy for transportation infrastructure, including planning, information dissemination, and operations management; this involves integrating various modes of transportation and fostering collaboration among stakeholders to enhance overall efficiency.

Logistics is a strategic activity that increases competitiveness for businesses. The fundamental objective is to deliver the right product to the customer at the right time and in the right place. This approach is important in terms of cost control, service quality, and time management (Christopher, 1993; Fawcett and Clinton, 1996; Czajkowska & Stasiak-Betlejewska, 2015). From the public sector perspective, logistics strengthens coordination between production sectors and supports economic development. However, in many countries, the public and business perspectives are disconnected. This disconnect can fragment data production and policy design (Cedillo-Campos et al., 2022). Therefore, holistic approaches that strengthen inter-institutional data sharing

and coordination are considered an important factor that can increase the efficiency of logistics performance and trade systems.

Digitalization is defined as the integration of digital technologies into economic and social activities. Digital mobility refers to the capacity to access and effectively use these technologies in different locations. Technological advances increase efficiency, reduce costs, and strengthen coordination (Shahzad, et al., 2025). The development of technologies such as big data, block chain, and artificial intelligence has significantly transformed the way trade operates. Internet-based platforms have enabled the restructuring of processes, innovative applications have become widespread, and trade costs have decreased. These developments have increased business efficiency and enhanced the value provided to stakeholders (Zhu & Zhou, 2025). Parallel to this situation, the increase in e-commerce volume has also made digital logistics applications imperative. Transport planning, inventory management, and supply coordination are being managed more effectively with digital solutions (Kazak et al., 2025). This transformation also impacts border processes. Customs administrations are tasked with promoting trade while simultaneously maintaining border security. Balancing these two functions is a vital requirement of contemporary customs management (Vijayakumar, 2025). Furthermore, increasing competition and evolving customer expectations have accelerated the digital transformation process. Sustainability challenges in the supply chain agenda have increased due to climate change and environmental impacts (Moldabekova et al., 2021). The use of digital tools for customs procedures, risk management via data, and coordination through platforms has become essential for digital logistics systems to increase operational efficiency and promote sustainable trade practices.

The main aim of this section is to present a conceptual framework explaining the role of digital logistics infrastructure in sustainable trade performance. In this context, the section aims to show that having digital infrastructure that combines data and coordinates operations makes logistics systems work better and that these data-focused systems help track carbon emissions and manage environmental performance. Furthermore, it aims to highlight the relationship between digital infrastructure investments and carbon integration capacity and to provide analytical insights for policymakers and logistics system managers.

1.1. Digital Transformation of Global Trade Systems

Global commerce has transformed from a simple, linear structure into a multi-layered, multi-actor system. Production, assembly, financing, insurance, certification, transportation, and customs procedures are carried out in different countries, and processes are distributed among numerous corporate actors

(Juhel, 2001; Chen & Ma, 2015). This situation forces companies not only to manage the physical flow of goods but also to standardize the flow of documents and information. Improving the speed of verification processes and ensuring inter-organizational coordination have become fundamental performance requirements in trading systems. As a result, trade costs are increasingly shaped by administrative delays and the predictability of processes (Balci & Surucu-Balci, 2021). These developments show that competitive advantage in global value chains is becoming increasingly dependent on information integration and data management capabilities.

Digitalization is not a process that can be explained solely by the widespread use of e-commerce platforms. Today, digital transformation encompasses an integrated technology environment in which cloud computing infrastructures, IoT-based data collection systems, artificial intelligence-powered analytical tools, and data governance mechanism work together (Mirzaye & Mohiuddin, 2025). Hence, the mere existence of digital technologies does not determine trade performance. The key determinant is the extent to which these technologies are integrated into trade and logistics systems and made capable of working together.

Today, logistics infrastructure is no longer explained solely in terms of port capacity, terminal equipment, or physical connections. Digital coordination capacity has also become an integral part of the infrastructure. Port Community Systems (PCS) type platforms standardize the flow of information between port stakeholders, synchronize data sharing, and improve process performance. Indeed, various studies have shown that PCS applications positively affect port performance in terms of operational efficiency and effectiveness (Bisogno et al., 2015; Caldeirinha et al., 2020). However, in structures where digital infrastructure and port governance are designed together, performance gains do not stem solely from accelerated processes. Data standardization and interoperability between systems ensure that decision-making processes are carried out in a more consistent and coordinated manner (Tijan et al., 2021). Therefore, logistics infrastructure is now considered a multidimensional system that must be evaluated not only in terms of physical capacity elements but also in terms of digital data integration and corporate coordination capacity.

Digital transformation extends beyond the port scale. The digitization of document processes and data integration are transforming trade organization. In maritime logistics, big data, IoT, and block chain applications strengthen data integrity. Visibility is increasing and coordination is improving (Fruth & Teuteberg, 2017). The rise of e-commerce has also accelerated this process. Digital platforms have changed supply chain dynamics. Logistics

has become a more central part of corporate strategy (Ivanov et al., 2018). These developments show that logistics activities are no longer merely an operational support function but have become a strategic management area with data-driven decision-making and coordination capabilities.

The most noticeable effects of digital transformation are seen in border processes. Customs procedures constitute a significant component of international trade costs and can often lead to delays and uncertainty. To counter such situations, single window systems and electronic declaration applications simplify inter-agency interaction, accelerate information flow, and thus reduce processing times and administrative costs (Nizeyimana & De Wulf, 2015). Macro-level studies also show that digital trade facilitation applications increase trade flows (Portugal-Perez & Wilson, 2012; Hoekman & Nicita, 2011). Similarly, the positive contribution of increased digital connectivity to international trade flows has been empirically confirmed (Freund & Weinhold, 2004; Wahab, 2024). These findings demonstrate that digital infrastructure is a strategic capacity that strengthens countries' competitiveness in the global trading system, beyond reducing trade costs. Therefore, digital customs systems and data-driven trade facilitation applications contribute not only to reducing trade costs but also to making international trade processes more predictable, faster, and more coordinated.

1.2. The Missing Link Between Digital Infrastructure and Sustainability

The logistics performance literature has long prioritized operational indicators such as speed, cost, and reliability. This approach has made significant contributions to explaining the efficiency dimension of logistics systems. However, in most studies, environmental outcomes have been addressed at a secondary level. Nevertheless, the multidimensional impacts of infrastructure systems on sustainable development goals are increasingly being emphasized.

Sustainability literature, on the other hand, has focused more on emission reduction and regulatory compliance. Studies examining greenhouse gas reduction in maritime transport have mostly addressed technical and operational applications (Poulsen & Sampson, 2019). These studies have addressed the role of digital infrastructure to a limited extent. In contrast, macro-level findings suggest that there may be a meaningful relationship between digitalization and environmental performance. A negative relationship has been found between digital trade intensity and carbon emissions, and this effect has been observed to strengthen as digital sophistication increases (Li et al., 2024). Furthermore, it is emphasized that digital infrastructure investments support green innovation (Rao, 2025). Global panel analyses also reveal that

digital infrastructure can increase sustainable development performance in the long term (Sohail et al., 2025). These findings indicate that the relationship between digital logistics infrastructure and sustainability performance needs to be addressed in a more comprehensive manner.

Digital sensors and energy monitoring systems can contribute to reducing energy consumption in port operations. Similarly, data-driven operational planning can help reduce the carbon footprint of logistics activities. On the other hand, block chain-based systems can contribute to sustainable supply chain performance by increasing transparency and traceability (Kouhizadeh et al., 2021; Zhang et al., 2025b). Improving data integrity enables carbon reporting and sustainability certification processes to be carried out more reliably. At the same time, these mechanisms also support governance capacity by enhancing decision-making processes and enabling better compliance with sustainability regulations (Aslam et al., 2024). Nonetheless, current research predominantly focuses on the company or supply chain level, and a holistic framework connecting national trade performance to macro sustainability indicators is still lacking.

2. Digital Logistics Infrastructure and Operational Efficiency

Digital logistics infrastructure is not a simply combination of different digital technologies. It refers to an organizational architecture that integrates border processes, port operations, and supply chain coordination within a common information structure. This architecture requires the redesign of processes and the standardization of data flows (Cichosz et al., 2020; Baah et al., 2022). Therefore, digital logistics infrastructure is recognized not only as a technical tool in supply chain systems but also as an important organizational capacity that enables data-driven coordination.

The relevant literature shows that digital logistics infrastructure strengthens economic performance. Most studies explain this effect by reducing trade costs and shortening transaction times (Djankov et al., 2010; Masood & Martinez-Zarzoso, 2024). Nevertheless, the resultant impact is not restricted to the reduction of time spent. The use of digital infrastructure helps to increase the level of coordination between actors and lessen the information gap that exists between them. Additionally, the capacity to create trust inside the system is strengthened as a result of this feature. The electronic recording of operations and the integration of data flows become the means by which real-time monitoring can be accomplished. According to Pekarčíková et al. (2019), the utilization of a single communication network for the processing of data enables and facilitates faster and more consistent coordination. In addition, as stated by Kostiuik et al. (2024), big data analytics, the Internet

of Things, and the integration of block chains all contribute to an increase in visibility inside supply chain operations and a strengthening of decision-making accuracy. As a result, the influence of digital logistics infrastructure is also closely tied to the capacity of digital infrastructure in the region as well as the quality of policies implemented by the government, which can either enhance or hinder the effectiveness of supply chain operations and the adoption of advanced technologies.

2.1. Core Components of Digital Logistics Infrastructure

Digital logistics infrastructure depends on the capacity to generate and share data in areas such as border processes and port operations. This capability is enhanced by data verification and its application in decision-making processes. Process standardization and data integration are among the fundamental prerequisites for sustainable digital transformation (Cichosz et al., 2020). For example, sensor infrastructure and continuous data collection are essential for operational functionality. Intelligent software solutions are used for processing the collected data (Pekarčíková et al., 2019). Key elements of digital logistics infrastructure include digital customs systems, single-window platforms, data-driven risk management, blockchain-based traceability, and platform-based data integration.

The first fundamental component of digital logistics infrastructure is the digitization of customs processes. Electronic declaration systems reduce document circulation and shorten processing times (Hollweg & Wong, 2009). This change also reduces administrative uncertainty and makes processes more standardized and predictable. When combined with data-driven risk management practices, customs digitization achieves greater capacity. The expansion of trade volumes and security threats diminishes the efficacy of random inspections, potentially resulting in transaction delays and heightened expenses for enterprises involved in international commerce. Analyzing extensive data sets facilitates more precise identification of high-risk transactions. This facilitates the expedited processing of lower-risk transactions and creates a more efficient equilibrium between security and trade flows (Widdowson, 2020). Technological diversity is inadequate by itself; successful outcomes rely on the congruence of the chosen technology with objectives and processes, ensuring that the technology facilitates the organization's specific security protocols and trade efficiency targets (Vijayakumar, 2025). Single window systems are also an important complement to this structure. Single window applications simplify document processes and reduce administrative burdens by consolidating applications made to different public institutions on a single platform. They also facilitate inter-agency data sharing, contributing to more

orderly coordination (Nizeyimana & De Wulf, 2015). Thus, trade processes are shifting from a fragmented structure to a more integrated and coordinated one.

Block chain-based traceability systems are an important digital infrastructure component that enhances data integrity and trust. The distributed ledger structure increases information reliability by making data manipulation difficult (Aslam et al., 2024). This capacity is not limited to enhancing transparency. It also contributes to the more reliable execution of processes such as sustainability certification and carbon reporting (Kouhizadeh et al., 2021; Zhang et al., 2025b). Such technological components are interconnected through platform-based data integration. It is emphasized that information sharing in maritime supply chains is decisive for operational performance (Surucu-Balci et al., 2024). Port Community System (PCS) applications accelerate information flow, reduce processing times, and ensure smoother port operations by digitizing document and approval processes (Caldeirinha et al., 2020). However, the existence of platforms alone is not sufficient. An integrated digital design is required for effective results. Coordination between actors must be established through open and interoperable digital platforms (Tasueva & Borisova, 2021). This approach reduces sectorial fragmentation and strengthens internal system synchronization. The digital integration of the design, operation, and control processes of logistics systems shortens the response time to disruptions and enables more consistent process management (Nekrasov & Sinitsyna, 2020). In this context, digital platforms are not merely tools that accelerate data sharing in logistics systems, but also serve as an institutional infrastructure that strengthens coordination between actors and improves operational performance.

Consequently, digital logistics infrastructure is not merely the sum of technology modules. It represents an organizational architecture that generates data, verifies data, and enables data-driven coordination within a multi-stakeholder trade ecosystem. Digital customs systems, single window applications, data-driven risk management, traceability mechanisms, and platform integration form the core components of this architecture.

2.2. Operational Efficiency and Data-Driven Coordination

The impact of digital logistics infrastructure is particularly apparent in processing durations. Electronic declaration methods and single window apps diminish border crossing durations and administrative delays (Grainger, 2011). This advancement improves delivery dependability, accelerates inventory turnover, and diminishes the capital costs associated with inventory. The speeding of processes enhances cost predictability (Masood & Martínez-

Zarzoso, 2024). Decreased uncertainty enables corporations to diminish their risk premiums and more readily engage in long-term commercial partnerships.

Real-time data management is another important dimension of this transformation. Block chain and platform-based data sharing systems increase process visibility throughout the supply chain (Treiblmaier, 2018; Queiroz et al., 2019). Increased visibility speeds up decision-making processes and strengthens the capacity to adapt to operational disruptions. Institutionalized information sharing reduces information asymmetry and increases the level of coordination between actors (Barratt, 2004). Studies on logistics companies also reveal similar results. As visibility and analytical capacity increase, operational efficiency improves and the responsiveness of businesses increases. These developments also support the development of new logistics service designs (Herold et al., 2021; Gothania et al., 2026). Multimodal integration further deepens the impact of digital infrastructure. Data-driven integration of port, rail and road networks increases intra-system synchronization and contributes to reducing logistics bottlenecks. Such integrations also strengthen system resilience. However, the lack of coordinated development between the digital economy and logistics infrastructure can limit coordination gains (Guo et al., 2022). Therefore, for digital transformation to be effective, infrastructure, data governance, and institutional capacity must be developed in a balanced and integrated manner.

The coordination-focused approach is also supported by empirical studies. It has been shown that the relationship between digital transformation and operational efficiency strengthens as the level of coordination between actors increases. It is also emphasized that this effect can vary across sectors (Zhang et al., 2025a). Reduced uncertainty and increased coordination make trade performance more stable. This stability can also have indirect effects on environmental outcomes. Indeed, it has been found that digital trade intensity can have a carbon emission-reducing effect, and that this effect strengthens as the level of digital development increases (Li et al., 2024). Therefore, it can be said that digital logistics infrastructure is not only capable of improving operational processes, but also constitutes a structural capacity that can indirectly affect the environmental performance of trade systems.

This section's comprehensive evaluation indicates that digital logistics infrastructure is not solely a technical configuration that reduces processing durations. Digital infrastructure serves as a coordination tool that mitigates uncertainty and fosters trust within the system. The primary outcome of this mechanism is operational efficiency. The subsequent part examines the translation of this output into sustainable trade performance via carbon visibility and carbon integration.

3. Carbon-Integrated Logistics Architecture: A Conceptual Model

Digital logistics infrastructure creates an important corporate capacity that enhances operational efficiency. Digital solutions enhance data visibility and provide more transparent monitoring of activities across the supply chain. Enhanced data visibility also enables the assessment and oversight of the environmental effects of logistics operations (Fruth & Teuteberg, 2017). This illustrates that digital logistics infrastructure establishes a crucial system capacity that influences both operational and sustainability performance.

As argued in the previous section, digital logistics infrastructures create operational efficiency through data integration, process automation, and platform-based coordination (Pekarčíková et al., 2019; Cichosz et al., 2020). The same data infrastructure can also provide the necessary data foundation for tracking and reporting carbon emissions. So, the effect of digital logistics infrastructure on sustainable trade performance isn't direct but comes through a multi-stage mechanism involving data visibility and operational coordination.

In this context, the relationship between digital infrastructure and sustainable trade performance can be described in two stages. Digital infrastructure first improves operational efficiency by coordinating processes and integrating information. In the second stage, increased data visibility enables sustainability practices such as carbon tracking, energy efficiency, and regulatory compliance. Therefore, the relationship between digitalization and sustainability is established through data-driven corporate mechanisms, which include the use of analytics to optimize resource use, reduce waste, and enhance decision-making for sustainable practices.

3.1. Integrating Carbon Visibility into Digital Logistics Systems

One of the fundamental requirements of carbon management is the production of reliable data on logistics operations. Data collection and validation systems are critical for assessing the carbon impact of transportation, storage, and operational activities. Digital logistics infrastructures significantly increase data generation capacity. This infrastructure enables the evaluation of the environmental performance of different modes of transport. Road, rail, and sea transport exhibit different carbon intensities. Data-driven analytical techniques facilitate the evaluation and comparison of these differences. Therefore, in logistics planning, transportation alternatives can be evaluated not only according to cost and time criteria but also according to carbon footprint factors.

IoT sensors, platform-based data sharing platforms, and blockchain-based traceability mechanisms enable data generation across the supply chain. These

systems produce more precise data regarding the energy consumption and emission effects of operations (Fruth & Teuteberg, 2017; Yin et al., 2024). Maintaining data integrity enhances the dependability of carbon reporting and sustainability certification procedures (Kouhizadeh et al., 2021; Zhang et al., 2025b). Integrating carbon data into operational decision-making systems is a crucial component of sustainable logistics frameworks. Data analytics and artificial intelligence-driven decision support systems can evaluate the carbon footprint in operations such as route optimization and load consolidation. This facilitates logistical operations to be conducted with reduced carbon intensity (Pekarčíková et al., 2019). Table 1 shows the essential digital elements and their operational roles that enhance carbon visibility within digital logistics infrastructure.

Table 1. Digital Logistics Infrastructure and Carbon Visibility

Digital component	Operational mechanism	Carbon management implication
<i>Digital customs systems</i>	When customs procedures are digitalized, clearance processes become faster and documentation flows are standardized.	Faster processing reduces waiting times and idle times, which in turn reduces emissions generated during border operations.
<i>Single window platforms</i>	When multiple agencies exchange trade data through a single platform, institutional coordination improves and information duplication is reduced.	Improved coordination enables better monitoring of logistics activities and facilitates the integration of emission data into trade processes.
<i>IoT and sensor systems</i>	When real-time operational data are collected from vehicles, terminals and cargo flows, logistics activities become continuously observable.	Continuous monitoring allows energy consumption and emission levels to be measured and managed more accurately.
<i>Block chain systems</i>	When transaction records are verified through distributed ledgers, supply chain data become transparent and traceable.	Reliable traceability strengthens carbon reporting and supports sustainability certification processes.
<i>Data analytics and AI</i>	When large operational datasets are analysed through decision-support systems, logistics planning becomes data-driven.	Data-driven planning enables route optimization and load consolidation that reduce carbon intensity in logistics operations.

Source: Adapted from Fruth & Teuteberg (2017); Pekarčíková et al. (2019); Kouhizadeh et al. (2021); Yin et al., 2024; Gothania et al., 2026 developed by the authors.

Table 1 highlights the institutional role played by digital logistics infrastructure in generating and managing carbon data. Digital customs systems, data platforms, and sensor-based tracking tools make it possible to systematically gather operational data about logistics activities. By processing this data with analytical systems, carbon impact can be considered in operational decision-making processes. Thus, carbon visibility becomes more than just a reporting indicator; it becomes a source of information that guides logistics planning and management processes.

3.2. From Digital Infrastructure to Sustainable Trade Performance

The connection between digital logistics infrastructure and sustainable trade performance evolves via an indirect process. Digital systems diminish transaction durations and enhance coordination capabilities. This advancement enhances data generation and data transparency (Masood & Martínez-Zarzoso, 2024). Data visibility facilitates the creation of carbon tracking applications. Quantifying emissions data enables enterprises to evaluate their ecological performance. This data infrastructure additionally facilitates energy efficiency applications. Consequently, operational efficiency correlates with sustainability performance. This technique is also crucial for regulatory compliance. Carbon controls are increasingly prevalent in international trade. Digital data infrastructure enables enterprises to adhere to carbon reporting requirements. This facilitates enterprises' entry into international markets.

Digital infrastructure also strengthens supply chain resilience. Data-driven tracking systems enable earlier detection of operational disruptions. This allows for the faster implementation of alternative logistics solutions. Therefore, digital logistics infrastructure creates operational efficiency and contributes to the development of sustainable and resilient trade systems (Cichosz et al., 2020). To explain this relationship, the process from digital logistics infrastructure to sustainable trade performance is analytically presented in Table 2.

Table 2. The Relationship Between Digital Logistics Infrastructure and Sustainable Trade Performance

Stage	Mechanism	Resulting outcome
<i>Digital infrastructure</i>	When digital platforms integrate trade and logistics data across institutions, information flows become standardized and accessible.	Greater information visibility is created across the logistics network.
<i>Operational efficiency</i>	When integrated data systems accelerate processing and coordination, logistics operations become faster and more predictable.	Processing times decrease and uncertainty and operational costs are reduced.
<i>Data visibility</i>	When logistics activities are monitored through digital tracking and data analytics, energy use and emissions can be systematically observed.	Environmental performance becomes measurable and manageable.
<i>Carbon integration</i>	When emission data are incorporated into logistics planning and decision systems, transport routes and load structures can be optimized.	Logistics operations shift toward lower carbon intensity.
<i>System outcome</i>	When digital coordination and carbon-aware decision making operate together, logistics systems become more adaptive and efficient.	Sustainable trade performance improves through greater competitiveness and system resilience.

Source: Adapted from Fruth & Teuteberg (2017); Pekarčíková et al. (2019); Kouhizadeh et al. (2021); Cichosz et al. (2020); Baah et al., (2022); Li et al. (2024); developed by the authors.

The analytical framework presented in Table 2 shows that digital logistics infrastructure affects sustainable trade performance through a multi-stage mechanism operating via data visibility, operational coordination, and carbon integration. In this process, the digital infrastructure first increases operational efficiency, then the increased data visibility enables the measurement and management of the carbon impact. Thus, logistics decision-making processes are reshaped to include the environmental dimension.

4. Conclusion and Policy Implications

Digital logistics infrastructure is playing an increasingly decisive role in global trade systems. This section is designed to develop a conceptual

framework explaining the impact of digital logistics infrastructure on sustainable trade performance. The proposed framework emphasizes that digital infrastructure creates operational efficiency through data integration and coordination. Increased data visibility enables faster, more transparent, and predictable management of logistics processes, while also creating the necessary information infrastructure for monitoring carbon emissions and measuring environmental performance. Therefore, digital logistics infrastructure supports sustainable trade performance through a systematic relationship mechanism. Thus, it can be said that digitalization is not only a set of technologies that accelerate operational processes, but also creates an organizational architecture that generates data visibility, traceability, and governance capacity. Blockchain-based traceability systems and data sharing platforms strengthen information integrity throughout the supply chain, ensuring integration and increasing the reliability of sustainability reporting.

This section provides significant implications for policy formulation. Initially, investments in digital infrastructure and sustainability policy should be evaluated concurrently. Independent planning of these two sectors may lead to coordination deficiencies and inefficiencies in trading systems. The digitization of customs systems is crucial in this process. Electronic declaration systems and single-window applications reduce processing times and improve the predictability of border processes. Moreover, the progression of carbon data systems is essential. The incorporation of carbon data standards into digital commerce systems can improve the effectiveness of sustainable trade policies, as digital logistics infrastructure provides the necessary data framework for measuring and reporting carbon emissions.

Furthermore, the development of multimodal transport stands out as a key component of sustainable trade policies. Digital logistics platforms can support the implementation of lower carbon-intensive transport solutions by facilitating data integration between different modes of transport. In this context, the development of digital platforms that strengthen data sharing between the public and private sectors is also critical. Such platforms can contribute to the more efficient, sustainable, and resilient operation of logistics networks by increasing coordination in trade systems.

In conclusion, global trade systems are increasingly becoming more digital and data-intensive. This transformation is also changing the nature of logistics infrastructure. Logistics infrastructure no longer consists solely of physical capacity elements. Digital data infrastructure has become one of the key elements determining the coordination capacity of trade systems. This study demonstrates that digital logistics infrastructure affects sustainable

trade performance through operational efficiency and carbon integration mechanisms. Therefore, digital logistics infrastructure should be considered not only as a set of efficiency-enhancing technologies but also as a strategic institutional capacity that supports the development of sustainable and resilient trade systems.

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