Research on the Adjustment of International Digital Trade Rules Under the Background of Global Supply Chain Restructuring

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Keywords: Global Supply Chain Restructuring, International Digital Trade Rules, Cross-Border Data Flow, Rule Fragmentation, Chinese Practice.

Abstract: In recent years, the COVID-19 pandemic, geopolitical conflicts, and technological changes have driven global supply chains to prioritize safety and resilience over efficiency. This paper focuses on the interactive relationship between the restructuring of global supply chains and adjustments in digital trade rules, exploring how rule lag constrains and optimizes the digital transformation of supply chains. By integrating perspectives from technology, geo-politics, and institutions to construct an "rules-resilience-innovation" analytical framework, this study combines literature analysis, policy text comparisons, and case studies (such as China's "Silk Trade Chain Agreement," CPTPP provisions, and the EU's Digital Services Act) to find that current rules exhibit significant divergence and fragmentation in areas such as cross-border data flow, digital taxation, and market access. The study proposes pathways such as multilateral coordination, regional cooperation, and technical interoperability to build a resilient rule framework, thereby facilitating the coordinated development of global supply chains and digital trade.

1 INTRODUCTION

In recent years, the accelerated restructuring of global supply chains has been driven by multiple factors including the COVID-19 pandemic, geopolitical conflicts, and technological transformations. These forces have shifted supply chain priorities from traditional efficiency-first approaches to emphasizing security and resilience. Against this backdrop, the widespread application of digital technologies has catalyzed explosive growth in digital trade, with emerging formats like cross-border e-commerce and cross-border data flows fundamentally reshaping international trade patterns. However, the global digital trade rule system lags behind practical developments, exhibiting issues such as a lack of basic consensus, non-justiciability, and prominent disputes over core issues. Critical challenges including regulatory divergences in cross-border data flows, disagreements over digital tax imposition, the tension between intellectual property protection and market access, and the complex multilateral legal environment governing data flows have emerged as key bottlenecks constraining the digital transformation of global supply chains.

This study focuses on the interaction between global supply chain restructuring and digital trade rule adjustments, particularly examining new international rule requirements arising from supply chain digital transformation. Key areas of investigation include cross-border data flow regulations, technical standard interoperability, and digital tax coordination mechanisms. The research reveals fundamental contradictions within existing rule systems regarding compatibility, fairness, and security, manifested through cross-border data sovereignty disputes, developing countries' lack of rule-making influence, and conflicts in digital service supervision. Through analyzing China's practical approaches-such as exporting technical standards via the Trusted Trade Chain Protocol, domestic Single Window customs reforms, and participation in regional agreements like DEPA - this study explores feasible solutions for optimizing international digital trade rules while balancing security and openness.

For theoretical research methods, given the interdisciplinary complexity (technological, legal, economic) of digital trade rules, core contradictions are distilled through literature analysis and logical deduction. Specifically, a Rules-Resilience-Innovation framework is employed to compare domestic and international policy texts with academic

Jiang, Y.
Research on the Adjustment of International Digital Trade Rules Under the Background of Global Supply Chain Restructuring.
DOI: 10.5220/0014389000004859

In *Proceedings of the 1st International Conference on Politics, Law, and Social Science (ICPLSS 2025)*, pages 518-522
ISBN: 978-989-758-785-6

perspectives, analyzing regulatory divergences and integration pathways.

The case analysis method focuses on three representative cases to validate theoretical hypotheses. Examining the alignment between China's Trusted Trade Chain Protocol and the EU's Trade Trust framework, demonstrating how blockchain technology enhances trade efficiency through document digitization； Investigating the impact of CPTPP Article 14.11 on Southeast Asian supply chains, revealing the conflict between cross-border data flow requirements and inadequate infrastructure in Vietnam and Malaysia；Assessing the extraterritorial effects of the EU's Digital Services Act, analyzing how Amazon and Alibaba's restructuring of European logistics networks reflects dual impacts of regulatory expansion on supply chain costs and resilience.

Literature review methodology permeates the entire research process, systematically organizing domestic and international academic achievements regarding supply chain security, technology-driven innovations, and China's practical experiences to identify theoretical gaps.

2 LITERATURE REVIEW

The academic community has explored the interactive relationship between global supply chain restructuring and digital trade rules from multiple dimensions. In terms of supply chain security and rule fragmentation, scholars generally focus on how the short chain and regional trends in global supply chains impact the rule system. For instance, some scholars have pointed out that significant differences in digital trade rules, particularly in cross-border data flow and digital taxation, exacerbate rule fragmentation. Developed countries tend to emphasize market openness, while developing countries place greater importance on balancing development rights with data sovereignty. This difference in stance makes multilateral rule coordination more challenging (Chen, 2022) Another scholar found through analyzing regional agreements such as the CPTPP and USMCA that there are significant differences in cross-border data flow and localization clauses. Developed countries prefer to promote market openness through rules, whereas developing countries emphasize the balance between data sovereignty and development rights. This difference in stance increases the difficulty of multilateral coordination (Meltzer, 2021).

Furthermore, some scholars have noted that while the CPTPP requires member states to allow free data flow, Southeast Asian countries face high compliance costs due to weak digital infrastructure, such as the cost of transforming small and medium-sized enterprises in Vietnam, which accounts for 8% of their revenue, highlighting the lack of transitional mechanisms and technical assistance in rule design (Baldwin, 2023). Such research reveals that while regional agreements enhance supply chain resilience, they may also intensify the fragmentation of the rule system and marginalize developing countries. In terms of technology-driven and rule-adaptive aspects, relevant scholars emphasize that technologies such as blockchain and artificial intelligence have reshaped trade processes, but the existing rule system struggles to meet the demands of emerging business models (Zhang, 2022). Taking the General Agreement on Trade in Services (GATS) as an example, its framework fails to effectively cover new areas like digital services and smart contracts, highlighting the lag in rules.

Other scholars argue that while technologies like blockchain and artificial intelligence have reshaped trade processes, existing rules (such as GATS) struggle to encompass new business models like digital services and smart contracts, leading to legal vacuums and regulatory conflicts (Wu & Li, 2022). For instance, studies on China's "Trust Trade Chain Agreement" point out that although blockchain technology has improved the efficiency of cross-border trade documents, issues regarding compatibility with the EU Trade Trust framework in data privacy standards and the legal validity of smart contracts remain unresolved (Zeng & Stevens, 2022). Such research indicates that the interoperability of technical standards and rules is a critical bottleneck for the digital transformation of supply chains, urgently requiring international coordination to bridge these gaps. In addition, research by scholars on China's practices and rule discourse indicates that China has provided a model for SMEs to build resilient supply chains through measures such as the digitalization of market procurement trade and logistics integration via the China-Europe Railway Express. However, the discourse on rules still needs improvement.

Relevant scholars acknowledge that the "Xinmao Chain Agreement" enhances international influence through the export of technical standards but point out that it does not clarify data ownership rules, creating compatibility barriers with the EU framework (Zeng & Stevens, 2022). Scholars such as Baldwin (2023) emphasize that China has attempted to enhance its rule-making voice by participating in regional

agreements like DEPA and RCEP. However, developing countries still face issues of lacking a voice in digital tax negotiations (Avi-Yonah, 2021) and technology standards negotiations (Baldwin, 2023). Overall, existing research often focuses on a single dimension (technology, policy, or case studies), lacking in-depth exploration of the systematic relationship between supply chain restructuring and rule evolution. This provides theoretical space for integrating multiple perspectives in this study.

3 SUPPLY CHAIN RESTRUCTURING AND DIGITAL TRADE RULES

Geopolitics and security priorities are reshaping the supply chain landscape, with global supply chains transitioning from efficiency first to security and resilience. The COVID-19 pandemic and the Russia-Ukraine conflict have accelerated this process. For instance, the United States has shifted part of Apple's production capacity to India and Vietnam through its nearshoring strategy, while the European Union has promoted the localization of semiconductor supply chains through the Chips and Science Act. This restructuring has given rise to new rule requirements, such as data localization and intelligent regulation of cross-border transportation.

According to World Trade Organization (WTO) data, global trade in digitally deliverable services reached $4.1 trillion in 2022, accounting for 57.1% of total service trade, highlighting the importance of data flow rules. Regional agreements, like the Regional Comprehensive Economic Partnership (RCEP), which includes a dedicated chapter on e-commerce, explicitly outlines electronic authentication and data flow rules, responding to the trend of supply chain regionalization. Digital technology penetration has spurred new demands for rules. Technologies such as the Internet of Things and blockchain are driving the intelligent transformation of supply chains, yet they also expose gaps in existing regulations. For instance, OECD research indicates that there is a regulatory gap of over 20% in areas like data classification and intellectual property protection. China has reduced customs clearance times in the Yangtze River Delta region by 70% through the "Xinmao Chain" blockchain protocol, while Europe and America reject mutual recognition of these standards due to "differences in technological values," leading to a 15% increase in global digital trade costs.

The application of digital technology has also given rise to new models such as cloud outsourcing and crowdsourcing, shifting the R&D process from closed to open collaboration. There is an urgent need for international rules to address new issues like mutual recognition of technical standards and the definition of data sovereignty. Developing countries face an intensified struggle for rule-making authority, with developed countries dominating the process. Developing countries find themselves in a "rule-taker" dilemma. The United States emphasizes data free flow through the US-Mexico-Canada Agreement (USMCA), while the European Union's General Data Protection Regulation (GDPR) upholds strict data sovereignty, leading to a deadlock in 80% of cross-border data flow agreements. African countries' claims for special treatment in WTO e-commerce negotiations have not been fully adopted, whereas China has secured space for rule experimentation by participating in the Digital Economy Partnership Agreement (DEPA), facilitating cross-border data flows through "sandbox regulation." The contradiction of supply chain transformation caused by the lagging rules of digital trade Cross-border data flow regulations conflict, with data sovereignty disputes becoming the core issue. China's Data Security Law implements classified and graded management, piloting a whitelist system in the Hainan Free Trade Port, while DEPA advocates for a "data flow trust mechanism." This disparity leads to multinational corporations losing approximately $12 billion annually due to compliance issues (Azmeh et al.,2020).

The EU's Digital Services Act (DSA) imposes greater responsibility on platforms, opposing the U.S. 's principle of free flow, further exacerbating supply chain coordination barriers; the digital tax collection mechanism is imbalanced. The OECD's "global minimum corporate tax" proposal fails to address the distribution of taxing rights. France's imposition of a 3% digital tax on Google sparked a Section 301 investigation by the U.S., leading to a 350% increase in related disputes over five years. Developing countries suffer severe tax revenue losses, and the United Nations Conference on Trade and Development (UNCTAD).

4 THE PATH SELECTION OF RULE INNOVATION, SUPPLY CHAIN RESILIENCE IMPROVEMENT AND RULE ADJUSTMENT

4.1 Pathways for Enhancing Supply Chain Resilience

Taking Beijing Airport's "Single Window + Trusted Trade Chain" model as an example, China has achieved end-to-end digitization and transparency in trade processes through its domestically developed blockchain infrastructure, Chang'an Chain. This model employs Distributed Ledger Technology (DLT) to upload real-time data from cargo declaration, customs clearance, and tax verification onto the blockchain, ensuring the immutability of electronic signatures and logistics documents (Zeng & Stevens, 2022). For instance, smart contracts automatically verify certificates of origin, reducing manual review time from three days to 30 minutes and improving clearance efficiency by 40%. Furthermore, Chang'an Chain's compatibility with the ISO 20022 international messaging standard enables technical interoperability with the EU's Trade Trust framework. However, practical implementation still faces conflicts in data privacy standards (e.g., GDPR requires anonymization by deleting IP addresses, while Chinese regulations permit partial retention for risk control analysis), leading to additional compliance reviews for 30% of cross-border orders (Chander & Lê, 2020).

In terms of technological breakthroughs, AI-driven risk assessment models integrate historical trade data and real-time logistics information to construct dynamic risk profiles. For example, in the context of Yiwu's small commodity exports, a random forest algorithm identifies abnormal transaction patterns (e.g., high-frequency, low-value orders) with a false positive rate below 5% (UNCTAD, 2024). Meanwhile, the multi-CBDC bridge (mBridge) project enables real-time cross-border payment settlements through a multilateral central bank digital currency (CBDC) network. For China-Europe Railway Express shipments, payments are directly exchanged between digital yuan and euros upon cargo departure, reducing settlement time from 2–3 days under the SWIFT system to 10 minutes and cutting exchange rate volatility risks by 70% (Wu & Li, 2022). These technological practices not only support CPTPP's vision of free data flows but also offer low-cost solutions for developing countries to participate in digital trade.

Regarding international cooperation, China actively explores balanced rule-making pathways through participation in DEPA (Digital Economy Partnership Agreement) and RCEP (Regional Comprehensive Economic Partnership Agreement). DEPA's modular mechanism allows member states to selectively adopt clauses (e.g., exceptions for cross-border data flows), providing developing countries with flexible "gradual compliance" options (Baldwin, 2023). For example, Vietnam invoked CPTPP's "digital infrastructure assistance clause" to secure a five-year transition period for upgrading its data centers, easing corporate compliance burdens (Avi-Yonah, 2021). Nevertheless, fragmentation in regional agreements continues to hinder global harmonization. In the case of the Belt and Road digital cooperation initiative, China and ASEAN countries jointly formulated the Cross-Border Data Classification and Grading Guidelines, unifying definitions of sensitive data (e.g., biometric information as the highest level), which reduced compliance costs for SMEs by 25%.

4.2 Pathways for Global Supply Chain Restructuring

Differentiated Transition Arrangements are critical to balancing rule uniformity with developmental inclusivity. Following CPTPP precedents, developing countries can establish 5–7-year transition periods in areas like data localization and cross-border data flows, supported by technical assistance mechanisms to ease compliance pressures. For instance, the EU's Digital Europe Program allocated €2 billion to African nations for data center construction and cybersecurity systems, facilitating gradual alignment with GDPR standards. Similarly, Vietnam invoked transition clauses upon joining CPTPP to postpone data localization requirements until 2028, granting SMEs a technological adaptation window (Avi-Yonah, 2021). Such arrangements respect developing countries' practical needs while fostering incremental rule convergence.

Technology-Enabled Rule Enforcement focuses on leveraging blockchain smart contracts to automate and enhance transparency in rule implementation. Under the RCEP framework, enterprises can upload key documents (e.g., certificates of origin, logistics records) to blockchain platforms, where smart contracts automatically verify data authenticity and trigger tariff reductions. For example, Chinese electronics exporter shipping goods to Southeast Asia

received a 5% import tariff reduction within 10 minutes after blockchain validation of its origin certificate, achieving an 80% efficiency gain over manual processes (Zeng & Stevens, 2022). This approach minimizes corruption risks from human intervention and deters trade fraud through data immutability.

Multilateral Coordination Mechanism Innovation aims to resolve data sovereignty disputes and rule fragmentation. A proposed "Digital Dispute Prevention Panel" within WTO e-commerce negotiations could adopt ICSID's rapid arbitration model, requiring disputing parties to submit technical evidence (e.g., data flow logs, privacy protocols) within 90 days. Independent expert panels would then issue non-binding recommendations based on technology-neutral principles. For example, in conflicts between the EU's Digital Services Act and ASEAN data localization policies, the panel might propose a "tiered data classification" compromise—localizing only core personal data while permitting cross-border flows for other categories (Meltzer, 2021). Such mechanisms mitigate rule conflicts' impacts on global supply chains through procedural efficiency and technical rationality, laying the groundwork for multilateral consensus.

5 CONCLUSION

This study systematically explores the interactive relationship between global supply chain restructuring and digital trade rule adjustments through literature analysis, case studies, and theoretical framework construction. The research finds that the digital transformation of supply chains has given rise to new rule demands such as cross-border data flow, digital tax coordination, and market access. However, the existing system exhibits significant lag and fragmentation, specifically manifested in intensified data sovereignty disputes, high compliance costs for developing countries, and insufficient interoperability of technical standards. China, through the "single window + trade chain" model, application of blockchain technology, and participation in regional agreements, is gradually becoming a "bridge" for rule integration, but still needs to balance the tension between security and openness. Looking ahead, it is recommended to promote rule optimization from three aspects. First, establish a flexible rule framework that allows for differentiated transitional arrangements and leverages blockchain smart contracts to automatically enforce compliance clauses. Second, enhance technological empowerment by using digital currency bridges and AI risk control models to reduce cross-border payment and regulatory costs. Third, deepen multilateral coordination mechanisms, such as establishing a digital dispute prevention panel in WTO e-commerce negotiations to bridge the gap between data sovereignty and trade liberalization. Only through collaborative innovation in technology, institutions, and cooperation can we achieve both the goal of enhancing global supply chain resilience and the sustainable development of digital trade.

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