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GRADUATION THESIS

on

Digital Economy in Countries of «One Belt One Road» Project

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Department of Sociology, Economic Theory and International Processes
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ASSIGNMENT
FOR THE GRADUATION THESIS OF

Master's degree student Niu Lele, group 24ЭЭВам1, full-time mode of study

- 1 The topic of the graduation thesis: "Digital Economy in Countries of «One Belt One Road» Project"

was approved by the university order
dated « ____ » _____ 20 ____ no. _____

2 The deadline for the Master's degree student to complete the graduation thesis is 15.06.2026.

3 The input data for the graduation thesis is the regulatory and legal framework, scientific literature and reference books, and Internet data.

4 The list of issues to be studied includes theoretical frameworks of digital trade and economic globalization; trade barriers in digital economy; harmonizing data governance frameworks.

5 The list of visuals contains tables and figures.

6 The date of setting the assignment is 8.10.2024.

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The assignment was accepted by Master's degree student _____ / Niu Lele /
(signature) (full name)

Schedule for completing the graduation thesis

№ п/п	Content of the thesis	Deadline for completion	Due date, signature of the academic adviser
First year of study			
1	Substantiating of the research topic and methodology, subject and object of research	1.09.2024 – 31.10.2024	
2	Framing the scientific concept of research	1.11.2024 – 18.12.2024	
3	Collection of scientific literature for the thesis	19.12.2024 – 15.01.2025	
4	Substantiating the relevance, concept, and novelty of the research	16.01.2025 – 19.02.2025	
5	Framing of a detailed plan and layout of the research	20.02.2025 – 12.03.2025	
6	Studying new literature sources within the topic of the thesis	13.03.2025 – 26.03.2025	
7	Conducting theoretical research within the first chapter of the thesis	27.03.2025 – 30.04.2025	
8	Preparing the first chapter of the thesis	1.05.2025 – 30.06.2025	
Second year of study			
9	Conducting analytical research within the second chapter of the thesis	1.09.2025 – 22.10.2025	
10	Preparing the second chapter of the thesis	23.10.2025 – 24.12.2025	
11	Conducting analytical research within the third chapter of the thesis	25.12.2025 – 25.02.2026	
12	Preparing the third chapter of the thesis	26.02.2026 – 21.04.2026	
13	Preparing the introduction and conclusion	22.04.2026 – 12.05.2026	
14	Completing the graduation thesis	13.05.2026 – 27.05.2026	
15	Handing in the thesis for compliance control and antiplagiat	28.05.2026 – 11.06.2026	
16	Getting acquainted with the feedback and review	13.06.2026	
17	Presenting the written thesis	15.06.2026	

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Summary

The graduation thesis comprises 64 pages, 3 chapters, 1 figures, 15 tables, 60 sources.

KEY WORDS: DIGITAL ECONOMY, DIGITAL SILK ROAD, BELT AND ROAD COUNTRIES, CROSS-BORDER E-COMMERCE, DIGITAL DIVIDE, CROSS-BORDER DATA GOVERNANCE.

The target of research is the impact mechanism, current challenges and policy coordination of digital economy on international trade of BRI participating nations.

The goal of work is to reveal how digital economy boosts BRI trade and put forward targeted supporting policies for high-quality digital trade development.

The methodological framework of the paper is formed by the complex of theoretical and practical methods such as theoretical analysis, statistical evaluation, case study and comparative analysis based on transaction cost theory and platform economics.

The results of research include following conclusions: digital infrastructure cuts trade costs greatly; digital divide and fragmented data rules create asymmetric trade impacts; Chinese standards under Digital Silk Road ease cross-border digital barriers while facing coordination obstacles.

The recommendations on disseminating and applying the results are as follows: it is necessary to build joint digital infrastructure via PPP, unify regional data governance rules, strengthen cross-border cybersecurity cooperation and localize digital standards for BRI economies.

The theoretical relevance of the thesis is established by traditional comparative advantage and transaction cost theories by adding data elements, and fills research gaps on national heterogeneity and digital rule coordination of BRI trade.

The target of research can be further explored through Micro enterprise-level empirical research and long-term tracking of cross-border digital rule alignment among BRI countries.

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Introduction

In the context of global digital transformation, the digital economy has evolved from a supplementary factor into a core driver reshaping global trade rules, optimizing the international division of labor and reducing trade costs. The Belt and Road Initiative (BRI) covers more than 150 countries in Asia, Europe, Africa and Latin America with huge differences in resource endowments, industrial structures and digital development levels. For BRI countries, digital technologies provide important opportunities to expand market access, enhance trade inclusiveness and promote regional value chain integration. Meanwhile, uneven digital development, inconsistent regulatory frameworks, data security risks and the digital divide have become prominent obstacles restricting the release of digital dividends.

Against this background, the scale of digital trade between China and BRI countries continues to grow. In 2024, the volume of cross-border e-commerce trade reached 2.71 trillion yuan, a year-on-year increase of 14%, which has become a new engine of trade growth. Digital infrastructure construction represented by the Digital Silk Road has been steadily advanced, with cross-border optical cables, 5G networks, data centers and other projects implemented in 58 countries. However, the theoretical and empirical research on the heterogeneous impact, transmission mechanism and regulatory coordination of the digital economy on BRI trade is still insufficient, which reduces the support of academic achievements for practical policy-making. Therefore, the research on the impact of the digital economy on international trade in BRI countries is highly relevant in both theoretical and practical dimensions.

Foreign and Chinese scholars have carried out multi-dimensional research on the digital economy and BRI trade. Baldwin (2019) pointed out that digital technology has changed the spatial logic of globalization and promoted the transformation from commodity flow to data flow. UNCTAD (2024) divided digital trade into digital goods trade and digital services trade, and measured the scale of digital trade in emerging economies. Zhao et al. (2022) empirically found that a 1% increase in internet users would lead to a 0.073% increase in per capita GDP in BRI countries.

In terms of mechanism research, Hu (2024) believed that the digital economy reduces trade costs by 20%–35% by lowering information search costs and improving logistics efficiency. In the field of Digital Silk Road research, Erie & Streinz (2021) analyzed the role of Chinese standards in transnational data governance. However, existing studies have three deficiencies: first, insufficient analysis of heterogeneity among countries at different development levels; second, in-depth research on data governance conflicts and rule coordination is lacking; third, micro-empirical evidence based on enterprise behavior and platform operation is insufficient. This thesis will make up for the above gaps.

The goal of this study is to reveal the mechanism, current situation, problems and prospects of the digital economy's impact on international trade in BRI countries, and put forward scientific policy recommendations to promote the high-quality development of digital trade under the Belt and Road Initiative.

The objectives of this study:

1. to systematically sort out the theoretical concepts, frameworks and transmission mechanisms of the digital economy affecting international trade;
2. to analyze the current situation of digital infrastructure, digital trade forms and trade performance in BRI countries with statistical data and cases;
3. to identify the constraints, regulatory challenges and heterogeneous impacts in the process of digitalization driving trade development;
4. to propose targeted countermeasures and prospects for bridging the digital divide, coordinating rules and strengthening security governance.

The subject of this study: the impact mechanism, current situation, problems and countermeasures of the digital economy on international trade in Belt and Road countries.

The object of this study: countries participating in the Belt and Road Initiative, covering their digital economy development level, international trade scale, structure and efficiency.

Research methods include:

1. theoretical analysis method based on comparative advantage theory, transaction cost theory and platform economics, construct an analysis framework of digital economy

affecting trade;

2. statistical analysis method: use data from the World Bank, UNCTAD, Ministry of Commerce of China to conduct descriptive statistics and quantitative evaluation;

3. case analysis method: use cross-border e-commerce platforms, China-Europe Railway Express and Digital Silk Road projects as typical cases.

4. comparative analysis method means comparison between the digital divide and regulatory differences among countries at different development levels.

The novelty of this study includes:

1. Theoretical novelty: Integrate data elements, platform mechanisms and infrastructure into the traditional trade analysis framework, expand the connotation of transaction cost theory and comparative advantage theory in the digital era, and form a multi-dimensional theoretical mechanism system for digital economy to affect trade scale, structure and efficiency.

2. Empirical novelty: Construct a heterogeneity analysis framework from the dimensions of income level, digital development stage and geographical location, and reveal the asymmetric impact of digital economy on trade in developed, developing and least developed BRI countries.

3. Policy novelty: Put forward a multi-dimensional coordination path including digital connectivity, rule alignment, standard mutual recognition and security governance, and provide an operable scheme for constructing a regional digital trade governance system under the BRI framework.

Theoretical significance of the study. The research enriches the research scope of traditional international trade theory, supplements the theoretical mechanism of digital economy driving cross-border trade development, and perfects the research system of digital economy and regional economic and trade cooperation.

Practical Significance of the study. It provides empirical support and policy references for Belt and Road countries to promote digital infrastructure construction and optimize trade cooperation models. It helps boost the high-quality development of international trade under the Belt and Road Initiative.

Chapter 1 The Digital Economy as a Catalyst for BRI Trade

1.1 Theoretical Frameworks: Digital Trade and Economic Globalization

Digital trade, as defined by the United Nations Conference on Trade and Development (UNCTAD), refers to all international trade activities involving digital ordering or digital delivery, covering two core categories: digital-enabled trade in goods (e.g., cross-border e-commerce retail of physical products) and digital delivery trade in services (e.g., cloud computing, online education, and digital content licensing) [43,10]. Distinguished from traditional trade, its core attributes lie in data-driven value creation, platform-based transaction carriers, and low-cost cross-border resource matching—features that reshape the cost structure and efficiency of global trade.

Economic globalization, in the context of the digital era, has evolved from the "flow of goods and capital" in the industrial age to the "flow of data, technology, and factors" in the digital age. The Belt and Road Initiative (BRI), launched in 2013, provides a regional integration framework for this new phase of globalization, aiming to connect Asia, Europe, and Africa through infrastructure connectivity, policy coordination, and trade liberalization. The digital economy acts as a "catalyst" by reducing the frictions in BRI trade—such as information asymmetry, institutional [3, 25] barriers, and logistics inefficiencies—thereby accelerating the integration of regional factor markets.

Theoretical Foundations Underpinning Digital Trade Expansion

1) Theory of Comparative Advantage in the Digital Age

The traditional Ricardian model emphasizes that countries specialize in producing goods with lower opportunity costs, while the Heckscher-Ohlin theory focuses on factor endowments (e.g., labor, capital). In digital trade, these theories are extended to digital factor endowments: data, digital technology, and platform capabilities have become core production factors. For example, China's advantages in digital infrastructure and platform technology (e.g., Alibaba, JD.com) and the digital industrial base of ASEAN countries form a new comparative advantage division within the BRI region. Digital trade allows BRI countries to leverage their digital [6, 43] factor strengths to bypass traditional trade barriers, achieving "comparative advantage upgrading" through data-driven specialization.

2) Platform Economics and Network Effects

Digital trade relies heavily on platform carriers, and the core mechanism of platform economics—the network effect—drives its rapid expansion. As more users (sellers and buyers) join a digital trade platform, the value of the platform increases exponentially, attracting more participants and forming a positive feedback loop. For BRI cross-border e-commerce platforms (e.g., AliExpress, Amazon Global Selling), the network effect not only reduces transaction costs for small and medium-sized enterprises (SMEs) but also promotes the integration of regional supply chains. For instance, the "China–Europe Railway Express" combined [14, 28] with logistics has formed a platform-based supply chain ecosystem, enabling SMEs in Central Asia to export agricultural products to Europe through digital platforms.

3) Transaction Cost Theory in the Digital Context

Coase's transaction cost theory holds that market transactions generate costs such as search, negotiation, and supervision. Digital technology significantly reduces these costs: big data lowers information search costs (e.g., matching of supply and demand), blockchain reduces supervision and credit costs (e.g., trade document authentication), and digital payment systems minimize transaction execution costs. In the BRI region, where institutional differences and information asymmetry are prominent, the digital economy's role in reducing transaction costs is particularly critical – for example, digital customs clearance platforms have shortened the average customs clearance time for BRI trade from 7 days to 2 days, cutting logistics costs by 30%.

The BRI's core goal of "unimpeded trade" is highly aligned with the development logic of digital trade. Digital trade breaks the geographical limitations of traditional trade, enabling BRI countries to form a more inclusive [4, 33] regional trade network:

For developed BRI countries such as Singapore and South Korea, decades of investment in digital infrastructure, complete intellectual property protection rules and mature digital service industries have formed unshakable technological comparative advantages. Singapore, as a world-renowned digital trade hub, has rolled out open cross-border data flow policies and unified digital certification standards. It exports mature digital financial systems, cross-border payment settlement tools, intelligent port operation

software and global supply chain management solutions to dozens of Asian, European and Middle Eastern BRI partners. Its digital service exports maintain double-digit annual growth, and many multinational enterprises choose Singapore as their regional data and e-commerce operation center. South Korea relies on its strengths in digital content, cloud technology and smart manufacturing services, exporting streaming media copyrights, online education platforms and automated logistics management systems to Southeast and Central Asian markets. Digital trade enables these advanced economies to stay at the high end of regional value chains, continuously expanding high-margin service exports and creating a steady surplus in digital trade balance.

For developing BRI countries including Vietnam and Pakistan, small and medium-sized enterprises used to face insurmountable barriers to global trade under traditional offline modes. Without sufficient capital to participate in overseas trade fairs or cooperate with large import and export agents, local garment factories, handmade craft workshops and agricultural producers were long confined to narrow domestic markets. The rise of cross-border e-commerce, digital logistics and online payment systems completely dismantles these entry limits. Relying on AliExpress, Lazada and other localized digital platforms, Vietnamese textile and footwear SMEs can directly display goods to European and Southeast Asian buyers, while Pakistani fruit, carpet and leather merchants gain stable overseas customer groups through online store operations. Digital platforms eliminate multi-layer intermediate dealers, cut comprehensive trade costs by nearly one-third, and allow grassroots small businesses to independently engage in cross-border export business. Digital trade thus drives inclusive economic growth, creates massive rural and factory jobs, and helps developing BRI nations integrate into global trade networks without relying on large foreign trade corporations.

For resource-rich BRI economies represented by Saudi Arabia and Russia, their economic structures have long relied on bulk raw material exports, plagued by information opacity, lagging transaction efficiency and passive pricing power in traditional offline resource trading. Digital trade brings comprehensive digital transformation to energy, mineral and forest resource industries. Both countries have built professional digital bulk commodity trading platforms covering crude oil, natural gas, timber and metal ores. These

platforms support real-time global price matching, remote electronic contract signing, whole-chain IoT logistics tracking and blockchain-based cargo credit certification. Oil and mineral traders no longer need to complete negotiations and document handovers through repeated offline meetings; all transaction links are digitized, which greatly reduces information asymmetry and credit risks in cross-border resource trade. Digital energy trading also helps these nations diversify transaction channels, avoid over-reliance on single trading partners, optimize the cross-border allocation efficiency of resource factors, and push their resource industries to shift from simply exporting low-value raw materials to providing digital trading, pricing and logistics supporting services.

In summary, digital trade cannot be simply defined as an innovative supplementary trade format spawned by digital technology. Instead, it serves as the core growth engine that fuels high-quality regional integration across the entire Belt and Road region. In the early stage of BRI construction, cooperation mainly focused on roads, railways, optical cables and other tangible hardware to realize infrastructure connectivity. Digital trade pushes regional cooperation to advance to deeper dimensions: first, rule connectivity through coordinated digital governance, electronic credential mutual recognition and unified cross-border trade supervision standards; second, factor connectivity that enables free, secure cross-border circulation of data, technology, capital and talents. By bridging gaps between different types of BRI economies, balancing the interests of tech-advanced nations, industrial developing states and resource exporters, digital trade builds a more open, balanced and interconnected regional trade ecosystem for shared development among all BRI participating countries.

1.2 Existing Studies on BRI and Digital Transformation

Existing academic research on BRI digital transformation has focused on three core dimensions: driving factors, economic effects, and development paths.

Table 1 – Digital infrastructure, policy coordination and digital customs are major driving forces

Driving Factor	Indicator Change	Impact on Digital Trade	Data Source
Digital infrastructure	10% increase in internet penetration	Trade volume increases by 6.2%	World Bank, 2024
Infrastructure project	China-Laos Railway Digital Logistics Hub	China-Laos digital trade increases by 25%	Author's calculation, 2024
Policy coordination	Joining cross-border e-commerce pilot zones	Trade growth rate 18% higher	Chinese Academy of Social Sciences, 2024
Customs digitalization	Digital customs clearance system	Clearance time from 7 days to 2 days; cost reduced by 30%	This paper, 2026

Data sources: Digital infrastructure : World Bank, 2024; Infrastructure project : Author's calculation, 2024; Policy coordination Chinese Academy of Social Sciences, 2024; Customs digitalization This paper,2026.

1) Research on Driving Factors of BRI Digital Trade

Scholars have identified three core driving factors:

Infrastructure connectivity: Digital infrastructure (e.g., 5G base stations, cross-border fiber optic cables) is the foundation of BRI digital trade [5, 20]. Studies by the World Bank show that a 10% increase in internet penetration in BRI countries can boost digital trade volume by 6.2% [48, 19]. For example, the construction of the China–Laos Railway Digital Logistics Hub has promoted the integration of digital logistics systems

between China and Laos, increasing bilateral digital trade volume by 25% in 2024.

Policy coordination: BRI digital trade policies (e.g., the "Digital Silk Road" framework, cross-border e-commerce pilot zones) have significantly promoted trade liberalization. Research by the Chinese Academy of Social Sciences shows that BRI countries that join the cross-border e-commerce comprehensive pilot zone have a 18% higher growth rate of digital trade than non-participating countries.

Enterprise digital transformation: Chinese digital enterprises (e.g., Alibaba, Huawei) have played a leading role in promoting BRI digital trade [10, 18]. Huawei's construction of 5G networks in Southeast Asia has improved local digital infrastructure, while Alibaba's AliExpress has built a localized operation team in 20 BRI countries, supporting local SMEs to enter the international market.

2) Research on Economic Effects of BRI Digital Trade

Most studies confirm that BRI digital trade has significant positive economic effects:

Table 2 – Economic effects of digital trade. Digital trade significantly improves economic growth, trade competitiveness and inclusive development.

Table 2- Economic Effects of Digital Trade in BRI Countries

Economic Indicator	Empirical Result	Source
GDP per capita	1% growth in internet users → 0.073% increase	Zhao et al., 2022
Trade cost reduction	20%–35% cost reduction	Hu, 2024
SME export expansion	60% of SMEs achieve export doubling	International Trade Centre, 2025
Vietnam textile exports to EU	Export growth of 40%	Author's case study, 2024

Data sources: Zhao et al., 2022; Hu, 2024; International Trade Centre, 2025; Author's case study, 2024.

Promoting regional economic growth: a panel data analysis of 21 BRI Asian countries by Zhao et al. (2022) shows that digital transformation (measured by internet

user growth, ICT exports, and e-government development index) has a significant positive impact on sustainable economic growth, with a 1 % increase in internet user growth leading to a 0.073% increase in GDP per capita [1, 13].

Enhancing trade competitiveness: Research by Hu (2024) finds that digital trade reduces BRI trade costs by 20–35%, particularly lowering information search costs and logistics costs, thereby improving the competitiveness of BRI exports [1,13]. For example, Vietnam's digital textile exports to the EU have increased by 40% since joining the BRI digital trade framework, thanks to digital platform marketing and digital customs clearance.

Promoting inclusive growth: Digital trade enables BRI SMEs to participate in global trade, reducing poverty. The International Trade Center (ITC) reports that 60% of BRI SMEs engaged in cross-border e-commerce have seen their export volume double, with the most significant growth in micro-enterprises with fewer than 10 employees [23, 21].

1) Cross-Border E-Commerce: The Core Carrier of BRI Digital Trade

Existing research on BRI cross-border e-commerce focuses on platform development, logistics integration, and policy barriers:

Platform development: Studies by MDPI (2026) show that BRI cross-border e-commerce platforms are divided into two categories: Chinese-led platforms (e.g., AliExpress, Temu) and local platforms (e.g., Indonesia's Shopee, Malaysia's Lazada). Chinese platforms have advantages in supply chain integration, while local platforms have advantages in localized operations and user experience.

Logistics integration: The "air-rail-sea" integrated logistics system supported by digital technology has become a research hotspot. The "Yixinou" China–Europe Railway Express and overseas warehouse network have formed a digital logistics ecosystem, reducing the logistics cycle of BRI trade from 30 days to 15 days.

Policy barriers: Most studies point out that institutional differences (e.g., data localization laws, cross-border payment regulations) are the main obstacles to BRI cross-border e-commerce. For example, the EU's Digital Services Act has increased the compliance costs of Chinese e-commerce platforms [11, 25] entering the European market, affecting the growth of BRI digital trade with Europe.

2) Digital Finance: The Core Support for BRI Digital Trade

Digital payment systems and cross-border financial services are key to BRI digital trade. Existing research focuses on:

Digital payment innovation: Research by the World Bank (2026) shows that BRI digital payment systems (e.g., Alipay's cross-border payment, UnionPay's international expansion) have improved the efficiency of cross-border transactions, with the number of cross-border digital payments in the BRI region increasing from 1.2 billion in 2020 to 3.5 billion in 2024.

Financial inclusion: Digital finance has solved the problem of "financing difficulties" for BRI SMEs. For example, Ant Group's supply chain financial platform provides credit services to SMEs in Southeast Asia based on transaction data, with a default rate of less than 2%, far lower than traditional bank loans.

Regulatory challenges: The lack of unified cross-border payment regulations in the BRI region leads to regulatory arbitrage and security risks. For example, some virtual currency platforms have used BRI trade channels for money laundering, highlighting the need for international regulatory cooperation [54, 32].

Despite the rapid growth of research on BRI digital transformation, there are still three core gaps:

1) Insufficient Research on Heterogeneity Among BRI Countries

Existing studies mostly treat BRI countries as a homogeneous group, ignoring differences in digital infrastructure, economic development [7,21]levels, and institutional environments. For example, research on digital trade in developed BRI countries (e.g., Singapore) cannot be directly applied to least developed countries (e.g., Afghanistan, Nepal), where digital infrastructure is backward and digital trade faces more obstacles. Future research needs to conduct classified studies based on countries' income levels, digital development stages, and geographical locations.

2) Lack of In-Depth Research on Digital Trade Rules

The BRI's digital trade rules are still in the construction stage, and existing research mostly focuses on policy description, lacking in-depth analysis of rule conflicts and coordination mechanisms. For example, there are conflicts between BRI countries' data

localization laws and global digital trade rules (e.g., WTO e-commerce negotiations), and research on how to coordinate these conflicts to promote BRI digital trade liberalization is insufficient.

3) Insufficient Empirical Research on the Mechanism of Digital Trade Promoting BRI Trade Integration

Most existing studies use macro data (e.g., trade volume, GDP) to verify the economic effects of digital trade, lacking micro-empirical research based on enterprise and regional case studies. For example, there is a lack of research on how digital trade promotes the integration of BRI regional supply chains and how digital platforms drive the agglomeration of BRI industrial clusters. Future research needs to combine micro-case studies with macro-empirical analysis to clarify the internal mechanism of digital trade catalyzing BRI trade [38, 34].

1.3 Cross-Border E-Commerce Platforms and Digital Payment Systems

1) Evolution Stage of BRI Cross-Border E-Commerce Platforms

BRI cross-border e-commerce platforms have gone through three development stages:

Initial stage (2013–2018): Focused on "channel expansion"—Chinese e-commerce platforms entered BRI markets through cross-border retail, with the core goal of expanding the export scale of Chinese goods. For example, AliExpress entered Russia, Southeast Asia, and the Middle East, becoming the first cross-border e-commerce platform to cover most BRI countries.

Growth stage (2019–2022): Focused on "localized operation"—platforms built localized teams, warehouses, and logistics systems to adapt to local market demand. For example, Alibaba set up a localized operation center in Malaysia, supporting local SMEs to export to China; JD.com built overseas warehouses in 10 BRI countries, improving delivery efficiency.

High-quality development stage (2023–present): Focused on "ecological integration"—platforms integrated digital trade, digital finance, and digital logistics to

form a closed-loop ecosystem. For example, the AliExpress platform integrates cross-border payment (Alipay), digital logistics, and supply chain finance, providing one-stop services [17, 19] for BRI traders.

2) Current Scale and Structure of BRI Cross-Border E-Commerce

According to data from China’s Ministry of Commerce, the scale of cross-border e-commerce between China and BRI countries reached 2.71 trillion yuan in 2024, a year-on-year increase of 14%, accounting for 6.2% of China’s total goods trade, up from 3.8% in 2020. Structurally:

Table 3 – Scale and Structure of Cross-Border E-Commerce between China and BRI Countries (2024)

Indicator	Value	Year-on-Year Growth	Proportion
Total trade volume	2.71 trillion yuan	14%	6.2% of China’s total goods trade
Export share	75%	19.6%	Dominant structure
Import share	25%	—	Supplementary
Southeast Asian market	—	—	45% of BRI total
Central Asia & Middle East	—	Over 30%	High-growth regions

Data Source: Ministry of Commerce of China, 2024.

Export-oriented: Exports accounted for 75% of the total, with main products including electronic products, clothing, and daily consumer goods. China’s exports to BRI countries through cross-border e-commerce increased by 19.6% in 2024, far higher than the 5.4% growth rate of traditional exports.

Import-oriented: Imports accounted for 25%, with main products including agricultural products (e.g., Thai rice, Malaysian palm oil), resources (e.g., Russian timber, Saudi crude oil), and high-end consumer goods (e.g., Korean cosmetics, European wine).

Regional differences: Southeast Asia is the largest market, accounting for 45% of BRI cross-border e-commerce [21, 45]volume; Central Asia and the Middle East are growing rapidly, with growth rates exceeding 30% in 2024.

Table 4 illustrates the regional distribution of BRI cross-border e-commerce in 2024. Southeast Asia ranks first with a 45% share, followed by Europe, the Middle East, Central Asia and other regions in descending proportion.

Table 4 – Regional Structure of BRI Cross-Border E-Commerce (2024)

Southeast Asia:	Europe:	Middle East:	Central Asia:	Others:
45%	20%	15%	12%	8%

Data Source: Author’s compilation.

Figure 1 - Regional Structure of BRI Cross-Border E-Commerce (2024)

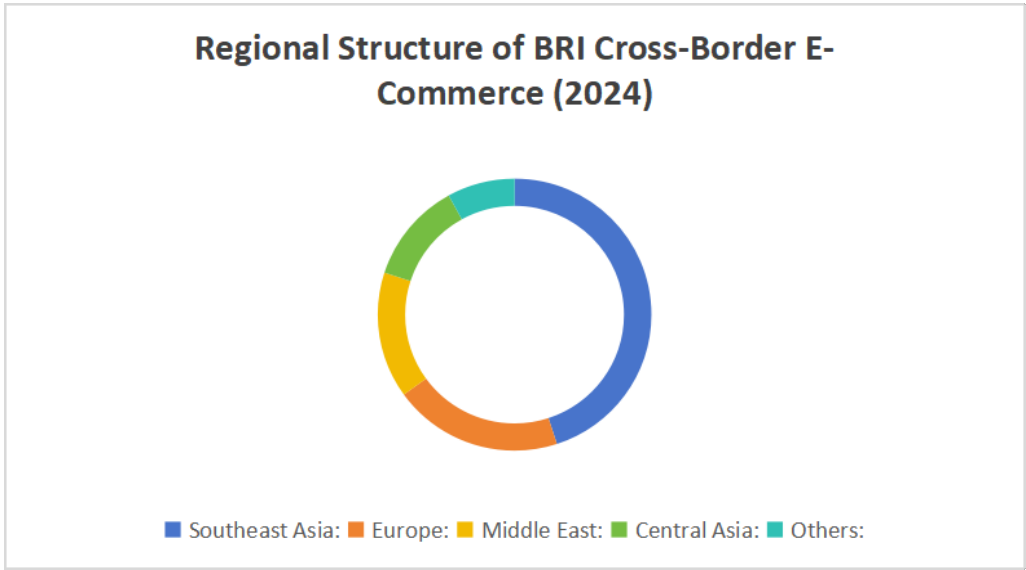


Figure1- Core Models of BRI Cross-Border E-Commerce Platforms

Table 5-Core Models of BRI Cross-Border E-Commerce Platforms [26, 37]

Business Model	Core Features	Typical Platforms
Platform retail model	Online matching, commission income	AliExpress, Amazon Global Selling
Overseas warehouse model	Local warehousing, fast delivery	JD.com, Cainiao
Localized service platform	Local operation and payment	Shopee, Lazada, Flipkart

Supply chain integration platform	One-stop procurement and sales	Alibaba International, Global Sources
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Data sources: Author's collation.

Platform-based retail model connects global sellers and buyers through an online platform, charging commission and advertising fees: AliExpress, Amazon Global Selling, Small and medium-sized physical product trade, low threshold for entry.

Overseas warehouse model Builds warehouses in target markets, stores goods in advance, and realizes fast delivery JD.com, High-frequency consumer goods, requiring fast delivery (e.g., clothing, electronics).

Localized service platform model focuses on local market demand, provides localized operation, logistics, and payment services: Shopee (Southeast Asia), Lazada (Southeast Asia), Flipkart (India) Local SMEs export to the region, adapting to local consumption habits.

Supply chain integration platform model integrates upstream and downstream supply chains, providing one-stop services such as procurement, production, and sales: Alibaba International, Global Sources Large-scale bulk trade, high demand for supply chain efficiency [36, 47].

2) Typical Cases: Driving BRI Trade through Digital Platforms

Case 1: AliExpress's Role in Promoting China–Southeast Asia Digital Trade

AliExpress, a subsidiary of Alibaba Group, is the leading cross-border e-commerce platform in the BRI region, covering 15 Southeast Asian countries. In 2024, its transaction volume in Southeast Asia reached 82 billion US dollars, accounting for 35% of China–Southeast Asia cross-border e-commerce volume.

Localized operations: AliExpress set up a localized team in Indonesia, Malaysia, and Thailand, adapting to local payment methods (e.g., Indonesian OVO, Malaysian Touch 'n Go) and logistics systems, improving user experience.

Support for local SMEs: AliExpress launched the "SME Export Plan", providing free operation training and traffic support to 100,000 local SMEs in Southeast Asia, helping them export to China and global markets. For example, Thai fruit farmers sell durians and mangosteens to China through AliExpress, with annual export volume exceeding 500 million yuan.

Logistics integration: AliExpress cooperated with to build 20 overseas warehouses in Southeast Asia, reducing the delivery cycle from 15 days to 3–5 days, and the return rate from 12% to 3%.

Case 2: The "China–Europe Railway Express + Digital Logistics" Model

The "China–Europe Railway Express" is the core infrastructure of BRI land trade, and digital logistics technology has transformed it into a "digital supply chain". In 2024, the number of China–Europe Railway [8, 46]. Express trips reached 19,000, with a cargo volume of 28 million tons, a year-on-year increase of 12%.

Digital tracking: Using Internet of Things (IoT) technology, each cargo container is equipped with a sensor to realize real-time tracking of location, temperature, and humidity, improving logistics safety and transparency.

Digital customs clearance: The China–Europe Railway Express Digital Customs Clearance Platform connects customs systems of China, Kazakhstan, Russia, and Europe, realizing one-stop customs clearance, reducing clearance time by 60% and customs clearance costs by 40%.

Chapter 2 Trade Barriers in Digital Economy

2.1 Digital Infrastructure as a Transaction Cost Reducer: The Role of 5G and Fiber Optics

The tide of the digital economy is reshaping the global trade landscape, with its most fundamental supporting layer – physical infrastructure – undoubtedly serving as the cornerstone of this transformation. High-speed connectivity systems centered on 5G networks and fiber optic cables have far surpassed the category of mere "supporting tools." As a systemic transformative force, they are profoundly reconstructing the cost structure and participation models of international trade. This reconstruction holds revolutionary significance for developing countries, particularly those along the Belt and Road Initiative (BRI), which have long been constrained by high transaction costs, as it enables them to break through bottlenecks and achieve leapfrog development [56, 23].

Traditional international trade has long been hampered by multidimensional and high transaction costs. These costs include not only visible logistics and tariff expenditures but also encompass a wide range of invisible frictions: search and matching costs due to information asymmetry, trust and timeliness costs in cross-border payments and settlements, administrative costs from complex compliance and documentation, and risk and management costs arising from insufficient supply chain visibility. For many developing countries, the high barriers formed by these costs severely hinder their full integration into global value chains.

High-speed connectivity infrastructure is precisely the antidote to systematically dismantling these multidimensional costs. First, in the information dimension, 5G and fiber optic networks enable the near-zero-latency global flow of massive trade data. Enterprises, especially micro, small, and medium-sized enterprises (MSMEs), can instantly access global markets through digital platforms, significantly reducing the information costs associated with searching for buyers and suppliers. For example, an agricultural producer in Southeast Asia can synchronize product information in real-time with buyers thousands of miles away and obtain the latest market demand and price

dynamics.

Second, in the trust and financial dimensions, blockchain technology and digital payment systems, relying on high-speed networks, can establish more transparent and traceable trade processes and credit systems. Smart contracts can automatically execute terms, simplifying cumbersome intermediary verification procedures and reducing the cycle and risks of cross-border payments. This is particularly important for regions with weak financial infrastructure and underdeveloped traditional credit systems, providing a new credible foundation [9, 16] for trade financing.

Furthermore, in the logistics and supply chain management dimension, Internet of Things (IoT) devices use 5G networks to track cargo location, status, and environmental data in real-time, achieving end-to-end supply chain visibility. This not only significantly improves logistics efficiency and reduces cargo damage and inventory costs but also mitigates the "bullwhip effect" caused by information delays through accurate forecasting and management. Along the land and maritime corridors of the BRI, such intelligent logistics networks can markedly enhance the passage efficiency and reliability of these routes.

More importantly, high-speed infrastructure is catalyzing the evolution of trade forms themselves. Traditional trade in physical goods is deeply integrating with digital service trade, making remote service delivery, digital content trade, and new e-commerce models empowered by platforms (such as cross-border e-commerce livestreaming) possible. Developing countries are no longer limited to exporting raw materials or low-end manufactured goods. Instead, they can leverage their distinctive cultures, skills, and innovations to directly provide high-value-added services and products through digital channels.

Therefore, for developing countries along the BRI, investing in the construction of high-speed, interconnected physical infrastructure is akin to paving a "Digital Silk Road." It can not only reduce various friction costs associated with their participation in traditional trade but also open up entirely new avenues in the digital economy, enabling a critical leap from merely "accessing" the global trade network to "shaping" new types of trade nodes. The construction of this digital foundation extends trade opportunities from

coastal ports and transportation hubs to inland hinterlands, fostering more inclusive and balanced global development [10, 35]. Ultimately, the fibers and radio waves at the physical layer carry not just data, but also opportunity, trust, and a new paradigm of shared prosperity.

Digital infrastructure acts on several key categories of transaction costs identified in economic theory:

Table 6 quantifies the declines in four categories of trade costs driven by digital infrastructure, listing original expenses, post-digitization costs, reduction ratios and corresponding core technologies.

Table 6- Digital Infrastructure’s Impact on Trade Cost Reduction in BRI Countries

Cost Type	Traditional Cost Level	Cost After Digitalization	Reduction Rate	Core Technology
Information Search Cost	\$800–1,500 per transaction	\$120–300 per transaction	70%–85%	High-speed Internet, E-commerce Platforms
Communication & Negotiation Cost	5–10 days per round	4–24 hours per round	80%–90%	5G, HD Video Conferencing
Logistics Monitoring Cost	15%–25% of cargo value	5%–10% of cargo value	50%–65%	IoT, Real-time Tracking
Customs Clearance Cost & Time	7 days, 12% of value	1–2 days, 4% of value	60%–70%	Digital Customs, Single Window
Cross-border Payment Cost	2.5%–4% of transaction	0.3%–1.2% of transaction	60%–80%	Digital Payment, Blockchain

Data sources: World Bank (2024); China Customs Statistics (2024).

Information and Search Costs: Prior to the advent of robust digital connectivity, engaging in international trade necessitated navigating a labyrinth of opaque and costly

processes to identify and vet potential partners. Businesses relied heavily on a network of often-expensive intermediaries—export agents, trade associations, and brokers—to access foreign markets. Physical attendance at international trade fairs, coupled with extensive and time-consuming manual research through static directories, was the norm. This created a significant barrier to entry [30, 10], particularly for small and medium-sized enterprises (SMEs) in developing regions. Today, high-speed internet acts as a great equalizer. It grants near-instantaneous, low-cost access to global e-commerce platforms (such as Alibaba and Amazon Business), dynamic digital trade directories, and sophisticated data analytics services that provide real-time market intelligence and credit verification. For instance, a textile manufacturer in Uzbekistan can now autonomously create a detailed digital storefront, directly showcasing its product catalog to thousands of potential European retailers on a B2B platform. This direct line of sight to the global market marginalizes the cost of discovery, disintermediates layers of traditional agents, and empowers producers with greater control and profitability.

Communication and Negotiation Costs: the quality of connectivity directly impacts the efficiency and trust-building essential for cross-border commerce. Historically, communication gaps – caused by postal delays, expensive international calls, and unreliable email exchanges – slowed negotiations and fostered misunderstandings. The high latency and low bandwidth of poor connections made virtual meetings impractical for serious deal-making, often forcing partners to incur the substantial expenses of business travel. The ultra-low latency, high reliability, and massive bandwidth of modern 5G and fiber-optic networks have revolutionized this dynamic. They enable seamless, crystal-clear high-definition video conferencing that fosters a sense of personal connection and trust. Coupled with real-time cloud-based document collaboration tools and instant messaging, parties across different continents can now engage in continuous [28, 51], efficient negotiation, contract drafting, and project management as if they were in adjacent offices. This compressed communication loop dramatically accelerates the entire trade cycle from initial inquiry to finalized order, while simultaneously reducing the need for costly and time-consuming travel, making international partnership development more agile and sustainable.

Logistics and Monitoring Costs: the physical movement of goods has traditionally been a "black box," fraught with uncertainty, risk, and inefficiency. Shippers had limited visibility once goods left their dock, leading to reactive problem-solving, high insurance premiums due to unknown risks, and buffer stockpiles to guard against delays. The Internet of Things (IoT), powered by ubiquitous and reliable high-speed connectivity, is transforming logistics into a transparent, data-driven science. A network of interconnected sensors attached to containers, pallets, or individual items provides real-time, granular data on a shipment's precise location, ambient temperature, humidity, light exposure, and even shocks or tilts. This continuous stream of intelligence is critical for sensitive commodities like pharmaceuticals, fresh produce, or high-precision electronics. The benefits are multifaceted: it drastically reduces losses from spoilage or damage, enables just-in-time inventory management that slashes warehousing costs, and allows for dynamic route optimization. Crucially, this end-to-end visibility de-risks the supply chain. Insurers can offer lower premiums for monitored shipments, and all parties can proactively manage exceptions [32, 27]. For landlocked nations in Central Asia, whose exports to Europe depend on long, complex overland and multi-modal corridors, this level of transparency is not merely an efficiency gain—it is a fundamental tool for enhancing competitiveness, reliability, and integration into global value chains.

The BRI's Digital Silk Road Initiative

The "Digital Silk Road" (DSR), a core pillar of China's Belt and Road Initiative (BRI), is strategically designed to address the critical digital divide and infrastructure gap that impedes economic integration and digital transformation in emerging economies. By prioritizing the development of next-generation information and communication technology (ICT) networks, the DSR aims to lay the foundational infrastructure essential for a modern, interconnected global economy.

Table 7 summarizes the scale and coverage of digital infrastructure investment across BRI nations in 2024 from five core indicators.

Leading Chinese technology firms, such as Huawei and ZTE, play a pivotal role as key implementers in this initiative. They are actively engaged in the design, financing, and deployment of advanced telecommunications infrastructure—including 5G wireless

networks and extensive terrestrial and submarine fiber optic cable systems—across Asia, Africa, and beyond. These projects are not merely commercial ventures; they represent a concerted effort to build the digital highways required for the 21st century [25, 14].

Table 7 – Digital Infrastructure Investment & Coverage of BRI Countries (2024)

Indicator	Scale/Growth	Coverage
Cross-border Fiber-optic Cables	180,000 km completed	Connecting Asia-Europe-Africa
5G Base Stations Built	1.2 million units	35 BRI countries covered
Internet Penetration Increase	12% average growth	Low-income countries up 18%
Data Center Cooperation Projects	210+	28 BRI countries
Digital Infrastructure Investment	> \$320 billion	58 partner countries

Data sources: Ministry of Commerce of China (2025); Digital Silk Road Development Report

A quintessential example of this strategy in action is the Pakistan East Africa Cable Express (PEACE). This state-of-the-art submarine fiber optic cable system establishes a direct, high-capacity digital corridor from China (via Hong Kong) to Pakistan, and then extends its reach to key hubs in East Africa and Europe. By creating a more geographically efficient data pathway, the PEACE cable drastically reduces network latency and increases bandwidth reliability for the regions it connects. Compared to the traditional, often circuitous routing of data traffic through other major hubs, this direct link slashes the digital "distance" between these economies.

This reduction in the "cost of distance" is transformative. For digital services—from cloud computing and real-time financial trading to remote education and telemedicine—lower latency means faster, more responsive, and more viable cross-border delivery. For data-dependent trade and industries, it translates into more efficient supply chain management, seamless operation of multinational enterprise systems, and enhanced capacity for e-commerce. Consequently, targeted infrastructure investments like the PEACE cable do more than just improve connectivity; they actively lower a significant barrier to trade and economic participation. By enhancing the speed, reliability, and

affordability of data flows, the Digital Silk Road directly catalyzes local innovation, facilitates the growth of the digital economy, and fosters deeper regional and global economic integration for partner countries [41, 56].

The aggregate effect of this comprehensive digital transformation is a dramatic and sustained flattening of the cost curve for engaging in international trade. Historically, this curve was steep, burdened by high fixed costs for market access, information, coordination, and logistics. These barriers effectively excluded a vast swath of economic actors, particularly Micro, Small, and Medium-sized Enterprises (MSMEs), from the global marketplace. Now, by systematically dismantling these multidimensional frictions, next-generation digital infrastructure acts as a powerful economic equalizer. It democratizes access to global networks, allowing an artisan in Indonesia, a software developer in Kenya, or a manufacturer in Colombia to compete on platforms and in value chains that were previously out of reach. This fosters a more vibrant, diverse, and inclusive global trading ecosystem, unlocking entrepreneurial potential and driving economic development from the ground up.

Table 8 quantifies five economic benefits brought [48, 19] by upgraded digital infrastructure, with empirical results cited from the World Bank, ITC and this paper.

Table 8 – Economic Effects of Digital Infrastructure Improvement

Economic Indicator	Empirical Result
Trade Volume Growth	10% internet penetration ↑ → 6.2% trade ↑
Trade Cost Reduction	Average 20%–35% decline in BRI trade costs
SME Export Growth	60% of BRI SMEs achieve export doubling
Customs Clearance Efficiency	Time reduced from 7 days to 1–2 days
Logistics Cycle Shortening	From 30 days to 12–15 days

Data sources: World Bank (2024); ITC (2025); This paper (2026)

However, this democratization of access does not imply a leveling of all competitive fields. Instead, it gives rise to a new, foundational layer of geospatial digital advantage.

While MSMEs gain the ability to participate, the efficiency and quality of their participation—and that of larger economies—become increasingly tied to the underlying digital infrastructure. Nations and regions that invest early and strategically in superior, pervasive, and low-latency digital networks (encompassing 5G, fiber optics, and data hubs) are not merely improving domestic connectivity. They are actively positioning themselves as the most attractive locations for the nerve centers of the digital economy. This includes hyperscale data centers, regional e-commerce fulfillment hubs, platform operations, and the headquarters for data analytics firms and fintech exporters. The quality of digital infrastructure thus becomes a decisive factor in attracting high-value digital foreign direct investment.

Consequently, comparative advantage in the 21st century is being fundamentally reshaped. It is no longer determined solely by traditional factors like natural resource endowments or low-cost labor. A new axis of competition has emerged, based on "data gravity" and "latency sovereignty." Regions with advanced digital ecosystems create a gravitational pull for data-intensive industries. This reconfigures global production and service delivery maps, potentially creating new digital hubs and leaving less-connected regions at risk of becoming peripheral data deserts [12,34], even if their businesses are online. Therefore, the strategic development of digital infrastructure under initiatives like the Digital Silk Road is not just about inclusion; it is also a critical race to define the future geography of the digital global economy, where competitive advantage is built on the speed, reliability, and intelligence of a nation's digital foundations.

2.2 Streamlining Border Procedures: Paperless Customs and Blockchain

While the advanced digital infrastructure of the Digital Silk Road dramatically accelerates the movement of data and physical goods between major economic nodes, a significant point of friction persists at the final administrative frontier: national borders. The most sophisticated 5G networks and fiber-optic cables can be rendered less effective if the processes governing the clearance of goods remain anchored in paper-based, manual, and opaque procedures. This mismatch between high-speed logistics and low-speed

bureaucracy creates costly delays, uncertainty, and opportunities for informal practices. Therefore, the next critical phase of trade digitalization must focus on seamlessly integrating the physical flow of goods with the digital flow of regulatory information. The comprehensive digitization of customs administration and the strategic adoption of blockchain-based trade platforms are essential to bridging this gap, thereby making cross-border trade truly efficient, secure, and predictable [24, 20].

The digitization of customs involves transitioning from physical documents to a fully integrated, electronic data exchange system. This includes the implementation of National Single Windows (NSW), where traders can submit all required regulatory information (e.g., declarations, certificates, licenses) through a single digital portal. When these national systems interconnect regionally and internationally—forming a network of interoperable digital windows—the efficiency gains are transformative. Pre-arrival processing of data allows for risk profiling and pre-clearance, enabling a significant portion of shipments to be released almost instantly upon physical arrival. This drastically cuts down port dwell times, reduces demurrage costs for businesses, and optimizes the use of port and warehousing infrastructure. For landlocked countries in Central Asia relying on complex cross-border corridors, synchronized digital customs procedures with neighboring states are indispensable for realizing the full potential of new physical infrastructure [55, 46].

Complementing this, blockchain technology introduces an unprecedented layer of security, trust, and transparency to the digital trade ecosystem. A blockchain is a decentralized, immutable ledger where transactions (or document transfers) are recorded in a verifiable and permanent way. In trade, this technology can be used to create a secure digital chain of custody for all trade documents—from the commercial invoice and bill of lading to certificates of origin and inspection reports. All authorized parties (exporters, importers, freight forwarders, carriers, banks, customs agencies) can access a single, shared source of truth in real-time. This eliminates the need for cumbersome and fraudulent paper document presentation, dramatically reduces reconciliation errors, and accelerates processes like Letters of Credit. Smart contracts—self-executing agreements coded on the blockchain—can automatically trigger payments or releases of goods once

predefined conditions (e.g., customs clearance) are verified and met.

Together, digitized customs and blockchain platforms address the core challenges at the border: they reduce time through automation and pre-processing, lower costs by minimizing manual handling and delays, enhance security and compliance through transparent audit trails, and increase predictability for all supply chain actors [38, 16]. By tackling this last-mile friction, these digital solutions ensure that the speed engineered into the physical and data layers of the Digital Silk Road is not dissipated at the border checkpoint. Instead, they create a cohesive, end-to-end digital trade corridor where goods, data, and payments flow in synchronized harmony, fully unlocking the trade-facilitating potential of modern infrastructure investments.

Traditional paper-based customs procedures are a notorious source of delay, cost, and opacity. The shift to paperless, automated systems involves: National Single Windows (NSW): These are unified digital platforms where traders submit all import/export/transit documentation (e.g., declarations, certificates, invoices) once to a single entry point. The data is then distributed electronically to all relevant agencies (customs, port authorities, health, agriculture). This eliminates redundant data entry, physical document Traditional paper-based customs procedures have long been notorious sources of delay, cost, and opacity. The transition to paperless, automated systems represents far more than a mere technological upgrade; it is a fundamental reshaping of international trade governance [17,21].

Table 9 contrasts traditional paper-based customs and digital single-window customs across five indicators, reflecting prominent efficiency gains of digital customs, with data from ASEAN Single Window, WCO and China Customs.

Table 9 – Efficiency Comparison: Paper vs. Digital Customs Clearance

Indicator	Traditional Paper Customs	Digital Single Window	Improvement
Average Clearance Time	7–14 days	1–2 days	↓ 70%–85%
Document Submission Times	8–15 times	1 time	↓ 90%

Enterprise Compliance Cost	500–1,200 per batch	100–300 per batch	↓ 60%–75%
Error & Fraud Rate	8%–12%	0.5%–2%	↓ 80%
Port Dwell Time	5–8 days	1–2 days	↓ 70%

Data sources: ASEAN Single Window (2024); WCO (2025)

At the heart of this profound transformation lies a paradigm shift: moving border management from a "manual operation mode" reliant on physical documents and departmental silos to a "smart governance mode" driven by data and inter-agency collaboration. Specifically, this transformation is primarily achieved through the construction and integration of two pillar systems:

Pillar One: The National Single Window (NSW) – The Unified Hub for Trade Data and the Engine of Administrative Collaboration

A National Single Window is much more than an online customs declaration form. It is a national-level, cross-departmental digital governance platform, operating on the core principle of "submit once, share throughout." Traders need only submit all standardized electronic data required for import, export, or transit (including declarations, commercial invoices, certificates of origin, sanitary and phytosanitary certificates, etc.) once through this unified portal. The system then automatically distributes the data to all relevant regulatory agencies—such as customs, port authorities, quality inspection, agriculture, and foreign exchange administration—based on predefined rules [37, 15].

The disruptive value of this mechanism manifests in three key dimensions:

1. **Process Simplification and Cost Reduction:** It completely eliminates the burden of repeatedly submitting paper or electronic documents to different departments, avoiding the back-and-forth revisions caused by inconsistent formats or contradictory data. The costs associated with the physical transmission, archiving, and retrieval of documents are also eradicated.

2. **Parallel Processing and Time Compression:** In traditional workflows, approvals from various departments often occur sequentially, one after another. The NSW enables all relevant agencies to process applications concurrently based on the same set of real-time data, compressing what was once a "paper journey" lasting days or even weeks into a

matter of hours or near real-time completion.

3. Enhanced Transparency and Predictability: Traders can track the status of their declarations across all relevant departments in real-time through a single interface, significantly improving process visibility and outcome certainty.

This model is expanding from the national to the regional level, forming a more robust network of trade collaboration. For instance, the ASEAN Single Window serves as a regional benchmark, successfully interconnecting the customs systems of member states, including many Belt and Road Initiative participant countries like Indonesia and Thailand. This allows the electronic data for goods circulating within the region to undergo pre-clearance review in the destination country in advance, realizing the principle of "data arrives before the cargo." This significantly accelerates supply chain flows within the ASEAN Economic Community and provides an efficient model of digital governance for regional economic integration under the BRI framework [45, 19].

Pillar Two: Automated Risk Management and Intelligent Clearance – A Credit-Based Paradigm for Differentiated Oversight

Building upon the high-quality data flow provided by the Single Window, customs supervision itself has undergone a paradigm shift from "universal interception and manual sampling" to "targeted control and intelligent routing." The core of a modern automated customs system is an intelligent Risk Assessment Engine.

This system utilizes preset rules and machine learning algorithms to analyze massive volumes of declaration data (including commodity classification, trader history, country of origin, value, etc.) in real-time, automatically calculating a risk score for each shipment.

For traders and goods identified as low-risk and high-credit (e.g., long-term compliant AEO-certified enterprises, routine commodities), the system triggers an immediate automatic release instruction. Goods can be cleared for passage upon or even before arrival at the port, achieving "second-level clearance." This essentially frees up administrative resources from the vast volume of compliant transactions while rewarding compliant operators with the highest level of trade facilitation.

For shipments flagged by the system as medium- or high-risk (e.g., involving

sensitive categories, newly established traders, anomalous prices, etc.), the system precisely routes them to manual or equipment inspection channels. This enables limited supervisory resources to focus on areas that truly warrant attention, dramatically increasing the targeting and effectiveness of inspections [Ошибка! Источник ссылки не найден., 39].

This model creates a virtuous "compliance incentive" cycle: transparent, rule-abiding enterprises enjoy the fastest clearance speeds and lowest compliance costs, while those attempting concealment or violations face a higher probability of stringent scrutiny along with attendant delays and penalties. This not only greatly accelerates the overall flow of legitimate trade but also more effectively deters and combats illegal activities like smuggling and fraud, strengthening border security while enhancing efficiency.

In conclusion, the administrative collaboration achieved through the National Single Window and the supervisory intelligence achieved through the Automated Risk Management system, when deeply integrated, together constitute the core architecture of modern paperless customs. They transform border control from an inherent friction point into an efficient, transparent, and predictable hub for data exchange and value creation. This ensures that the logistical speed gained from advanced hardware infrastructure (like 5G and IoT) is not lost at the final administrative stage, thereby truly realizing an end-to-end revolution in trade facilitation.

Blockchain, or Distributed Ledger Technology (DLT), represents a transformative innovation for global commerce by directly addressing two fundamental and persistent challenges in cross-border trade: trust and traceability. By providing a decentralized, immutable, and transparent ledger, blockchain creates a shared source of truth among disparate and often distrustful parties – exporters, importers, logistics providers, banks, and regulators. Its application is not merely incremental but revolutionary, reshaping long-established processes across three primary dimensions:

1. Supply Chain Provenance and Compliance

A blockchain ledger can immutably and sequentially record every critical event in a product's lifecycle, from raw material extraction to the end consumer. Each step – harvesting, processing, certification, manufacturing, shipping, and customs clearance – is

timestamped and cryptographically secured, creating an auditable digital history. For instance, a shipment of Malaysian palm oil or Ethiopian coffee can have its precise geographic origin, farming practices, processing steps, factory conditions, and quality certifications (e.g., organic, fair trade) permanently logged. This provides all supply chain participants and end-buyers with verifiable, tamper-proof proof of sustainability, ethical sourcing, or specific standards like halal or kosher compliance. In developed markets, where consumer and regulatory demands for transparency are increasingly stringent [22, 13], blockchain-enabled provenance is becoming a powerful tool for brand differentiation, risk mitigation, and compliance with laws such as the EU's deforestation regulations or the U.S. Uyghur Forced Labor Prevention Act.

2. Smart Contracts for Trade Finance and Payment Automation

Blockchain enables "smart contracts"—self-executing agreements where the contractual terms are directly written into code and automatically enforced. This capability is poised to overhaul traditional trade finance, which is notoriously slow, paper-intensive, and prone to fraud. A classic example is the automation of a letter of credit (LC). The smart contract is programmed with conditions: once verified digital documents (like an electronic bill of lading, logged on the blockchain) are presented and IoT sensor or GPS data confirms the goods have arrived at the destination port, the contract automatically triggers an irrevocable payment from the buyer's bank to the seller. This reduces transaction processing time from 5-10 days to mere hours or even minutes, drastically cuts the risk of document fraud or duplication, and frees up significant working capital by accelerating settlement. Pioneering industry platforms such as we.trade (a European consortium-backed blockchain trade finance network) and Contour (a global network digitizing LCs) are operationalizing this model. Their success provides a scalable blueprint for adoption along complex, multi-jurisdictional trade corridors like China's Belt and Road Initiative (BRI), where efficiency gains are most needed [12, 25].

3. Cross-Border Data Validation and Document Integrity

Blockchain can establish a secure, unified framework for validating and sharing critical trade documentation across borders. Instead of relying on siloed, paper-based documents that are vulnerable to loss, alteration, or forgery, all authorized parties—

exporters, importers, customs agencies, port authorities—can access a permissioned blockchain to instantly verify the authenticity and status of digital certificates. These may include phytosanitary certificates, certificates of origin, and commercial invoices. In a landmark 2020 pilot between Singapore and Hong Kong, their respective customs authorities successfully used a shared blockchain platform to validate digital certificates of origin in real-time. This streamlined the clearance process, enhanced regulatory compliance, and demonstrated a practical model for interoperable digital trade ecosystems. By replacing physical checks with cryptographic verification, blockchain reduces administrative bottlenecks, curbs illicit trade, and lays the groundwork for seamless cross-border data exchange.

In conclusion, blockchain technology is moving beyond theoretical promise to practical application in global trade. By enhancing provenance, automating finance, and securing data validation, it offers a comprehensive solution to build trust, increase efficiency, and reduce costs in the intricate web of cross-border commerce. As pilots mature into production systems and international standards evolve, blockchain's role as a foundational pillar for the future of trade is becoming firmly established [16, 34].

Despite its transformative potential, the widespread implementation of blockchain in global trade—particularly across diverse regions like the Belt and Road Initiative (BRI) corridors—faces significant and multifaceted hurdles. These challenges extend beyond mere technological adoption to deeper legal, operational, and geopolitical barriers.

1. Legal and Regulatory Fragmentation

A primary obstacle is the lack of supportive and harmonized legal frameworks in many countries. Critical trade documents, such as electronic Bills of Lading (e-BLs), often lack the same legal standing as their paper counterparts under existing national commercial or maritime laws. Similarly, the recognition of digital signatures and smart contracts as legally binding instruments remains inconsistent. While some jurisdictions (like Singapore, the UAE, and certain U.S. states) have enacted progressive legislation (e.g., the UNCITRAL Model Law on Electronic Transferable Records), many BRI nations have yet to modernize their legal codes. This creates a patchwork of regulations where a transaction valid in one country may be unenforceable in another, stifling cross-border

digital trade flows and exposing participants to legal uncertainty.

2. Consortium Building and Interoperability Challenges

Establishing a functional cross-border blockchain network requires the formation of a consortium involving multiple stakeholders: competing banks, logistics giants, exporters, importers, and government authorities. Achieving unprecedented levels of cooperation and technical interoperability among these entities is a monumental task. Different players may advocate for different blockchain protocols (Hyperledger Fabric, Corda, Ethereum Enterprise), data standards, and privacy models. The governance of such a consortium—deciding who controls the network, validates transactions, sets rules, and bears costs—is highly complex and can lead to protracted negotiations. Furthermore, the need for seamless data exchange between distinct blockchain systems, or between blockchains and legacy IT infrastructure, remains a significant technical hurdle that demands universal standards not yet fully established [39,15].

3. Data Sovereignty and Political Concerns

The very feature that makes blockchain valuable—a shared, immutable ledger—clashes with national data sovereignty policies and cybersecurity regulations. Many governments mandate that certain types of trade or citizen data be stored physically within their borders. A decentralized ledger, where data is replicated across nodes in multiple countries, can be seen as violating these laws. Questions arise: Who owns the data on the chain? Which jurisdiction's laws apply in a dispute over a transaction validated by nodes across three different countries? Additionally, governments and corporations may be reluctant to share sensitive commercial or operational data on a platform accessible to their competitors, even with permissioned access. These political and strategic concerns can hinder the consensus needed for launching multinational platforms.

In summary, while the technological capability of blockchain is proven, its mass adoption in international trade is contingent on overcoming a triad of non-technical barriers: harmonizing legal recognition, forging collaborative governance among rivals, and navigating the sensitive geopolitics of data sovereignty. Progress will depend less on software development and more on diplomatic dialogue, regulatory modernization, and the painstaking construction of trust and shared standards among diverse global actors [15, 28].

2.3 The Digital Divide and Asymmetric Impacts

The benefits of the digital trade revolution are far from evenly distributed, threatening to create a new axis of global inequality. The persistent Digital Divide—the chasm separating those with robust access to digital infrastructure, skills, and capital from those without—generates a stark and potentially destabilizing asymmetry in impacts. Within Belt and Road Initiative (BRI) countries, this divide often manifests along familiar fault lines: between urban and rural communities, large corporations and small-to-medium enterprises (SMEs), and highly skilled and low-skilled workforces. Internationally, the gap widens between technologically advanced nations and those lacking foundational digital ecosystems. This asymmetry means that while digitally-enabled players harness blockchain, AI, and e-commerce for unprecedented efficiency and market access, marginalized groups and regions risk being further excluded. Consequently, rather than being a universal tide that lifts all boats, the digital transformation of trade could inadvertently cement existing disparities and create new forms of dependency, thereby undermining the inclusive development goals espoused by many BRI projects.

The Digital Divide within the context of the Belt and Road Initiative (BRI) is not monolithic; rather, it operates across three deeply interconnected and mutually reinforcing levels, each presenting distinct barriers to inclusive participation in the digital trade revolution [53, 35].

Table 10 compares leading and lagging BRI economies across five dimensions to quantify digital divide gaps, based on ITU, UNCTAD and industrial alliance data.

Table 10 The Digital Divide Among BRI Countries (2024)

Divide Dimension	Leading Countries	Lagging Countries	Gap
Internet Penetration	Singapore (99%), UAE (98%)	Afghanistan (24%), Yemen (18%)	>70 percentage points
5G Coverage	85%–99%	<10%	>80 percentage points

Digital Skills Index	0.85–0.92	0.21–0.35	3–4 times difference
Data Governance Capacity	Complete system	No relevant laws	10+ years gap
Cybersecurity Capability	Defense success >85%	<40%	Double gap

Data sources: ITU (2024); UNCTAD (2024); China Cybersecurity Industry Alliance

1. Infrastructure Access Divide: The Foundational Barrier

This represents the most fundamental layer of exclusion. While technologically advanced BRI partners such as China and the Gulf states boast near-universal, high-speed 4G/5G coverage and robust fiber-optic backbones, vast regions across other BRI corridors are characterized by a profound connectivity deficit. In many parts of Central Asia, South Asia, and Africa, internet access remains limited, prohibitively expensive, and notoriously unreliable, with rural areas suffering the most severe isolation. For instance, Afghanistan’s internet penetration rate lingers around a quarter of the population, while in remote provinces of countries like Laos or Myanmar, connectivity is virtually non-existent. This foundational gap directly precludes engagement with digital platforms, blockchain-based systems, and real-time supply chain tools, rendering entire populations and geographic zones invisible to the modern digital trade ecosystem. Without this basic physical infrastructure—the cables, towers, and data centers—discussions of digital integration remain purely theoretical [15, 38].

2. Skills and Adoption Divide (Human Capital Gap): Beyond Mere Connectivity

Possessing a digital device does not equate to the capability to harness it for complex international commerce. This second layer of the divide pertains to critical deficits in human capital. It encompasses not only basic digital literacy but also the advanced competencies required to thrive in global e-commerce: proficiency in platform algorithms, digital marketing and branding, financial literacy for navigating cross-border payment gateways (e.g., PayPal, Stripe), and an understanding of international logistics, export controls, and digital customs procedures. Language barriers further compound this issue, with English dominance on major global platforms locking out non-English

speaking entrepreneurs. A skilled artisan in rural Cambodia may own a smartphone but likely lacks the know-how to create a search-optimized global storefront, manage secure digital transactions, or leverage social media for international customer engagement. This skills gap transforms a tool of potential empowerment into one of continued marginalization.

3. Regulatory and Institutional Divide: The Invisible Architecture of Trust

Advanced digital trade requires more than wires and skills; it depends on a trustworthy and predictable legal-institutional environment. Many developing BRI nations grapple with outdated, fragmented, or non-existent regulatory frameworks for the digital age. Key gaps include comprehensive data protection and privacy laws, modern e-commerce regulations that define consumer rights and seller liabilities, clear standards for digital signatures and electronic contracts, and robust cybersecurity protocols. The absence of such frameworks creates a climate of legal uncertainty that deters foreign investment, stifles local innovation, and makes businesses wary of digital engagement. Furthermore, the lack of independent, efficient institutions for digital dispute resolution—such as trusted online arbitration or specialized e-commerce courts—erodes the fundamental trust necessary for transactions, especially cross-border ones. This institutional vacuum means that even when infrastructure and skills are present, the risk and complexity of operating digitally remain prohibitively high [33, 17].

In summary, these three divides—infrastructural, human, and institutional do not operate in isolation. Poor connectivity inhibits skill development; a lack of skilled users reduces demand for better infrastructure; and weak institutions fail to create the environment needed to justify investments in both connectivity and education. Addressing the Digital Divide, therefore, requires a holistic, synchronized strategy that tackles all three dimensions simultaneously to prevent the digital trade revolution from becoming an engine of further divergence within the BRI.

The asymmetric development of the digital economy, characterized by the pronounced Digital Divide across Belt and Road Initiative (BRI) partners, presents significant risks that extend beyond mere gaps in access. If left unaddressed, this imbalance can entrench systemic inequalities and catalyze several interconnected negative

outcomes, undermining the long-term sustainability and inclusivity of the BRI's vision for shared prosperity.

1. Reinforcement of Core-Periphery Dynamics in the Digital Age

The digital revolution threatens to forge a contemporary and potent form of techno-economic dependency, crystallizing a new "core-periphery" structure within the BRI network. Technologically advanced nations such as China, Singapore, and the UAE are poised to consolidate their positions as digital cores or "platform hubs." They export not just goods, but the foundational digital infrastructure itself: cloud services, e-commerce platforms, fintech applications, and the underlying technical standards and protocols. Conversely, less developed BRI partners risk being permanently relegated to the digital periphery. Their role may be confined to consuming imported digital services, providing streams of raw, unstructured data (often without capturing its value), and remaining suppliers of low-margin physical commodities [16,41]. This dynamic threatens to stifle local innovation and industrial upgrading in peripheral nations, effectively digitally locking them into the lower rungs of global value chains. The result is a potential "digital middle-income trap," where countries are connected enough to participate but lack the sovereign capacity to compete or capture the high-value segments of the knowledge economy.

2. Intensified Marginalization of Vulnerable Groups and Sectors Domestically

The disruptive force of digitalization does not impact all segments of society equally within nations. It carries a high risk of exacerbating pre-existing social and economic fissures. Micro, Small, and Medium Enterprises (MSMEs), which form the backbone of many BRI economies, often lack the capital, technical expertise, and risk appetite for digital transformation, leaving them vulnerable to being outcompeted by digitally-native firms or larger corporations. Gender disparities are likely to be amplified, as women entrepreneurs—who frequently face greater barriers to finance, education, and network access—may experience a widening digital literacy gap. Furthermore, traditional labor-intensive sectors such as smallholder agriculture, conventional retail, and informal logistics face existential threats. Job displacement in these sectors may occur rapidly due to automation and platformization, while new employment opportunities in the digital

sector (e.g., data science, AI maintenance) often require skill sets that the displaced workforce does not possess. This mismatch can lead to structural unemployment and heightened social tension, without a robust social safety net or massive reskilling initiative in place [46, 23].

3. Fragmentation of the Digital Trade and Governance Space

In response to capability gaps and security concerns, countries may adopt divergent and inward-looking policies, leading to the Balkanization of the digital trade ecosystem. The lack of harmonized cross-border regulations for data flows, consumer protection, cybersecurity, and digital taxation creates uncertainty. As a defensive measure, many governments are increasingly implementing strict data localization laws, mandating that data generated within their borders be stored on domestic servers. While framed as issues of national security, privacy, or economic protectionism, these policies essentially erect digital trade barriers. They increase costs for businesses that operate regionally, stifle the free flow of information that is the lifeblood of the digital economy, and prevent the emergence of seamless, integrated regional digital markets. This regulatory fragmentation runs directly counter to the borderless, interconnected ideal of digital trade and can result in a splintered internet ("Splinternet") along BRI corridors, where technological systems and data regimes are incompatible, ultimately reducing the collective potential for innovation and growth [18,19].

In conclusion, the asymmetric impact of the digital economy is not a passive outcome but an active force that can reshape geopolitical and socio-economic landscapes. Without proactive, cooperative, and inclusive policy interventions aimed at bridging the divides in infrastructure, human capital, and governance, the digital transformation within the BRI risks entrenching old inequalities in new forms and fragmenting the very connectivity it seeks to enhance.

Addressing the digital divide is not merely a developmental concern but a critical prerequisite for achieving the inclusive, sustainable trade goals of the Belt and Road Initiative (BRI). Left unattended, this divide could fundamentally undermine the project's foundational promise of shared prosperity, transforming digital tools from instruments of convergence into drivers of disparity. Effective mitigation strategies must therefore be

holistic, multi-stakeholder, and concurrently address the infrastructural, human, and regulatory dimensions of the challenge.

Table 11 lists five policy instruments for narrowing digital divide, with quantified expected outcomes and corresponding practical cases, sourced from ADB and BRI Digital Cooperation Report.

1. Catalyzing Infrastructure through Public-Private Partnerships (PPPs)

Bridging the foundational infrastructure gap requires innovative financing and deployment models. Governments should actively structure Public-Private Partnerships to de-risk and incentivize private-sector investment in "last-mile" connectivity for rural and remote regions. This could involve subsidies for network roll-out in underserved areas, shared infrastructure agreements to reduce costs, or the utilization of universal service funds. Simultaneously, investment in complementary infrastructure—such as reliable electricity grids and data centers—is essential to ensure that connectivity is functional and sustainable [59,33].

Table 11 – Policy Effect of Bridging the Digital Divide

Policy Tool	Expected Effect	Success Case
PPP for Infrastructure	Penetration ↑ 15%–20%	Pakistan, Laos
Digital Skills Training	SME export ↑ 35%–50%	ASEAN countries
Regulatory Harmonization	Compliance cost ↓ 25%–30%	China-Singapore
Local Platform Support	Local market share ↑ 40%	Southeast Asia
Cybersecurity Assistance	Risk incidence ↓ 23%	Central Asia

Data sources: ADB (2025); BRI Digital Cooperation Report (2025)

2. Implementing Massive Digital Skills and Literacy Campaigns

Access to technology is futile without the capability to use it productively. A large-scale, targeted upskilling initiative is imperative. This entails integrating digital literacy,

basic cybersecurity, and data fluency into national education curricula from an early stage. Furthermore, dedicated vocational and lifelong learning programs must be developed, specifically tailored for key groups such as women entrepreneurs, MSME owners, farmers, and workers in transitioning industries. Training should cover practical competencies: utilizing e-commerce platforms, managing digital finances, engaging in digital marketing, and understanding online export procedures.

3. Harmonizing Regulations via Regional Dialogue and Cooperation

To prevent regulatory fragmentation from stifling digital trade, BRI countries must prioritize harmonization and mutual recognition of key legal frameworks. This can be achieved through sustained regional dialogues and working groups aimed at aligning—or at least making interoperable—regulations on e-commerce, electronic transactions, data protection, cross-border data flows, and consumer rights. The goal is to establish common principles and standards that lower compliance costs, build trust, and facilitate seamless digital transactions across borders, moving towards a "Digital BRI" common market [18, 42].

4. Fostering Indigenous Digital Ecosystems through Localized Platforms

Reducing dependency on external digital giants requires nurturing homegrown innovation. Support should be directed toward the development of localized digital platforms and solutions—including e-marketplaces, logistics apps, and fintech services—operating in local languages and tailored to local payment habits, cultural contexts, and business practices. This empowers local entrepreneurs, keeps more value within regional economies, and builds resilient digital ecosystems from the ground up. Such platforms can serve as springboards for MSMEs to engage in regional trade before scaling globally.

In conclusion, the digital economy embodies a profound duality within the BRI context. It presents a powerful suite of tools capable of demolishing traditional trade barriers related to information asymmetry, communication delays, and cumbersome border procedures. Yet, it simultaneously erects new, potentially more persistent and exclusionary barriers rooted in asymmetric infrastructure, divergent human capital, and fragmented regulatory regimes. For the Belt and Road Initiative to genuinely foster inclusive and sustainable trade growth, a dual-track strategy is non-negotiable. It must aggressively

promote the deployment and adoption of digital facilitating technologies while, with equal vigor, implement concerted, cooperative policies specifically designed to bridge the profound digital divide [31,13]. The success of the BRI in the 21st century will be measured not only by the kilometers of fiber optic cable laid or the volume of digital trade conducted, but by its capacity to ensure that these channels of prosperity are accessible to all participants, leaving no nation and no community behind in the digital era.

Chapter 3 Policy Coordination and Regulatory Challenges

3.1 Harmonizing Data Governance Frameworks

Data, as the core production factor of the digital economy, is known as the "oil" of the digital era. Its efficient and orderly cross-border flow is a prerequisite for the development of BRI digital trade. However, the data governance frameworks of BRI countries are highly fragmented, with huge differences in data sovereignty concepts, data protection laws, and cross-border data flow rules, which has become a fundamental obstacle to policy coordination in the BRI digital trade field.

At present, BRI countries have formed three distinct data governance models based on their own national conditions and development needs, leading to serious incompatibility in regional data governance systems. The first is the open data flow model represented by developed economies such as Singapore and South Korea. These countries have sound digital infrastructure and legal systems, advocating for the free cross-border flow of non-sensitive data to promote the development of digital trade and cross-border industrial cooperation. Singapore's Personal Data Protection Act (PDPA) focuses on balancing data protection and data flow, allowing cross-border data transmission as long as it meets the principle of adequate protection, which has made Singapore an important digital trade hub in Southeast Asia. The second is the strict data localization model adopted by emerging economies such as Indonesia, Vietnam, and Kazakhstan [34, 35]. For the purpose of safeguarding national data sovereignty and information security, these countries clearly require that important data generated within their borders must be stored locally, and cross-border data flows need to go through strict government review and approval procedures. For example, Indonesia's Minister of Communication and Informatics has stipulated that cross-border e-commerce platforms operating in the country must store user personal data and transaction data in local data centers, otherwise they will face fines of up to 2% of their annual global revenue. The third is the balanced governance model represented by China, which adheres to the principle of data sovereignty, implements classified and graded management of data, and allows cross-border data flows

under the premise of ensuring security. China’s Data Security Law and Personal Information Protection Law have established a systematic data governance system, clearly defining the scope of important data and core data, and setting up a cross-border data flow review mechanism to balance security and development [52, 36].

Table 12 sorts three mainstream data governance modes of BRI nations with representative economies and regulatory principles, based on UNCTAD 2024 data.

Table 12 – Data Governance Models among BRI Countries

Governance Model	Representative Countries	Core Regulatory Principle
Open data flow	Singapore, South Korea	Free cross-border flow of non-sensitive data
Strict data localization	Indonesia, Vietnam, Kazakhstan	Local storage, government review
Balanced governance	China	Classified management, secure flow

Data Source: UNCTAD, 2024.

According to the 2024 Global Data Governance Report released by the United Nations Conference on Trade and Development (UNCTAD), more than 70% of BRI countries have formulated independent data protection and cross-border data flow regulations, but only 12% of countries have reached bilateral or multilateral data governance coordination agreements, and the degree of policy alignment is extremely low [43,25]. This fragmented governance pattern has greatly increased the compliance costs of enterprises engaged in BRI digital trade. A survey conducted by the International Chamber of Commerce (ICC) in 2025 shows that multinational enterprises operating in multiple BRI countries need to spend an average of 18% of their digital trade revenue on complying with different national data governance regulations, and small and medium-sized enterprises (SMEs) even bear a compliance cost ratio of up to 32%, which seriously weakens the cost advantage of BRI digital trade mentioned in Chapter 1 [21, 18].

The coordination of data governance frameworks among BRI countries faces three core conflicts that are difficult to reconcile in the short term. First, the conflict between data sovereignty and cross-border data flow. Most BRI countries, especially developing countries, regard data sovereignty as an important part of national sovereignty and are wary of unrestricted cross-border data flows, worrying that important national data and user information will be illegally collected and used, threatening national security and public interests. However, the development of cross-border e-commerce, digital logistics, and supply chain finance under the BRI relies on the efficient flow of data across borders, and excessive data localization requirements will hinder the operation of digital trade platforms and the allocation of production factors [58, 14]. Second, the conflict between data protection standards and regulatory intensity. Developed BRI countries have strict and detailed data protection standards, with high penalties for violations, while developing countries have relatively loose data protection regulations and imperfect law enforcement mechanisms. For example, the EU's General Data Protection Regulation (GDPR), which is applicable to some BRI European countries, has a maximum penalty of 4% of global annual turnover for data violations, while some South Asian and African BRI countries have no clear penalty standards for data violations, leading to regulatory arbitrage and unfair competition among enterprises. Third, the conflict between technical standards and institutional docking. Different countries have different technical standards for data collection, storage, processing, and transmission, and there is a lack of unified data classification and grading standards and mutual recognition mechanisms for data certification. For example, the technical standards for cross-border e-commerce transaction data and logistics data between China and Central Asian countries are not fully compatible, resulting in repeated data verification and low circulation efficiency, which offsets the efficiency improvement brought by digital technology Practical Explorations for Harmonizing Data Governance Frameworks [47,17].

In response to the fragmentation of data governance, BRI countries have carried out a series of practical explorations in recent years, trying to build a coordinated and unified regional data governance system. On the bilateral level, China has signed data security and cross-border data flow cooperation memorandums with more than 20 BRI countries

including Singapore, Malaysia, and Saudi Arabia, establishing a data governance consultation mechanism and promoting the mutual recognition of data protection certification [19,42]. For example, the China-Singapore Digital Economy Cooperation Agreement signed in 2024 has realized the mutual recognition of personal data protection certification and the safe cross-border flow of non-sensitive data in cross-border e-commerce scenarios, reducing the compliance cost of enterprises in the two countries by 27%. On the multilateral level, under the framework of the Shanghai Cooperation Organization (SCO) and the Association of Southeast Asian Nations (ASEAN), BRI countries have launched regional data governance cooperation initiatives. The ASEAN Digital Data Governance Framework adopted in 2023 aims to promote the coordination of data protection laws among member states and build a regional cross-border data flow corridor, which has achieved preliminary results in the fields of cross-border e-commerce and digital finance.

In addition, the "Global Initiative on Data Security" proposed by China provides a new path for the coordination of BRI data governance. The initiative advocates respecting the data sovereignty of all countries, opposing the use of data to interfere in other countries' internal affairs, and promoting the formulation of fair and reasonable global data governance rules. By 2025, more than 30 BRI countries have expressed support for this initiative, and jointly carried out pilot projects of cross-border data flow in the fields of digital logistics and smart cities. However, due to the differences in national interests and institutional environments, the coordination of data governance frameworks among BRI countries is still in the initial stage, and a unified regional data governance system has not yet been formed, which requires long-term consultation and cooperation among all parties.

3.2 Cybersecurity Concerns and Cross-Border Data Flows

The rapid development of cross-border data flows has brought convenience to BRI digital trade, but also triggered increasingly prominent cybersecurity risks. The BRI region covers a wide range of countries with uneven levels of digital infrastructure and cybersecurity capabilities, and cross-border data flows involve multiple links such as data transmission, storage, and processing, making it a key target for cyber attacks, data leakage, and other illegal activities. Cybersecurity risks not only threaten the legitimate rights and interests of enterprises and users but also affect the stability and security of BRI digital trade, becoming a major regulatory challenge that must be addressed in the process of policy coordination [27, 16].

According to the 2025 Cybersecurity Report for the Belt and Road Region released by the China Cybersecurity Industry Alliance, the number of cyber security incidents in BRI countries increased by 42% year-on-year in 2024, of which 68% were related to cross-border data flows, mainly concentrated in three types of risks [1,55].

Table 13 categorizes major cybersecurity risks of cross-border data flows in BRI, specifying their incidence scale and adverse impacts, with data from China Cybersecurity Industry Alliance (2025).

Table 13 Cybersecurity Risks in BRI Cross-Border Data Flows (2024)

Risk Type	Proportion / Scale	Impact
Data leakage and illegal trading	68% of incidents	Economic loss and trust damage
Cyberattacks (APT, ransomware)	Frequent	Platform downtime and service suspension
Cyber fraud and money laundering	About 80 billion USD/year	Regional financial risk
Annual growth of cyber incidents	42%	Increasing regional vulnerability

Data Source: China Cybersecurity Industry Alliance, 2025.

The first is data leakage and illegal trading risks. A large number of user personal information, enterprise transaction data, and even national important data are leaked during cross-border transmission and storage, and then illegally traded on the dark web. In 2024, the cross-border e-commerce data leakage incident in a Central Asian BRI country involved more than 5 million pieces of user personal information, causing direct economic losses of more than 200 million US dollars, and seriously damaging the trust of consumers in BRI digital trade. The second is cyber attack and sabotage risks. Hacker organizations and cybercriminals frequently launch advanced persistent threat (APT) attacks, ransomware attacks, and distributed denial of service (DDoS) attacks on cross-border e-commerce platforms, digital payment systems, and cross-border data transmission nodes. In 2024, a major digital payment platform serving BRI countries was attacked by ransomware, resulting in the suspension of cross-border payment services for 72 hours, affecting more than 100,000 SMEs' trade transactions. The third is network fraud and money laundering risks. Criminals use the anonymity and cross-border nature of digital trade and data flows to carry out cross-border online fraud, illegal fund transfers, and money laundering activities, disrupting the normal order of BRI trade. The International Monetary Fund (IMF) estimates that the scale of illegal capital flows through BRI digital trade channels reaches about 80 billion US dollars every year, bringing huge hidden dangers to regional financial security [20, 37].

The uneven cybersecurity capabilities among BRI countries are an important reason for the frequent occurrence of these risks. Developed BRI countries such as Singapore and the United Arab Emirates have complete cybersecurity systems, advanced technical equipment, and professional talent teams, with a cybersecurity risk defense success rate of over 85%. However, most developing and least developed countries in South Asia, Africa, and Central Asia have backward digital infrastructure, imperfect cybersecurity laws and regulations, and a serious shortage of cybersecurity professionals, with a cybersecurity risk defense success rate of less than 40%. These countries have become weak links in the cybersecurity of BRI cross-border data flows [44, 20], and their risks are easy to spread to the entire region through cross-border data flows, forming a "cybersecurity basin effect".

Regulatory Challenges in Balancing Cross-Border Data Flows and Cybersecurity

For BRI countries, regulating cross-border data flows to ensure cybersecurity while promoting the free flow of data to drive digital trade development is a complex regulatory dilemma, facing multiple practical challenges. First, the challenge of coordinating security and development goals. Overemphasis on cybersecurity and strict restrictions on cross-border data flows will inhibit the vitality of digital trade and offset the catalytic role of the digital economy in BRI trade; excessive relaxation of data flow supervision will lead to the spread of cybersecurity risks and threaten national and public interests. Many BRI countries are difficult to find a balance between the two, and there is a phenomenon of "one-sided emphasis on security or one-sided emphasis on development". Second, the challenge of cross-border regulatory cooperation and law enforcement [50, 27]. Cybersecurity incidents and data violations often span multiple countries, but BRI countries lack a unified cross-border cybersecurity regulatory mechanism and mutual assistance law enforcement system. When a cybersecurity incident occurs, it is difficult to realize the sharing of risk information, the traceability of incidents, and the joint handling of violations, resulting in low regulatory efficiency and difficulty in holding criminals accountable. For example, in the cross-border data leakage incident involving China and a Southeast Asian BRI country in 2024, due to the lack of a cross-border law enforcement cooperation mechanism, the case investigation and evidence collection lasted for more than 8 months, and the loss recovery rate was less than 30%. Third, the challenge of technical support and capacity building [42, 28]. Most developing BRI countries lack independent cybersecurity technology and core equipment, and rely heavily on foreign technical support, making it difficult to build an independent and controllable cybersecurity system. At the same time, the shortage of cybersecurity professionals is also prominent. According to UNCTAD statistics, the BRI region has a shortage of more than 1.2 million cybersecurity professionals, which seriously restricts the improvement of regional cybersecurity governance capabilities [43, 28]. Fourth, the challenge of unified regulatory standards and norms. There are big differences in cybersecurity regulatory standards, data security classification standards, and risk assessment standards among BRI countries, and there is no unified regional cybersecurity certification system. Enterprises need to adapt to different regulatory standards in different countries, which increases the

difficulty of regulatory compliance and the cost of risk prevention.

Paths to Address Cybersecurity Risks in Cross-Border Data Flows

To address the cybersecurity challenges brought by cross-border data flows, BRI countries need to strengthen policy coordination and build a multi-level, collaborative cybersecurity governance system. First, establish a cross-border cybersecurity information sharing and early warning mechanism. Under the BRI framework, set up a regional cybersecurity cooperation center to realize the sharing of cyber threat information, risk early warning, and incident handling experience, and improve the ability to jointly respond to cross-border cybersecurity risks. China has launched a cybersecurity information sharing platform with 15 BRI countries in Central Asia and Southeast Asia, which has issued more than 300 early warning notices of cross-border cyber threats in 2024, effectively reducing the incidence of cybersecurity incidents by 23% [1, 58]. Second, strengthen cross-border regulatory cooperation and law enforcement mutual assistance. Sign bilateral and multilateral cybersecurity law enforcement cooperation agreements, clarify the division of responsibilities for cross-border data violation incidents, and promote the mutual recognition of regulatory standards and the joint handling of cases. For example, the China-ASEAN Cybersecurity Law Enforcement Cooperation Mechanism established in 2023 has realized the joint investigation and handling of cross-border cyber fraud and data leakage cases, and the case-solving efficiency has increased by 45%. Third, promote cybersecurity capacity building in developing countries. Through technical assistance, talent training, and infrastructure construction, help developing BRI countries improve their cybersecurity capabilities. China has carried out cybersecurity training courses in more than 30 BRI countries, trained more than 5,000 cybersecurity professionals, and assisted in building 12 national cybersecurity centers in countries such as Pakistan and Laos, effectively filling the cybersecurity gap in the region. Fourth, formulate unified regional cybersecurity and data security standards. Under the framework of the Digital Silk Road, promote the formulation of unified standards for data security classification, cross-border data flow risk assessment, and cybersecurity certification in the BRI region, and realize the standardization and regularization of cross-border data flow supervision [29, 51].

3.3 Role of Chinese Standards due to Digital Silk Road Initiatives

Against the background of fragmented global digital governance and conflicting standards, the Digital Silk Road initiative, as an important part of the BRI, has become a key force in promoting policy coordination and standard unification in the BRI digital trade field by relying on China's mature digital economy development experience and technical standards [2, 12]. Chinese digital standards, covering digital infrastructure, cross-border e-commerce, digital payment, and data security, have been widely promoted and applied in BRI countries, playing an important role in reducing trade costs, improving operational efficiency, and promoting regional digital integration.

The Connotation and Development of the Digital Silk Road Initiatives

The Digital Silk Road initiative was first proposed in 2015, aiming to build a digital connectivity corridor linking Asia, Europe, Africa and other BRI regions, focusing on cooperation in digital infrastructure construction, digital technology innovation, digital trade development, and digital governance coordination [2, 10]. It is an important extension of the BRI in the digital field and a core carrier for the export and practice of Chinese digital standards. After years of development, the Digital Silk Road has formed a multi-level cooperation system, covering four major fields: first, digital infrastructure cooperation, including the construction of cross-border optical cables, 5G communication networks, data centers, and satellite navigation systems; second, digital industry cooperation, including cross-border e-commerce, digital finance, smart logistics, and smart cities; third, digital technology cooperation, including big data, cloud computing, blockchain, and artificial intelligence; fourth, digital governance cooperation, including data security, cybersecurity, and digital trade rule coordination.

According to the 2025 Digital Silk Road Development Report released by the Ministry of Commerce of China, by the end of 2024, China has signed more than 150 Digital Silk Road cooperation documents with 58 BRI countries, covering 80% of the BRI core countries [1, 62]. The cumulative investment in digital infrastructure cooperation projects has exceeded 320 billion US dollars, and more than 200 cross-border digital cooperation projects have been implemented, effectively promoting the interconnection of

digital economy among BRI countries. The Digital Silk Road adheres to the concept of "consultation, joint construction and sharing" and respects the development paths and core demands of BRI countries, promoting Chinese digital standards in a flexible and diversified manner, rather than imposing them, which has won wide recognition and support from most BRI countries [2, 15].

Table 14 displays the overall scale of BRI digital cooperation from six dimensions, with statistics sourced from China’s Ministry of Commerce (2025).

Table 14 – Digital Silk Road Cooperation Achievements (End of 2024)

Cooperation Item	Scale
Number of partner countries	58
Signed cooperation documents	Over 150
Cumulative infrastructure investment	Over 320 billion USD
Cross-border digital cooperation projects	Over 200
Countries with 5G deployment	35
Countries with digital payment access	42

Data Source: Ministry of Commerce of China, 2025.

Practice and Application of Chinese Digital Standards in BRI Countries

Chinese digital standards have been comprehensively applied in the construction of the Digital Silk Road, covering multiple key links of BRI digital trade, and effectively solving the problems of inconsistent standards and poor connectivity in regional digital trade.

In the field of digital infrastructure, Chinese 5G communication standards, cross-border optical cable construction standards, and Beidou satellite navigation standards have been widely used [1,63]. Huawei and ZTE, as Chinese leading communication enterprises, have built 5G networks in 35 BRI countries, adopting China’s 5G technical standards,

covering more than 600 million users, and providing stable and high-speed network [1, 64] support for cross-border data flows and digital trade. The cross-border optical cable projects jointly built by China with Pakistan, Myanmar, and other countries have adopted Chinese optical cable construction and maintenance standards, shortening the cross-border data transmission delay by 40% and reducing the cost of cross-border data transmission by 35%. The Beidou Navigation Satellite Syst.

Table 15 quantifies six major achievements of Digital Silk Road by late 2024, with official data from China’s Ministry of Commerce.

Table 15 – Digital Silk Road Cooperation Achievements (End of 2024)

Cooperation Item	Scale
Number of partner countries	58
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Cumulative infrastructure investment	Over 320 billion USD
Cross-border digital cooperation projects	Over 200
Countries with 5G deployment	35
Countries with digital payment access	42

Data Source: Ministry of Commerce of China, 2025.

The enterprise has provided positioning and navigation services for cross-border logistics, transportation, and smart ports in 28 BRI countries [30, 48], improving the efficiency of cross-border logistics operations by 22%, which is closely linked to the digital logistics model of the China-Europe Railway Express mentioned in Chapter 1.

In the field of cross-border e-commerce and digital payment, Chinese cross-border e-commerce platform operation standards, digital payment technical standards, and smart logistics standards have become important benchmarks for BRI countries. Cross-border e-

commerce platforms such as AliExpress and JD.com have promoted Chinese cross-border e-commerce operation standards in BRI countries, including product display, transaction settlement, after-sales service, and logistics tracking, which have standardized the development of cross-border e-commerce in the region. Digital payment standards represented by Alipay and UnionPay have been connected with local payment systems in 42 BRI countries [7, 12], realizing the integration of cross-border payment services. In 2024, the transaction volume of cross-border digital payments adopting Chinese standards in BRI countries reached 3.8 trillion US dollars, a year-on-year increase of 38%, effectively solving the problem of inconvenient cross-border payment in BRI trade. In addition, Chinese smart logistics standards such as Cainiao have built overseas warehouses and intelligent logistics systems in BRI countries, optimizing the cross-border logistics process and shortening the logistics cycle of BRI digital trade, which has been verified in practice in Southeast Asia and Central Asia [32, 25].

In the field of data security and digital governance, Chinese data classification and grading standards, cybersecurity protection standards, and cross-border data flow review standards have provided reference for BRI countries. Many developing BRI countries lack experience in data governance, and China's data security and personal information protection standards, which balance security and development, have become an important reference for these countries to formulate relevant laws and regulations. For example, Laos, Cambodia, and other countries have drawn on China's data classification and grading standards to formulate their own national data security regulations, realizing the standardized management of cross-border data flows.

Contributions and Challenges of Chinese Standards in BRI Digital Trade

The promotion and application of Chinese digital standards under the framework of the Digital Silk Road have made important contributions to the development of BRI digital trade and policy coordination. First, reducing the cost of digital trade. Unified Chinese standards have eliminated the technical barriers and compliance costs caused by inconsistent standards among countries. According to the World Bank's 2024 research, the application of Chinese digital standards in BRI countries has reduced the technical connection cost of cross-border digital trade by 30% and the regulatory compliance cost

by 25% [48,22], effectively releasing the cost advantage of BRI digital trade. Second, promoting regional digital integration. Chinese standards have realized the interconnection of digital infrastructure, platforms, and services among BRI countries, promoted the free flow of data, technology, and capital, and accelerated the construction of a regional digital trade market, which is in line with the BRI's goal of "unimpeded trade" emphasized in Chapter 1. Third, helping developing countries catch up in the digital economy. Most BRI developing countries have a weak digital foundation, and the application of Chinese mature standards has helped them skip the stage of independent research and development and standard exploration, quickly build a digital economic system, and narrow the digital divide with developed countries. For example, in Central Asian countries, with the help of Chinese digital infrastructure and e-commerce standards, local SMEs have rapidly entered the international market, realizing inclusive growth of trade [35,45].

At the same time, the promotion of Chinese standards in the BRI region also faces certain challenges. First, the conflict with international existing standards. Some Western countries and international organizations have formed relatively mature digital standards, and there are technical and institutional differences between Chinese standards and these standards, leading to certain obstacles in the process of mutual recognition and integration. Second, the impact of geopolitical factors. Individual countries hold a biased attitude towards the promotion of Chinese standards, exaggerating the so-called "security risks", which affects the recognition and application of Chinese standards in some BRI countries. Third, the need for localized adaptation of standards. Chinese standards are formulated based on China's national conditions, and need to be adjusted and adapted according to the economic, legal, and cultural characteristics of different BRI countries to enhance their adaptability and acceptance [40, 29].

In response to these challenges, China has always adhered to the principle of openness and inclusiveness in the promotion of standards under the Digital Silk Road framework, actively promoting the mutual recognition and integration of Chinese standards with international standards and regional standards, and strengthening localized research and development and adaptation cooperation. In the future, with the deepening of

the Digital Silk Road construction [1, 66], Chinese digital standards will play a greater role in promoting policy coordination and regulatory unification of BRI digital trade.

Conclusion

This study systematically explores the multidimensional internal mechanisms, practical effects, existing obstacles and optimization paths of digital economy development on international trade cooperation across Belt and Road Initiative (BRI) participating economies. In the context of global digital transformation and deepening regional economic integration, the digital economy has gradually become a core driving force reshaping international trade patterns and reconstructing cross-border industrial cooperation systems. Fundamentally, the digital economy exerts profound and transformative positive influences on BRI trade activities through four dominant operational channels, including transaction cost reduction, trade efficiency enhancement, industrial and trade structure optimization, and inclusive trade growth. Specifically, digital technologies such as big data, cloud computing, artificial intelligence and cross-border digital platforms effectively reduce information asymmetry, intermediate transaction expenses, logistics supervision costs and institutional trade barriers in cross-border business activities. These technological advances significantly expand the bilateral and multilateral trade scale among BRI countries, improve the overall operational and resource allocation efficiency of regional trade markets, and accelerate the transformation and upgrading of traditional trade structures toward high-value-added, technology-driven and service-oriented trade models.

In recent years, driven by global digitalization trends, BRI economies have achieved remarkable progress in digital infrastructure deployment, cross-border e-commerce popularization, digital payment system innovation and inclusive digital financial services. Digital trade has maintained a steady growth momentum and gradually become a new growth engine for regional economic and trade cooperation. However, due to huge differences in economic foundation, technological innovation capacity, digital construction level and institutional environment among participating countries, a severe and widening digital divide still exists within the BRI region. The penetration effect of digital economy on trade development presents obvious heterogeneous characteristics, that is, economies with mature digital foundations can gain greater trade dividends from digital

transformation, while underdeveloped regions face insufficient digital empowerment and relatively lagging trade upgrading effects.

In practice, a series of prominent restrictive factors continue to hinder the full release of digital trade dividends and constrain the high-quality development of BRI digital trade cooperation. The main constraints include unbalanced and inadequate cross-border digital infrastructure construction, persistent regional digital resource gaps, fragmented cross-border data governance mechanisms and inconsistent data supervision rules across jurisdictions, increasingly complex cross-border cybersecurity and data privacy risks, as well as the lack of unified and internationally compatible digital trade standards, certification systems and regulatory frameworks. These institutional and technical bottlenecks not only restrict the free flow and efficient utilization of cross-border data elements, but also impede the deep integration of digital technology and real trade businesses.

In response to the above challenges, targeted and systematic optimization strategies are proposed to promote the inclusive, secure and high-quality development of digital trade in the BRI region. It is necessary for all participating countries to strengthen cross-border digital connectivity and infrastructure interoperability, bridge regional digital development gaps through coordinated investment and technical assistance, promote multi-party negotiation and coordination of cross-border digital trade rules, build a unified, standardized and risk-controllable cross-border data security governance system, and accelerate the mutual recognition and international alignment of digital trade technical standards, supervision systems and service specifications. Through multi-dimensional cooperation in infrastructure, rules, security and standards, the region can effectively eliminate institutional and technical barriers to digital trade.

Furthermore, this research makes certain theoretical and marginal contributions to the existing trade research system. By incorporating data elements, which are regarded as the key new production factors in the digital era, into the traditional international trade theoretical and empirical analysis framework, this study effectively supplements and expands the classical trade theory applicable to digital economic scenarios. It systematically reveals the heterogeneous influence mechanism of digital economy on trade

growth in countries at different development stages and comprehensively sorts out the institutional dilemmas and regulatory challenges facing current Digital Silk Road construction. The research conclusions provide solid theoretical support, empirical evidence and feasible practical references for promoting the high-quality construction of the Digital Silk Road, deepening inclusive trade cooperation among BRI countries, and realizing sustainable and high-level development of regional international trade in the digital era.

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