Open Access Library Journal
2025, Volume 12, e14566
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Digital Empowerment and Geopolitical Adjustment: A New Path and Practical Innovation for High Quality Development of China Europe Railway Express

Dengheng Zheng, Zixuan Hu, Kuan Wang, Qi Liu, Zhengqian Pang, Huibing Cheng*

Guangzhou Railway Polytechnic, Guangzhou, China
Email: *chbgzrp2022@163.com

How to cite this paper: Zheng, D.H., Hu, Z.X., Wang, K., Liu, Q., Pang, Z.Q. and Cheng, H.B. (2025) Digital Empowerment and Geopolitical Adjustment: A New Path and Practical Innovation for High Quality Development of China Europe Railway Express. *Open Access Library Journal*, **12**: e14566.
https://doi.org/10.4236/oalib.1114566

Received: November 7, 2025
Accepted: November 30, 2025
Published: December 3, 2025

Abstract

As the core logistics carrier of the "the Belt and Road" initiative, China Europe Express has entered a critical period of quality improvement and efficiency optimization from the initial stage of channel construction. As of June 2025, its cumulative operating volume has exceeded 110,000 trains, with a cargo value of over 450 billion US dollars, covering more than 300 cities in over 40 countries on the Eurasian continent, becoming a "steel camel caravan" that stabilizes the global supply chain. However, multiple challenges such as barriers to entry caused by geopolitical games, inefficient coordination due to the digital divide, and resource depletion caused by regional competition have constrained the transformation of trains from "accumulation of quantity" to "leap of quality". This article is based on the analysis framework of "digital empowerment-geopolitical adjustment", and combines typical cases such as Shijiazhuang Land Port Multi Product Collection and Zhengzhou Digital Intelligence Innovation R&D Center to systematically explore the coupling path between digital transformation and geopolitical risk response. Research has found that the application of digital technology can improve the efficiency of train operations by more than 30% (e.g., Xi'an International Land Port has improved train operation efficiency by nearly 50% compared to the initial stage through digital scheduling), while multilateral coordination mechanisms can effectively reduce the clearance costs caused by geopolitical barriers; The coordinated promotion of the two is the key to solving traditional problems such as insufficient return goods, high transportation costs, and subsidy dependence. Finally, from the three dimensions of technological innovation, mechanism construction, and industrial integration, it is proposed to build a high-quality development system of "digital drive + geographical adaptation + industrial link-

age", providing theoretical support and practical reference for the sustainable operation of China Europe railway express and the interconnection of Asia Europe trade.

Subject Areas

Transportation Engineering

Keywords

China Europe Railway Express, Digital Transformation, Geopolitical Risk, High Quality Development, Supply Chain Resilience

1. Introduction

1.1. Research Background

Since the launch of the China Europe railway express (Xi'an) from Xi'an International Port Station in 2013, this railway corridor connecting Asia and Europe has achieved a leapfrog development. 128 cities within China have opened for operation, connecting 229 cities in 26 European countries and over 100 cities in 11 Asian countries, forming an overseas network pattern with three domestic channels in the west, center, and east, and three parallel lines in the north, center, and south. Against the backdrop of frequent disruptions in global supply chains and the rise of trade protectionism, China Europe railway express play an irreplaceable role in high-end manufacturing trade such as new energy vehicles and electronic and electrical products, thanks to their comparative advantage of "saving time and being cheaper than air freight". By 2024, the proportion of three types of high value-added goods has exceeded 60% [1].

But as the scale expands, deep-seated contradictions in development become increasingly prominent. On the one hand, the intensification of non-tariff barriers caused by geopolitical conflicts, coupled with the "triple shackles" of Polish border closures, Russian customs inspections, and EU enlargement reviews, has resulted in some trains being delayed for several months; On the other hand, the lack of digitalization has resulted in "information silos" intertwined with traditional problems such as regional disorderly competition and inconsistent infrastructure standards, which have prevented the full utilization of the efficiency advantages of train operations. In this context, how to break through collaborative bottlenecks through digital empowerment and resolve external risks through geopolitical adjustment has become the core proposition for achieving high-quality development of the China Europe railway express [2].

1.2. Research Significance

Theoretical significance: Existing research mostly focuses on a single dimension, or explores the impact of digitization on logistics efficiency, or analyzes the impact

of geopolitics on train operations, lacking systematic research on the synergistic effects of the two. This article constructs an integrated analysis framework of "digital empowerment-geo adaptation" to enrich the theoretical system of sustainable development of international logistics channels and provide a new perspective for interdisciplinary research on cross-border infrastructure construction.

Practical significance: Currently, the China Europe railway express is facing practical difficulties such as high return empty container rates, intense regional competition, and insufficient market-oriented operation capabilities. Some routes rely on government subsidies to maintain operation. The digital transformation path and geopolitical coordination mechanism proposed in the study can be directly applied to train operation practice, helping to reduce transportation costs, enhance cargo organization capabilities, promote the transformation of trains from policy driven to market driven, and provide practical solutions for trade facilitation in countries along the route.

1.3. Literature Review

Domestic and foreign scholars have conducted extensive research on the development status, problems, and countermeasures of the China Europe railway express. In terms of development effectiveness, scholars generally believe that the China Europe railway express has improved the efficiency of Asia Europe trade and enhanced the resilience of the global supply chain, especially demonstrating strong risk resistance during the epidemic. In the existing problem research, insufficient return goods, high transportation costs, inconsistent infrastructure standards, and disorderly regional competition are considered as the main limiting factors. Some studies have pointed out that government subsidy dependence leads to distorted market mechanisms, and the complex customs clearance procedures in countries along the route are key bottlenecks affecting operational efficiency.

In terms of exploring solutions, there are two main perspectives in existing research: one is the technology empowerment perspective, which emphasizes improving operational efficiency through optimizing route planning, simplifying customs clearance processes, and developing multimodal transport; The second perspective is institutional coordination, advocating the establishment of multilateral cooperation mechanisms, unified technical standards, and integration of line resources. In recent years, digital transformation has become a research hotspot, with cases such as the "one ticket system" for Zhengzhou trains and the smart port in Xi'an receiving widespread attention. However, research on how digital technology can help respond to geopolitical risks is still relatively weak. On the basis of existing research, this article focuses on analyzing the coupling effect of digitization and geopolitical adaptation, filling the gap in related research.

1.4. Research Ideas and Methods

Research Approach: Taking the core contradiction of high-quality development

of China Europe railway express as the starting point, this study first examines the current development status and dual challenges, and then constructs an analytical framework of "digital empowerment-geopolitical adjustment". Combining typical case studies, the study empirically analyzes the synergistic mechanism between the two, and finally proposes systematic development strategies [3].

Research method: Using literature review method, systematically sorting out relevant research results and policy documents at home and abroad; Using case analysis method, deeply analyze the innovative practices of typical cases such as Shijiazhuang Land Port and Zhengzhou Digital Intelligence R&D Center; By using data analysis methods and statistical data such as train operation volume, cargo value, and timeliness, the actual effectiveness of digitalization and geopolitical coordination can be quantitatively analyzed.

2. The Current Development Status and Dual Challenges of China Europe Railway Express

2.1. Development Status and Effectiveness

The scale continues to expand and the network continues to improve: In the first seven months of 2025, Shijiazhuang International Land Port will operate 629 China Europe railway express, a year-on-year increase of 150%, including 387 return trains, with a return to return ratio of 1:1.6, achieving a virtuous cycle of "heavy trains going and heavy trains returning". At the national level, the category of railway express has expanded to 53 categories and over 50,000 types of goods, successfully solving the safety problems of railway transportation for new energy vehicles and consumer lithium batteries, and enabling China's "new three types" of manufacturing to go global.

Service model innovation and operational efficiency improvement: Various regions have launched characteristic services. Zhengzhou has opened a "cross-border e-commerce special train" to achieve full traceability, Wuhan has trial operated a cold chain special train to transport European meat and dairy products, Shijiazhuang has pioneered multi product consolidation business and opened the "Huanghua Port-Shijiazhuang-Moscow" sea rail intermodal transportation route. The level of facilitation in customs clearance continues to improve, and measures such as "railway clearance" and "one order system" have reduced the transportation time from Xi'an to Duisburg from the initial 20 days to around 12 days [4].

The capacity expansion and supporting role of ports have been strengthened: five port stations including Alashankou, Khorgos and the rear passage have been expanded and reconstructed, and the new construction of the same port has been put into use. The single day transfer capacity of six ports has reached 184 trains, providing a solid guarantee for the expansion of the train scale. The Ordos Comprehensive Bonded Zone has significantly improved the efficiency of enterprise capital turnover and customs clearance through the "tax refund upon entry" policy.

2.2. The Persistence of Traditional Challenges

Imbalance between supply and demand and high costs: Although some routes have achieved a virtuous cycle, the problem of insufficient return goods has not been fundamentally solved. Factors such as the imbalance in import and export trade between China and Europe, and the lack of unified transportation standards among countries along the route have led to a high overall empty container rate. Compared with sea freight, the scale effect of railway express is insufficient, coupled with high transit fees and transportation costs in countries along the route, which restricts market competitiveness.

Regional competition and subsidy dependence: Chengdu, Chongqing, Xi'an and other five major cities account for 86% of the national operating volume, and the competition in the "Western Triangle" is particularly fierce. Some cities have expanded their radiation range to 1500 kilometers away in order to compete for goods, and are competing to lower prices, leading to market disorder. According to statistics, most trains rely on local government subsidies to maintain operation. Once the subsidies are cancelled, they will face the risk of suspension, and the market-oriented operation capability urgently needs to be improved [5].

Infrastructure and standard barriers: Some countries along the route have outdated railway infrastructure and inconsistent rail widths, which leads to time-consuming container reloading and affects operational efficiency. Water transportation dominates within Europe, and the railway transportation network lacks connectivity. In addition, the lack of uniformity in technical standards and safety regulations among countries has increased the complexity of cross regional transportation.

2.3. Digitization and New Geopolitical Challenges

The digital divide leads to inefficient collaboration: Cross border logistics involves multiple entities such as customs, railways, and freight forwarders, with inconsistent data formats and insufficient information sharing forming a "data chimney", resulting in difficulties in tracking goods and delayed scheduling responses. Some small and medium-sized logistics enterprises have a low level of digitalization, which makes it difficult to adapt to the needs of intelligent operation and restricts the overall coordination efficiency of trains.

Geopolitics triggers multiple risks: intensified geopolitical competition leads to an increase in non-tariff barriers, Poland closes border ports under the pretext of "security", causing 90% of trains to be stranded; Russia has extended the customs inspection time from 15 days to 60 days, significantly increasing the warehousing costs for enterprises; The EU's inclusion of ordinary goods in the "dual-use" list has expanded the scope of review, resulting in a large number of goods being seized and compliance costs significantly increasing [6].

The disconnect between technology application and risk prevention: Existing digital applications are mostly concentrated in the domestic segment, and there is insufficient data sharing in the overseas segment, making it difficult to cope with

changes in customs clearance policies caused by geopolitical risks. Some digital platforms lack risk warning functions and lag in responding to unexpected situations such as border closures and policy adjustments, leading to increased losses for enterprises [7].

3. The Core Dimensions of High-quality Development of China Europe Railway Express: Digital Empowerment and Geopolitical Adjustment

3.1. Digital Empowerment: A Technological Path to Breakthrough Collaborative Bottlenecks

Digital empowerment, through the integration and optimization of data elements, solves the problem of information asymmetry in cross-border logistics, and improves efficiency throughout the entire process from source organization, transportation scheduling to customs clearance and settlement. It is the core driving force for the high-quality development of China Europe railway express.

Intelligent scheduling improves operational efficiency: With the help of big data analysis for route optimization and capacity allocation, precise matching of cargo sources and cabins can be achieved. The Zhengzhou Smart Innovation R&D Center has established an intelligent allocation system by integrating data from multiple nodes such as customs, railways, and seaports, effectively improving the turnover rate of goods and the punctuality rate of trains. Xi'an International Land Port has improved train operation efficiency by nearly 50% compared to the initial stage through digital scheduling, fully leveraging the time advantage of railway transportation [8].

According to the operational data statistics of 20 key China Europe railway express routes nationwide, the average operation efficiency of routes applying digital technology has been improved by more than 30% compared with routes without digital transformation, mainly reflected in the shortening of transportation time, the increase of punctuality rate, and the reduction of empty container rate [8].

Breaking through information barriers through data sharing: Building a standardized data sharing platform to achieve information interconnection and intercommunication among various entities in cross-border logistics. The Zhengzhou train has achieved full traceability of goods through the "one order system" service system, solving the problem of information fragmentation in traditional models. The Xinjiang consolidation and transportation platform achieves efficient consolidation of different sources of goods through data integration, reducing transportation costs. This model has national promotion value [9].

Integration of business formats expands development space: The integration and development of digital new business formats such as "train + cross-border e-commerce" and "train + bonded warehousing" have broadened the source of goods channels. The Zhengzhou train relies on a digital supply chain collaboration platform to promote the integration of manufacturing, commerce, and logistics data, providing "door-to-door" services for cross-border e-commerce and

driving the growth of demand for high value-added goods transportation.

3.2. Geopolitical Adjustment: Institutional Guarantee for Resolving External Risks

Geopolitical adjustment, by establishing multilateral coordination mechanisms and optimizing cooperation models, reduces the uncertainty brought by geopolitics and creates a stable operating environment for the China Europe railway express, which is an important guarantee for high-quality development.

Multilateral coordination mechanism to reduce customs barriers: establish a normalized communication mechanism through intergovernmental negotiations, simplify customs clearance processes, and unify inspection standards. The countries along the China Europe railway express have reduced duplicate inspection links and shortened customs clearance time through cooperation models such as the "China Railway Express". Establishing an emergency coordination mechanism for sudden situations such as the closure of the Polish border can quickly adjust transportation routes and reduce the risk of detention [10].

Localized cooperation enhances supply stability: Establishing deep cooperation with logistics enterprises and traders in countries along the route, expanding local supply channels, and alleviating the problem of insufficient return goods. Shijiazhuang Land Port has established a two-way trade channel by importing Central Asian feed wheat flour and other commodities, providing a source of goods guarantee for the "heavy truck return". Localized operations can also reduce the impact of geopolitical changes and enhance supply chain resilience [11].

Rule docking enhances compliance level: promotes mutual recognition and docking of railway standards and safety regulations between China and countries along the railway line, and reduces technical barriers. By familiarizing themselves with compliance requirements such as the EU's "dual-use" list and strengthening the review of goods declaration, enterprises can effectively avoid the problem of goods being detained due to expanded scrutiny. Industry associations should establish compliance guidance mechanisms to help enterprises enhance their risk response capabilities.

3.3. The Coupling Effect of Digital Empowerment and Geopolitical Adjustment

Digital empowerment and geopolitical adjustment do not exist in isolation, and the coupling effect formed by the two can generate a development efficiency of $1 + 1 > 2$. Digitalization provides technical support for geopolitical coordination, achieves transparency in customs clearance processes through data sharing, and reduces uncertainty caused by human intervention; Geopolitical coordination creates an institutional environment for the application of digital technology, and the signing of multilateral data sharing agreements breaks down policy barriers to cross-border data flow [12].

The practice of Zhengzhou Smart Innovation R&D Center has confirmed this coupling effect: on the one hand, it establishes a "single system" for multimodal

transportation through digital means, and on the other hand, it relies on the China Europe Customs data exchange mechanism to achieve cross-border information interconnection, significantly improving the efficiency of the overseas section of the train. Through digital scheduling of sea rail intermodal routes and coordinated cooperation with customs of countries along the route, Shijiazhuang Land Port has not only reduced transportation costs but also avoided the geopolitical risks of a single channel, achieving a dual improvement in efficiency and safety.

4. Typical Case Analysis

4.1. Case 1: Shijiazhuang International Land Port-Multi Mode Integration and Geochannel Optimization

As the core hub of the China Europe railway express in the Beijing-Tianjin-Hebei region, Shijiazhuang International Land Port has achieved leapfrog development through model innovation and channel optimization. In the first seven months of 2025, 63,744 standard containers were shipped with a cargo weight of 778,500 tons, an increase of 127% and 207% respectively year-on-year, creating significant economies of scale.

Its innovative practices are mainly reflected in three aspects: firstly, it pioneered the multi product name consolidation business, broke the restrictions of source categories, effectively integrated dispersed sources, and improved container loading rates; Secondly, the opening of the "Huanghua Port-Shijiazhuang-Moscow" sea rail intermodal transportation line has achieved seamless connection between sea and land transportation, expanded the source of goods hinterland and transportation channels, and reduced dependence on a single land transportation channel; The third is to actively expand the source of return goods, transport Central Asian feed wheat flour and other commodities back to China, and build a two-way trade pattern, so that the return to return ratio can reach a benign level of 1:1.6.

The inspiration of this case lies in the innovation of multimodal transport mode, which can optimize the layout of geopolitical channels and reduce the geopolitical risks of a single channel; The digital management of source organization can effectively improve the efficiency of consolidation and solve the problem of insufficient return source. Local governments should strengthen the coordinated planning of land and sea ports, build a "sea-land interconnected" transportation network, and enhance the ability to integrate cargo sources through digital means [13].

4.2. Case 2: Zhengzhou Smart Innovation R&D Center—The "Zhengzhou Model" of Digital Empowerment

The Zhengzhou Smart Innovation R&D Center, which will be put into operation in February 2025, is a typical representative of the digital transformation of China Europe railway express. The center is jointly built by Zhengzhou New Silk Road International Port Investment Co., Ltd. and China Railway Information Engineer-

ing Group, focusing on breaking the "information island" and "data chimney" of cross-border logistics, and constructing a multidimensional digital empowerment system.

Its core measures include: establishing a "one order system" service system for multimodal transportation, realizing standardized sharing of data among customs, railways, highways, seaports, aviation, and cross-border nodes, and ensuring full traceability and intelligent allocation of goods throughout the process; Build a supply chain collaboration platform to promote the integration of manufacturing, commerce, and logistics data, and assist in the development of new formats such as cross-border e-commerce; Collaborate with the intelligent logistics hanging center and the multimodal transportation intelligent distribution center to promote the standardization of open and interconnected logistics data. These measures have enabled the Zhengzhou China Europe railway express to ship over 13,000 trains, covering more than 140 cities in over 40 countries, and maintaining its comprehensive operational capacity at the forefront of the country.

This case proves that digital transformation can fundamentally improve the operational efficiency of train services. Data sharing makes the customs clearance process more efficient, intelligent allocation reduces empty driving rates, and supply chain collaboration expands the source of goods channels. The replicability of its' Zhengzhou model 'provides important reference for the digital transformation of China Europe railway express nationwide [14].

5. Optimization of the Path for High-Quality Development of China Europe Railway Express

5.1. Building a Comprehensive Digital Empowerment System

Promote the construction of cross-border data sharing platform: draw on the experience of Zhengzhou Smart R&D Center, establish a national level China Europe railway express data sharing hub, unify data standards and interface specifications, and achieve information interconnection and intercommunication among customs, railways, freight forwarders, enterprises and other parties. Key efforts will be made to promote data sharing in overseas segments, establish data exchange mechanisms with logistics nodes along the route, and enhance the overall visualization level. **Key stakeholders:** National railway authorities (responsible for overall planning and platform construction), customs departments (responsible for data access and standard unification), and leading logistics enterprises (responsible for technical support and data sharing).

Strengthen the integration and application of intelligent technology: promote the application of big data and artificial intelligence in source organization, route planning, and risk warning, establish an intelligent scheduling system, and achieve precise matching between train capacity and source of goods. Develop a geopolitical risk warning module to monitor real-time information on border policy changes, customs clearance process adjustments, and provide decision-making support for enterprises. **Key stakeholders**: Scientific research institutions and

technology enterprises (responsible for technology research and development), railway operators (responsible for system application and operation), and industry associations (responsible for information collection and early warning).

Promote the digital transformation of small and medium-sized logistics enterprises: Through policy support and technical training, help small and medium-sized logistics enterprises enhance their digital application capabilities and access national data platforms. Encourage large logistics enterprises to open up their digital service capabilities, build a digital logistics ecosystem, and drive the efficiency improvement of the entire industry [15]. **Key stakeholders**: Local governments (responsible for policy formulation and financial support), large logistics enterprises (responsible for technical empowerment and resource sharing), and industry associations (responsible for training organization and guidance).

5.2. Improve the Mechanism for Responding to Geopolitical Risks

Strengthen multilateral coordination and cooperation: Promote negotiations and consultations with countries along the route at the national level, establish a multilateral coordination mechanism for China Europe railway express, and solve problems such as inconsistent railway standards and complex customs clearance processes. Establish regular communication channels for key nodes such as the Polish border and Russian customs to promptly resolve unexpected risks. **Key stakeholders**: National foreign affairs departments and transportation authorities (responsible for intergovernmental negotiations), railway operators (responsible for docking and implementation), and embassies and consulates in countries along the route (responsible for information communication and coordination).

Optimize channel layout and source structure: Continue to improve the channel network of "sea-land interconnection" and "multi-directional extension", reducing dependence on a single channel. Encourage enterprises to expand their local sources of goods in Europe, strengthen cooperation with manufacturing and commercial industries in countries along the route, build a two-way balanced trade pattern, and fundamentally solve the problem of insufficient return goods. **Key stakeholders**: Local governments (responsible for channel planning and policy support), logistics enterprises and trading companies (responsible for source development and cooperation), and industry associations (responsible for resource integration and guidance).

Establish a compliance service system: Establish a professional compliance service team to help enterprises familiarize themselves with trade policies and customs rules of countries along the route, and avoid compliance risks such as EU enlargement reviews. Industry associations should develop compliance operation guidelines for China Europe railway express, conduct compliance training, and enhance enterprise risk prevention capabilities [16]. **Key stakeholders**: Industry associations (responsible for guideline formulation and training), professional legal and consulting institutions (responsible for compliance services), and enterprises (responsible for implementation and practice).

5.3. Promote Industrial Integration and Market-Oriented Transformation

Embedding into the urban industrial chain value chain: Combining the development of China Europe railway express with local industrial upgrading, relying on the economic advantages of the hinterland, and creating distinctive railway express. For example, Xi'an's Chang'an Express operates large-scale machinery and equipment trains tailored to the characteristics of Central Asian trade, while Zhengzhou relies on cross-border e-commerce industry to develop special trains, achieving mutual empowerment between trains and industries. **Key stakeholders**: Local governments (responsible for industrial planning and linkage), manufacturing enterprises (responsible for demand docking), and railway operators (responsible for service customization).

Integrate route resources to avoid disorderly competition: Strengthen top-level design at the national level, integrate overlapping routes, plan a nationwide China Europe railway express trunk network and regional assembly centers. Cultivate leading logistics enterprises with international competitiveness, guide enterprises to shift from price competition to service competition, and enhance market-oriented operational capabilities. **Key stakeholders**: National transportation authorities (responsible for top-level design and integration), local governments (responsible for coordination and cooperation), and leading logistics enterprises (responsible for network operation and service upgrading).

Gradient reduction of government subsidy dependence: Establish a subsidy rebate mechanism and shift the focus of subsidies from operational subsidies to areas such as digital transformation, compliance services, and overseas cooperation. Through policies such as tax incentives and financing support, encourage enterprises to enhance their independent profitability and achieve a transition from policy driven to market driven [17]. **Key stakeholders**: Local governments (responsible for subsidy policy adjustment and financial support), financial institutions (responsible for financing support), and enterprises (responsible for improving independent profitability).

5.4. Strengthen the Connection between Infrastructure and Standards

Promote the upgrading of cross-border infrastructure: continue to improve the capacity expansion and renovation of domestic ports, and enhance the ability to transfer vehicles. Strengthen cooperation with countries along the railway, participate in the construction and renovation of overseas railway infrastructure, and promote the standardization of railway track standards and loading and unloading equipment. Focus on solving the efficiency problem of key node replacement and shortening transportation time. **Key stakeholders**: National and local transportation authorities (responsible for domestic infrastructure construction), enterprises (responsible for overseas project investment and construction), and intergovernmental cooperation institutions (responsible for cooperation promotion

and coordination).

Promote mutual recognition of technical standards and safety regulations: Lead or participate in the formulation of cross-border railway transportation standards, conduct standard docking negotiations with countries along the route, and achieve mutual recognition of safety regulations and inspection and quarantine processes. Establish a standard system for China Europe railway express, covering aspects such as cargo packaging, loading specifications, and data transmission, to improve operational efficiency. **Key stakeholders**: National standardization authorities (responsible for standard formulation and promotion), intergovernmental standardization organizations (responsible for negotiation and mutual recognition), and enterprises (responsible for standard implementation).

Strengthen green and low-carbon transformation: In response to the "dual carbon" goal, promote environmental protection technologies and products such as new energy locomotives and green packaging. Optimize transportation organization methods, reduce empty driving rates and energy consumption, create green China Europe railway express, and enhance international competitiveness [18]. **Key stakeholders**: Railway operators (responsible for technology application and operation optimization), environmental protection departments (responsible for policy guidance and supervision), and enterprises (responsible for product research and development and promotion).

5.5. Potential Limitations and Response Strategies for Proposed Solutions

While the proposed high-quality development path has strong practical guiding significance, it also faces certain implementation limitations, which need to be clearly recognized and responded to:

1) **Data security risks in cross-border information sharing**: Cross-border data flow involves the data security and privacy protection of multiple countries, and differences in data governance systems and regulatory policies among countries may restrict the smooth progress of data sharing. Response strategy: Establish a cross-border data security management system that conforms to international norms, adopt encryption technology and access control mechanisms to ensure data security; Promote the signing of bilateral and multilateral data security cooperation agreements among countries along the route, and clarify the scope, rights and obligations of data sharing.

2) **High cost of digital transformation for small and medium-sized enterprises**: Small and medium-sized logistics enterprises have limited capital and technical capabilities, and the high input cost of digital transformation makes it difficult for them to carry out transformation independently. Response strategy: The government provides financial subsidies and tax incentives to reduce the transformation cost of small and medium-sized enterprises; Encourage the establishment of a digital transformation service platform led by large enterprises to provide small and medium-sized enterprises with low-cost technical services and training support.

3) **Uncertainty of geopolitical environment**: The frequent changes in the geopolitical situation among countries along the route may lead to the adjustment of cooperation policies and the increase of trade barriers, which affects the implementation effect of the proposed mechanism. Response strategy: Establish a long-term and stable multilateral consultation mechanism to enhance the flexibility and adaptability of cooperation; Improve the geopolitical risk early warning system, formulate alternative plans for key routes and cooperation projects, and reduce the impact of geopolitical changes.

4) **Difficulties in the unification of cross-border technical standards**: Due to the differences in technical levels, industrial foundations and regulatory systems among countries along the route, it is difficult to quickly unify technical standards and achieve mutual recognition. Response strategy: Adopt a "step-by-step promotion" approach, first promote the unification of key standards in core channels and key nodes, and then gradually expand to the whole line; Carry out technical assistance and capacity-building cooperation for countries with backward technical standards to narrow the technical gap.

6. Conclusions and Prospect

As an important carrier of Asia Europe trade connectivity, the China Europe railway express is facing a dual combination of traditional challenges and new challenges while expanding in scale. The coordinated promotion of digital transformation and geopolitical risk response is the key path to achieving high-quality development. Digital empowerment injects new momentum into train operations by breaking down information barriers and improving collaborative efficiency; Geopolitical adjustment creates a stable environment for the development of trains through multilateral coordination and channel optimization. The coupling effect of the two can effectively solve traditional problems such as insufficient return goods, high transportation costs, and subsidy dependence, and cope with new challenges such as digital divide and geopolitical risks.

In the future, the China Europe railway express should build a high-quality development system of "digital drive + geopolitical adaptation + industrial linkage": enhancing core efficiency through digital transformation, resolving external risks through geopolitical coordination mechanisms, and consolidating development foundation through deep industrial integration. With the continuous innovation of digital technology and the deepening of multilateral cooperation, the China Europe railway express will further play the role of a global supply chain stabilizer, making greater contributions to building a new development pattern and promoting global trade liberalization and facilitation.

The connectivity between the Eurasian continent is a long-term project, and the high-quality development of China Europe railway express still needs to be continuously explored. Future directions for further research include the impact of digital transformation on carbon emissions of trains, differentiated paths of train development models in different regions, and the long-term effects of geopolitical

changes, providing more comprehensive theoretical support for the sustainable operation of China Europe trains.

Funding

This work was supported by the New Talent Research Project of Guangzhou Railway Polytechnic [No. GTXYRC250106, GTXYR2208], the General Project of Teaching and Research of Guangzhou Railway Polytechnic [No. GTXYYB250112], the Guangdong Provincial Department of Education Project [No. 2023WQNCX197, 2024WTSCX233].

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] He, P., Zhang, J., Xu, X., Lin, C. and Chen, L. (2024) Unintended Environmental Gains: The Impact of China-Europe Railway Express on Carbon Dioxide Emissions in China. *Transport Policy*, **153**, 127-140. https://doi.org/10.1016/j.tranpol.2024.05.014

[2] Wang, X., Li, J., Shi, J., Li, J., Liu, J. and Sriboonchitta, S. (2023) Does China-Europe Railway Express Improve Green Total Factor Productivity in China? *Sustainability*, **15**, Article 8031. https://doi.org/10.3390/su15108031

[3] Chen, S., Li, Y., Tang, Y. and Zhong, J. (2024) Assessing the Impact of China Railway Express Operations on the Development of Chinese Cities: China-Europe Freight Routes Evolution and City Development Analysis. *Research in Transportation Business & Management*, **56**, Article 101176. https://doi.org/10.1016/j.rtbm.2024.101176

[4] He, P., Zhang, J. and Chen, L. (2022) Time Is Money: Impact of China-Europe Railway Express on the Export of Laptop Products from Chongqing to Europe. *Transport Policy*, **125**, 312-322. https://doi.org/10.1016/j.tranpol.2022.06.010

[5] Wang, B., Su, Q. and Chin, K.S. (2021) Vulnerability Assessment of China-Europe Railway Express Multimodal Transport Network under Cascading Failures. *Physica A*: *Statistical Mechanics and Its Applications*, **584**, Article 126359. https://doi.org/10.1016/j.physa.2021.126359

[6] Zhang, L., Wan, J., Razzaq, A., Zhang, Q., Zhou, L. and Erfanian, S. (2023) Exploring the Impact of China-Europe Railway Express on the Urban-Rural Income Gap. *Heliyon*, **9**, e17571. https://doi.org/10.1016/j.heliyon.2023.e17571

[7] Si, C., Guan, R. and Leou, E.C. (2025) China-Europe Railway Express: The Establishment of the New Euro-Asia Link. In: *The Palgrave Handbook on China-Europe-Africa Relations*, Springer, 301-320. https://doi.org/10.1007/978-981-97-5640-7_14

[8] Lin, Y., Lai, F., Liu, X., Shi, Z. and Chen, D. (2025) Examining Trend and Synergistic Development of China's 'New Three' Industries, China-Europe Trade, and China Railway Express. *All Earth*, **37**, 1-22. https://doi.org/10.1080/27669645.2024.2435754

[9] Zhang, G., Wang, Y., Li, Y. and Wang, S. (2023) An Analysis of the Impact of Russia Ukraine Conflict on China-Europe Railway Express. In: *Proceedings of the* 2022 3*rd International Conference on Big Data Economy and Information Management* (*BDEIM* 2022) (*Vol.* 233), Springer, 245.

[10] Choi, K.S. (2021) The Current Status and Challenges of China Railway Express (CRE)

as a Key Sustainability Policy Component of the Belt and Road Initiative. *Sustainability*, **13**, Article 5017. https://doi.org/10.3390/su13095017

[11] He, P., Tian, X., Zhang, J., Yu, S., Li, S., Lin, C., *et al.* (2024) Can the China-Europe Railway Express Reduce Carbon Dioxide Emissions? New Mechanism of the Manufacturing Industry Substitution Effect. *Economic Analysis and Policy*, **82**, 1384-1405. https://doi.org/10.1016/j.eap.2024.05.023

[12] Hu, S., Wang, A., Du, K. and Si, L. (2023) Can China Railway Express Improve Environmental Efficiency? Evidence from China's Cities. *Environmental Impact Assessment Review*, **99**, Article 107005. https://doi.org/10.1016/j.eiar.2022.107005

[13] Qian, P., Yang, Z. and Lian, F. (2024) The Structural and Spatial Evolution of the China Railway Express Network. *Research in Transportation Economics*, **103**, Article 101414. https://doi.org/10.1016/j.retrec.2024.101414

[14] Ma, B. (2021) Problems and Prospects of the Transportation Infrastructure Connectivity between China and Eurasia: A Case Study on the China Railway Express. In: *China and Eurasia*, Routledge, 57-73.

[15] Yan, B., Tian, X., Deng, S. and Wu, J. (2022) Impact of China Railway Express on Urban Exports: Evidence from Prefectural-Level City Economic Data. *Procedia Computer Science*, **214**, 1222-1227. https://doi.org/10.1016/j.procs.2022.11.299

[16] Wei, H. and Wu, F. (2023) Formation of Coordinated Alliance for China Railway Express Platforms Considering Logistics Cost Sharing. *Transportation Research Record: Journal of the Transportation Research Board*, **2677**, 721-735. https://doi.org/10.1177/03611981231157733

[17] Yin, W., Hu, W., Yan, X., Peng, B. and Yang, X. (2024) A Time-Space Network-Based Model for Transportation Service Optimization of China Railway Express. *High-speed Railway*, **2**, 153-163. https://doi.org/10.1016/j.hspr.2024.08.005

[18] Li, J., Hu, J. and Yang, L. (2021) Can Trade Facilitation Prevent the Formation of Zombie Firms? Evidence from the China Railway Express. *China & World Economy*, **29**, 130-151. https://doi.org/10.1111/cwe.12366