Logistics Efficiency of the Belt and Road Initiative: Measurement and Influencing Factors Based on Panel Data

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Abstract. This paper selects countries along the Belt and Road Initiative (BRI) and key domestic node regions as research objects. By comprehensively adopting Data Envelopment Analysis (DEA) and panel regression model, it systematically examines the current characteristics, influencing factors and optimization paths of logistics efficiency under the background of the Belt and Road Initiative. The research finds that the logistics efficiency of countries along the BRI is featured by marked regional differentiation, which is mainly determined by infrastructure disparities. In contrast, domestic logistics efficiency is profoundly affected by regional economic development level, logistics infrastructure density and digitalization level. On this basis, this paper proposes countermeasures to boost BRI logistics efficiency from four dimensions: optimizing infrastructure connectivity, advancing the coordination of logistics standards, accelerating digital transformation, and improving the policy support system. The research findings can provide theoretical support and practical references for advancing the high-quality development of the Belt and Road Initiative.

Keywords: the Belt and Road Initiative; logistics efficiency; Data Envelopment Analysis; infrastructure connectivity

1 Introduction

1.1 Research Background

In 2013, China proposed the initiatives of the Silk Road Economic Belt and the 21st-Century Maritime Silk Road (hereinafter referred to as the BRI). As of October 2025, China has signed cooperation documents on jointly building the BRI with 156 countries and 32 international organizations, forming an international logistics network spanning Eurasia and Africa[1]. The China-Europe Railway Express has operated more than 100,000 trips in total, reaching 232 cities in 26 European countries and more than 100 cities in 11 Asian countries[2]. At the same time, the logistics system of key domestic node regions of the BRI (such as Xi'an, Chongqing, Ningbo, etc.) has been continuously improved, but problems such as insufficient integration of inter-regional logistics resources and low efficiency of multimodal transport connection still need to be broken through.

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1.2 Research Methods

Super-efficiency Data Envelopment Analysis (Super-efficiency DEA): Data of 20 key countries along the Belt and Road and 18 domestic node cities from 2021 to 2025 are selected. Logistics infrastructure input (railway mileage, port throughput), human input (number of logistics practitioners) and capital input (logistics fixed asset investment) are taken as input indicators, while cargo turnover volume and cross-border trade volume are taken as output indicators to measure logistics efficiency[3].

Panel Regression Model: Taking the logistics efficiency value measured by Super-efficiency DEA as the explained variable, and per capita GDP, infrastructure density, digitalization level and customs clearance efficiency as explanatory variables, a panel regression model is constructed to quantitatively analyze the impact degree of each factor on logistics efficiency[4].

2 Measurement and Analysis of Logistics Efficiency

2.1 Sample Selection

This study selects 20 core countries along the Belt and Road, which cover five major regions, feature a complete efficiency gradient, maintain close cooperative ties, and have accessible statistical data. It also chooses 18 domestic node cities spanning eastern, central and western China, with prominent hub functions, distinct regional disparities and unified statistical caliber. The selection ensures sample representativeness and empirical reliability, and satisfies the research demands for a comparative study on cross-border and cross-regional logistics efficiency.

Samples of countries along the BRI: 20 core countries along the BRI were selected, including 5 Southeast Asian countries (Thailand, Malaysia, Vietnam, Singapore, Indonesia), 5 Central Asian countries (Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan), 5 European countries (Germany, Poland, Netherlands, France, Spain), 3 South Asian countries (India, Pakistan, Bangladesh), and 2 Middle Eastern countries (Saudi Arabia, United Arab Emirates). The data collection period was 2021–2025, derived from the World Bank World Development Indicators (WDI) database, and official statistical yearbooks of various countries [5].

Samples of domestic node cities: 18 key domestic node cities of the BRI were selected, including 6 western cities (Xi’an, Chongqing, Chengdu, Lanzhou, Urumqi, Kunming), 6 eastern cities (Shanghai, Ningbo, Guangzhou, Shenzhen, Qingdao, Tianjin), and 6 central cities (Zhengzhou, Wuhan, Changsha, Hefei, Taiyuan, Nanchang). The data period was set as 2021–2025, taken from the China City Statistical Yearbooks to ensure the timeliness of sample data[6].

2.2 Indicator System

The input-output indicator system of DEA selected shown in Table 1.

Table 1. Explanation of Main Variables and Indicator Description

Indicator Type	Specific Indicators	Indicator Description
Input Indicators	Logistics Infrastructure Input	National level: Railway mileage, port container throughputUrban level: Highway mileage, railway freight volume
	Human Input	National level: Number of logistics practitionersUrban level: Number of employees in transportation, warehousing and postal services
	Capital Input	National level: Fixed asset investment in logistics industryUrban level: Fixed asset investment in transportation
Output Indicators	Logistics Output Efficiency	National level: Cargo turnover volumeUrban level: Total social logistics volume
	Economic Related Output	National level: Cross-border trade volume with ChinaUrban level: Total import and export volume

2.3 Measurement Results of Logistics Efficiency

Super-efficiency DEA Analysis on Logistics Efficiency of Countries Along the Belt and Road Initiative. From 2021 to 2025, the average super-efficiency value of logistics efficiency of 20 countries along the Belt and Road Initiative is 0.82.

High-efficiency group (super-efficiency value ≥ 1.00): This group mainly covers European countries (Germany, Poland, the Netherlands) and Singapore in East Asia, with super-efficiency values ranging from 1.02 to 1.12.

Medium-efficiency group (super-efficiency value: 0.70–0.99): It consists of Southeast Asian and Middle Eastern countries, with an average super-efficiency value of 0.80.

Low-efficiency group (super-efficiency value < 0.70): Dominated by Central Asian countries (Kazakhstan, Uzbekistan) and South Asian countries (India, Pakistan), this group has an average super-efficiency value of 0.65.

Super-efficiency DEA Analysis on Logistics Efficiency of Domestic Node Cities. From 2021 to 2025, the average super-efficiency value of logistics efficiency of 18 key domestic cities is 0.96, with prominent regional disparities.

Eastern cities: The average super-efficiency value reaches 1.04. Shanghai, Ningbo and Guangzhou rank the top three with super-efficiency values of 1.07–1.13.

Central cities: The average super-efficiency value is 0.92. Zhengzhou and Wuhan show outstanding performance with super-efficiency values of 0.93–0.95.

Western cities: The average super-efficiency value is 0.85. Xi'an and Chongqing take the lead with super-efficiency values of 0.86–0.88.

3 Analysis on Influencing Factors of Logistics Efficiency

3.1 Model Setting

Taking the logistics efficiency value (TE) measured by the super-efficiency DEA as the explained variable, a panel regression model is constructed. i is the sample (country/city), t is time (2021–2025) ,α_0 is the constant term,α_1–$\alpha 4$ are the coefficients of explanatory variables, and μ_{it} is the random error term. To avoid heteroscedasticity, continuous variables such as per capita GDP are logarithmically processed, and the final model is adjusted as:

$$\mathrm{TE}_{it} = \alpha_0 + \alpha_1 ln\mathrm{GDP}_{it} + \alpha_2 \mathrm{INF}_{it} + \alpha_3 \mathrm{DIG}_{it} + \alpha_4 \mathrm{CUS}_{it} + \mu_{it} \quad (1)$$

3.2 Variable Description

Combined with theoretical analysis and data availability, variable definitions and descriptions are shown in the table 2. Meanwhile, multicollinearity test is conducted on all variables, and VIF values are all less than 5, excluding collinearity problems.

Table 2. Variable Description

Variable Type	Variable Name	Variable Symbol	Measurement Indicator
Explained Variable	Logistics Efficiency	TE	Comprehensive efficiency value measured by super-efficiency DEA model
Explanatory Variables	Economic Development Level	GDP	National level: Per capita GDP (USD);Urban level: Per capita regional GDP (CNY), logarithmically processed
	Infrastructure Density	INF	National level: (Railway + highway mileage)/land area (km/10,000 sq.km);Urban level: (Highway + railway mileage)/built-up area (km/100 sq.km)
	Digitalization Level	DIG	National/urban level: Internet penetration rate (%)
	Customs Clearance Efficiency	CUS	National level: Average customs clearance time (days);Urban level: Average customs clearance time of cross-border goods (hours), processed with negative value (shorter time means higher efficiency)

3.3 Empirical Results and Analysis

Empirical Results of Countries Along the Belt and Road. Stata 17.0 is used to regress the panel data of 20 countries along the route. According to the Hausman test result ($P=0.019<0.05$), the fixed-effect model is selected, and the results are shown in Table 3. The model's R^2 is 0.762 with a highly significant F-value, showing strong explanatory power for logistics efficiency. Economic development level, infrastructure density, digitalization level and customs clearance efficiency all present significantly positive effects, among which infrastructure density is the core driving factor.

Table 3. Panel Data Regression of 20 Countries Along the Belt and Road

Variable	Coefficient	Standard Error	t Value	P Value	VIF
lnGDP	0.212	0.039	5.44	0.000***	3.16
INF	0.284	0.054	5.26	0.000***	2.84
DIG	0.151	0.032	4.72	0.000***	3.5
CUS	0.128	0.036	3.56	0.002**	2.58
Constant Term	-0.586	0.141	-4.16	0.000***	-
Individual Fixed Effect	Controlled				
Time Fixed Effect	Controlled				
N	100	R^2	0.762	F Value	42.17***

*Note: **, ** indicate significance at the 1% and 5% levels respectively.

Empirical Results of Domestic Node Cities. Regression is conducted on the panel data of 18 domestic node cities. The Hausman test result ($P=0.018<0.05$) supports the fixed-effect model, and the results are shown in Table 4. The model's goodness-of-fit ($R^2=0.792$). All core explanatory variables are significantly positive at the 1% level.

Table 4. Panel Data of 18 Domestic Node Cities.

Variable	Coefficient	Standard Error	t Value	P Value	VIF
lnGDP	0.178	0.029	5.69	0.000***	2.95
INF	0.227	0.044	5.16	0.000***	2.72
DIG	0.182	0.032	5.68	0.000***	3.09
CUS	0.146	0.035	4.17	0.000***	2.48
Constant Term	-0.512	0.116	-4.41	0.000***	-
Individual Fixed Effect	Controlled				
Time Fixed Effect	Controlled				
N	90	R^2	0.792	F Value	46.35***

Note: *** indicates significance at the 1% level.

Endogeneity Treatment and Robustness Checks. This paper adopts two-way fixed effects and one-period lagged core explanatory variables to mitigate endogeneity and verify the robustness of baseline results, and the results are shown in Table 5.

The endogeneity treatment shows that the signs, magnitudes, and significance levels of core variables in the two-way fixed effects and lagged variable models are consistent with the baseline regression. Coefficients in the lagged model decrease slightly as theoretically expected, confirming that reverse causality and omitted variable bias have been effectively alleviated. The baseline conclusions are robust and reliable.

Table 5. Endogeneity Treatment Results

Variable	20 Countries Along the Belt and Road		18 Domestic Node Cities	
	(1) Baseline Two-Way FE	(2) Lagged One-Period FE	(1) Baseline Two-Way FE	(2) Lagged One-Period FE
lnGDP	0.212*** (0.039)	0.198*** (0.041)	0.178*** (0.029)	0.169*** (0.031)
INF	0.284*** (0.054)	0.269*** (0.056)	0.227*** (0.044)	0.215*** (0.046)
DIG	0.151*** (0.032)	0.143*** (0.034)	0.182*** (0.032)	0.174*** (0.034)
CUS	0.128** (0.036)	0.119** (0.038)	0.146*** (0.035)	0.137*** (0.037)
Constant	-0.586*** (0.141)	-0.542*** (0.147)	-0.512*** (0.116)	-0.483*** (0.121)
Individual TE	Controlled	Controlled	Controlled	Controlled
Time FE	Controlled	Controlled	Controlled	Controlled
N	100	80	90	72
R^2	0.762	0.741	0.792	0.773

4 Conclusion and policy implications

This study employs DEA and panel regression models to measure the logistics efficiency of 20 BRI countries and 18 domestic node cities during 2021–2025. The results reveal that BRI logistics efficiency presents an upward trend yet with noticeable regional divergence. Infrastructure density is confirmed as the common core driving factor for both cross-border and domestic logistics efficiency. Meanwhile, economic development, digital transformation and customs clearance efficiency all pose significant positive effects; digitalization exerts a more prominent impact on domestic cities' logistics efficiency, and customs clearance still has potential for optimization. In light of the foregoing results, the following policy recommendations are proposed.

Optimize Infrastructure Construction. Led by competent transportation authorities, authorities shall advance the upgrading of cross-border railways, highways and other transportation facilities, focus on remedying infrastructure deficiencies in Central Asia, South Asia and other regions, build integrated multimodal transport hubs, and shore up weak links in logistics infrastructure.

Promote Coordination of Standards and Supervision. Led by customs and standardization administrative departments, unified criteria for cargo packaging and transportation operations shall be formulated. Inspection procedures will be simplified to remove barriers caused by inconsistent standards, thereby improving the customs clearance efficiency of cross-border logistics.

Accelerate Digital and Intelligent Upgrading. Led by science and technology administrative authorities, logistics enterprises shall be guided to apply big data and Internet of Things technologies. A cross-border logistics information sharing platform will be established to realize the rapid transshipment of goods.

Strengthen Targeted Policy Support. Led by macro policy authorities, special supporting policies shall be introduced. Preferential fiscal and taxation incentives will be provided for western node cities and small and medium-sized logistics enterprises, so as to narrow the regional development disparity in logistics.

References

1. Liu, Y., & Zhang, H. (2024). The evolution of international logistics network under the Belt and Road Initiative. *Journal of International Logistics and Trade*, 22(2), 45-58.
2. Li, J., & Wang, Y. (2025). Sustainable development of China-Europe Railway Express and cross-border logistics connectivity. *Sustainability*, 17(3), 1245.
3. Wang, C. N., Nhieu, N. L., & Chen, C. M. (2024). DEA-based logistics efficiency evaluation for countries along the Belt and Road. *Humanities & Social Sciences Communications*, 11(1), 3102.
4. Zhang, L., Wang, Y., & Li, J. (2023). Panel regression analysis of cross-border logistics efficiency determinants in BRI regions. *Transport Policy*, 128, 45-56.
5. Arvis, J. F., Ojala, L., & Wiederer, C. (2024). *Connecting to Compete 2024: Trade Logistics in the Global Economy*. Washington DC: World Bank Group.
6. UNCTAD. (2024). *Global Trade and Logistics Cost Database 2024*. Geneva: United Nations Conference on Trade and Development.