A Quantitative Analysis of Trade Flow Determinants Between China and Belt and Road Initiative Partner Countries

Yijia Peng

International Economics and Trade College, Central University of Finance and Economics, Beijing, China, 102206

3084255694@qq.com

Abstract. The Belt and Road Initiative (BRI) has significantly reshaped the global trade landscape. Therefore, it is crucial to understand the changing macroeconomic factors that drive bilateral trade flows. This study focuses on identifying the main determinants of trade flows between China and its major BRI partners, particularly Pakistan and Kazakhstan, from 2015 to 2025. The study collects relevant data from the World Bank, the United Nations Commodity Trade Statistics Database (UN Comtrade), and the Ministry of Commerce, and conducts an analysis. A random effects gravity model is adopted, and the outward direct investment (ODI) is subjected to an inverse hyperbolic sine transformation. Three main conclusions are drawn from this study. First, the growth of a partner country's economic scale is the most important driving force for expanding bilateral trade. Second, despite improvements in transportation infrastructure, geographical distance remains a structural barrier to the growth of trade volume. Third, although China's GDP, ODI, and free trade agreements have a positive guiding effect on bilateral trade, their immediate statistical significance in this specific group of countries is weak, indicating policy lags and investment implementation cycles.

Keywords: Belt and Road Initiative, Gravity Model, Trade Flows, Outward Direct Investment, Random Effects

1 Introduction

The Belt and Road Initiative has significantly altered the landscape of international trade, sparking extensive academic discussions aimed at formulating targeted infrastructure investment suggestions and exploring how policies influence international trade flows. Bania, Rocha, and Ruta utilized a structural gravity model to demonstrate that trade flows between economies participating in the Belt and Road Initiative increased by up to 4.1%, and they pointed out that the benefits would be maximized when transportation infrastructure upgrades and trade reforms complement each other[1]. Similarly, Amani and Kasi applied a panel EGLS gravity model to a study of 123 countries and found that while the performance of standard gravity variables met

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expectations, the inclusion of Belt and Road membership introduced a statistically significant positive dummy variable effect, fundamentally reducing bilateral trade barriers[2]. Additionally, Foo et al. employed a comprehensive trade gravity model to assess the impact of China's outward direct investment (ODI), confirming that despite geographical distance being a traditional barrier, the GDP of the host country and financial cooperation driven by the Belt and Road Initiative have positively promoted bilateral trade over a longer time frame[3].

Despite the abundant literature, research on how recent global fluctuations and changes in direct investment affect specific regional corridors remains warranted. This paper examines the current macroeconomic determinants that influence trade flows between China and its "Belt and Road" partners, and to understand how China's outward direct investment alters the traditional gravity framework with Pakistan and Kazakhstan.

To address these questions, this study employs an enhanced structural gravity model of international trade, uses panel data regression techniques, and applies the inverse hyperbolic sine transformation. The significance of this research lies in providing a detailed and up-to-date quantitative assessment of the trade dynamics of China's "Belt and Road". By strictly separating variables such as distance, economic size, policy agreements, and capital flows, the results are ensured to be reasonable. This analysis provides empirical support for policymakers and helps determine the direction and intensity of future infrastructure investment.

2 Research Methodology

2.1 Data Collection

To conduct this quantitative analysis, this paper constructs a dataset covering the period from 2015 to 2025. 2015 marks a crucial juncture for the full-scale implementation of the Belt and Road Initiative, while 2025 is the most recent year for which complete data is available. Selecting this time frame not only encompasses the core development stage following the initiative's implementation but also ensures the continuity and timeliness of the data, providing a reliable basis for analyzing dynamic trade changes. Additionally, this study adopts a panel data format, organizing the data of various countries on an annual basis, and constructs a balanced panel dataset for China, Pakistan, and Kazakhstan from 2015 to 2025, with a total of 22 observations, to ensure an adequate sample size for regression analysis. Bilateral trade volume data for the case study countries (Pakistan and Kazakhstan) were collected from the United Nations Commodity Trade Statistics Database[4] and cross-checked with data from the Global Trade and Industrial Growth Laboratory to ensure the authenticity and reliability of the data.

The nominal gross domestic product (GDP) of China and its partner countries in this article is sourced from the World Bank[5]. For the geographical distance component in the trade gravity model, to more effectively measure actual trade frictions, this article selects the CES - a geographical distance indicator based on the Constant Elasticity of Substitution weighted population distance, which is obtained from the CEPII geo-

graphical distance database[6]. Additionally, the data on China's outward direct investment (ODI) flows is from the Ministry of Commerce's "China's Outward Direct Investment Statistical Bulletin"[7]. Finally, to measure the free trade agreements (FTAs) between China and the case study countries and whether these FTAs are implemented, a binary dummy variable was manually coded.

Specifically, the bilateral trade volume (T_{ijt}) is used as the dependent variable, measuring the total annual import and export trade volume between China and its partner countries to reflect the scale of actual trade flows. The gross domestic product (GDP_{it}, GDP_{jt}) is used as the core explanatory variable, representing the economic scale of China and its partner countries respectively, to measure the market supply and demand capabilities of the two countries. Geographical distance (Distanceij) is used as a control variable, reflecting the physical friction costs of bilateral trade. The outward direct investment flow is used as an explanatory variable, measuring the intensity of China's capital input into its partner countries. For the free trade agreement dummy variable (FTA_{ijt}), a value of "1" indicates that the two countries have an FTA in effect in that year, and a value of "0" indicates that they do not, assigning values to the abstract variable to ensure effective regression.

2.2 Data Calculation

To determine the determinants influencing trade flows, this study employs an enhanced structural gravity model. The fundamental premise is the gravity model, which posits that bilateral trade is directly proportional to the economic size and inversely proportional to the geographical distance. As the data on foreign direct investment (FDI) flows contain negative values (indicating capital repatriation or divestment), the standard natural logarithm cannot be universally applied. Therefore, the inverse hyperbolic sine (IHS) transformation is adopted for the FDI variable, which retains zero and negative value observations to ensure result reliability.

The main equation structure used for data calculation is as follows:

$$\ln(Tijt)=\beta0+\beta1\ln(GDPit)+\beta2\ln(GDPjt)+\beta3\ln(Dij)+\beta4ihs(ODIijt)+\beta5FTAijt+\epsilon ijt \quad (1)$$

When handling data, this study employs the Hausman test to select between fixed effects (FE) and random effects (RE) estimators. To further confirm the validity of choosing the random effects (RE) model, the null hypothesis of the Hausman test assumes that "the random effects model is appropriate". When the p-value is greater than 0.05, the null hypothesis cannot be rejected. In this study, the p-value is 1.0000, significantly greater than 0.05, which makes the selection of the random effects model reasonable. Additionally, the geographical distance ($Distance_{ij}$) is a time-invariant variable (the geographical distance between two countries remains unchanged across years). The fixed effects (FE) model automatically eliminates time-invariant variables, thus unable to estimate their coefficients. In contrast, the random effects model can effectively retain this variable and estimate its impact on trade flows, which is one of the core reasons for choosing this model.

3 Results and Analysis

3.1 Data Presentation

Empirical analysis has revealed significant quantitative characteristics of the initial pattern of bilateral trade and the potential elasticity coefficient. Table 1 summarizes the bilateral trade volume and investment dynamics of the selected case study countries. Pakistan and Kazakhstan were chosen as research subjects mainly because of their key importance in the Belt and Road Initiative. Pakistan is the core country of the China-Pakistan Economic Corridor, representing South Asia; while Kazakhstan is an important hub of the China-Central Asia Corridor, representing Central Asia. Both countries maintain close trade and investment relations with China, but their development characteristics are quite different - Pakistan's trade shows a stable growth trend, while Kazakhstan's trade has demonstrated rapid and significant expansion. Therefore, they respectively represent different types of countries along the Belt and Road. Comparing and analyzing them together can provide a more comprehensive understanding of the key factors influencing trade between China and the countries along the Belt and Road, thereby making the research conclusions more representative and reliable.

Table 1. Bilateral Trade Volume, Geographical Distance and FTA Status between China and Partner Countries (2015-2024)

Trading Partner	Bilateral Trade 2015 (USD)	Bilateral Trade 2024 (USD)	Average Distance (km)	FTA Status
Pakistan	18,916,652,405	23,042,655,953	4314.1	Active throughout
Kazakhstan	14,290,187,795	43,865,952,035	3891.6	Active post-2019

Table 2 summarizes the regression coefficients of the gravity model derived from the random effects (RE) model estimations of 18 specific panel observations.

Table 2. Regression Results from the Random Effects Gravity Model

Explanatory Variable	Coefficient (β)	Standard Error	P>|z|	Significance
ln(GDPPartner)	1.3902	0.1912	0.000	***
ln(Distanceij)	-9.3215	1.0630	0.000	***
ln(GDPChina)	0.2077	0.1774	0.242	Not Sig.
ihs(ODIChina)	0.0016	0.0014	0.262	Not Sig.
FTA(Dummy)	0.0929	0.0807	0.249	Not Sig.
Constant (_cons)	58.4460	9.3379	0.000	***

Note: *** indicates statistical significance at the 1% level. Overall R-squared = 0.9463.

3.2 Data Analysis

The regression results in Table 2 strictly confirm the foundational hypotheses of the gravity model while uncovering nuanced realities within the China-Central/South Asia economic corridors.

Firstly, the partner country's economic scale is the most potent catalyst for trade. The coefficient for the partner's GDP (β= 1.390) is highly positive and statistically significant ($p = 0.000$). This indicates that for every 1% increase in the GDP of Pakistan or Kazakhstan, bilateral trade with China expands by approximately 1.39%. This demonstrates that domestic market capacity and economic strength are the primary demand-side drivers for Chinese exports and the main supports for their own export capacity.The growth of the gross domestic product (GDP) means the expansion of the domestic market and the enhancement of residents' purchasing power, which accordingly boosts China's import demand for capital goods, intermediate products and consumer goods.The growth of the gross domestic product (GDP) implies the expansion of the domestic market and the enhancement of residents' purchasing power, which accordingly boosts China's import demand for capital goods, intermediate products and consumer goods. Meanwhile, the expansion of the economic scale enhances the production capacity of partner countries, enabling them to export more specialized products to China, such as agricultural products from Pakistan and energy resources from Kazakhstan, thereby promoting the growth of bilateral trade. This outcome is highly consistent with the core theory of the gravity model, confirming the universal rule that "economic scale is the core driving force of trade flow", and also highlighting the catalytic effect of the economic development of partner countries under the Belt and Road Initiative on bilateral trade.

Secondly, geographical distance constitutes a serious structural barrier. Despite large-scale investment in transportation infrastructure under the Belt and Road Initiative to improve connectivity, geographic distance and cross-border logistics remain significant obstacles to trade flows.

Thirdly, although China's gross domestic product (GDP), outward direct investment (ODI), and free trade agreement (FTA) dummy variables all show the expected positive signs - indicating that they fundamentally create and promote trade - in this specific small sample regression, they all lack statistical significance ($p > 0.05$). The positive but insignificant coefficient for China's ODI ($\beta = 0.0016$) can be attributed to the long gestation period of infrastructure investment. Similarly, the FTA coefficient reflects that policy implementation requires a transition period before enterprises can fully benefit from tariff reductions.

4 Conclusion

Empirical research on the determinants of trade flows between China and its Belt and Road Initiative partner countries has confirmed the core principle of economic gravity. Quantitative analysis indicates that the economic size of partner countries (Pakistan and Kazakhstan) is the main gravitational factor. Conversely, geographical distance still severely restricts trade flows, suggesting that despite the continuous advancement of

logistics modernization, natural physical factors remain significant obstacles. Additionally, while China's ODI and FTAs show positive coefficients, their short-run statistical insignificance indicates that investment and policy effects require a longer period to translate into significant trade growth.

The main limitation of this study lies in the limited sample size, which is due to the research focus being restricted to only two countries. This small sample size weakens the statistical power to capture the significance of slowly changing variables such as Free Trade Agreements (FTAs) and Outbound Direct Investment (ODI). Furthermore, the use of aggregate macroeconomic data masks sectoral heterogeneity, and the model does not account for external shocks such as the COVID-19 pandemic or geopolitical tensions, which may distort bilateral trade patterns.

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