Impact of Transport Infrastructure Connectivity on International Economic between China and ASEAN Countries

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Abstract. With the signing of the "Belt and Road" initiative and the Regional Comprehensive Economic Partnership (RCEP) agreement, trade cooperation between China and ASEAN countries has been further strengthened, and trade between China and ASEAN has become one of the most important economic partnerships in the world. To verify the extent of the impact of transport infrastructure connectivity on economic trade between China-ASEAN countries, this paper analyses the effects of transport infrastructure on the relationship between China and ASEAN countries based on publicly available datasets such as the World Bank, UN Comtrade, etc. Using gravity model and boundary effect model, the analysis results show that the degree of influence of roadway on both sides of trade is higher in transport infrastructure, while railways are not significant. Based on the results of the analysis, recommendations are made to enhance transport infrastructure connectivity to promote trade cooperation, maintain the advantages of roadway transport, upgrade the quality of the transport network and develop railway facilities.

Keywords: International trade; Transport infrastructure; ASEAN; Gravity modelling

1 Introduction

Since 1990, China and Association of Southeast Asian Nations (ASEAN) have had increasingly significant economic and trade relations. In 2002, China and ASEAN signed the China-ASEAN Framework Agreement on Comprehensive Economic Cooperation, laying the foundation for the establishment of the China-ASEAN Free Trade Area (CAFTA). With the development of trade cooperation between China and ASEAN, the connectivity of transport infrastructure has become a key node for national trade[1]. Based on the current China-ASEAN research, Thia J P[2] provided a simple extension to the gravity model, which found that infrastructure quality differences between trade partners result in trade imbalances, which lead to liberalization accentuates. Karymshakov K[3]. aimed to investigate the impact of infrastructure on trade in regions

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based on the data of three countries: Kazakhstan, Kyrgyzstan, and Tajikistan. Ruan W X et al. [4] used the Lokta-Volterra model of population evolution to determine the eco-trade relationship between the two sides. They also studied the economic impact of the Transportation Centre and analyzed the extent of the impact of the ASEAN Economic Cooperation Forum (AECF) on China's GDP. In trade modelling research, Heid B[5] proposed a new gravity estimation procedure to analyze the resolution of disputes over foreign trade costs and endogenous mark-ups under monopoly. Rahman I U[6] used an augmented gravity model that incorporates infrastructure in the merchandise trade flows.

This paper uses gravity and boundary effect model to measure the impact of transport infrastructure connectivity on China-ASEAN trade between China and ASEAN, and further analyses the changes in the impact of transportation infrastructures between them by classifying roadway infrastructure and railway infrastructure in detail.

2 Model

2.1 Gravity Model

Gravity model, a widely utilized framework in economics to estimate the volume of trade between nations, draws from the concept of the law of gravity in physics. It posits that the volume of trade between China and ASEAN is directly proportional to the size of their economies and inversely proportional to the geographical distance between them[7]. The standard formulation of the trade gravity model is as follows:

$$Trade_{ij} = G \times \frac{GDP_i \times GDP_j}{D_{ij}^{\beta}} \tag{1}$$

In equation (1), we assume China's related variables as i and ASEAN countries' as j, where Tradeij represents the total volume of trade between country i and country j. GDPi and GDPj represent the gross domestic product of country i and country j, respectively. Dij, which is the distance between the two countries of the trade. G is a constant, which represents the proportionality coefficient of the model. β denotes the distance elasticity, which is usually taken to be 1 or higher, indicating the degree of attenuation of trade volume with increasing distance.

2.2 Boundary Effect Model

Building on the standard gravity model, the boundary effect model introduces an additional term to account for the influence of shared geographical borders on trade volume[8]. The extended boundary effect model is expressed as follows:

$$Trade_{ij} = G \times \frac{GDP_i \times GDP_j}{D_{ij}^{\beta}} \times \left(1 + \delta \times Bor_{ij}\right) \tag{2}$$

In equation (2), Trade_ij represents the total trade volume between country i and country j; GDP_i and GDP_j denote the gross domestic product of the two respective countries; G is a constant scaling factor; β denotes the distance elasticity; Bor_ij is a binary variable that equals 1 if the two countries have adjacent physically border and 0 otherwise; while δ represents the coefficient of the border effect, measuring the influence of adjacent border physically on trade volume.

3 Case Study

3.1 Background

In 2020, China signed the Regional Comprehensive Economic Partnership (RCEP) agreement with ten ASEAN countries and four other Asia-Pacific nations. The RCEP aims to further reduce tariff barriers and expand market access for trade, providing a new impetus for China's trade relations with ASEAN members. The ASEAN bloc consists of ten countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. Meanwhile, these countries, located between East and South Asia, benefit from strategic geographic positioning and complete transport corridors, making ASEAN one of China's most significant trading partners.

3.2 Trade Modelling

1) Trade Gravity Model

a) Model assumption

To construct the gravity model of trade between China- ASEAN based on Equation (1), the model is linearized as follows:

$$LnTrade_{ij} = Ln\alpha + \beta_1 LnGDP + \beta_2 LnD_{ij} + \beta_3 LnTRI_{ij} + \beta_4 LnRoad_{ij} + \beta_5 LnRailway_{ij} + \varepsilon_{ij} \quad (3)$$

In equation (3), Tradeij represents the total volume of trade between country i and country j, measured in tens of thousands of US dollars. GDP represents the sum of the gross domestic product of the two trading parties, measured in hundreds of millions of US dollars. Dij represents the distance between the two trading region countries, which measured in kilometers. α represents the constant term. TRIij represents the degree of influence of transport infrastructure on trade volume, by dividing the length and of roadway and railway networks of the countries on both sides of the trade by the sum of the national areas of the two countries. ε_{ij} represents the random error term.

Similarly, the boundary effect model between China and ASEAN countries is constructed based on Equation (2) and is linearized as follows:

$$LnTrade_{ij} = Ln\gamma + \lambda_1 LnGDP_i + \lambda_2 LnGDP_j + \lambda_3 LnD_{ij} + \lambda_4 LnTRI_{ij} + \lambda_5 LnRoad_{ij} + \lambda_6 LnRailway_{ij} + \mu Bor + \varepsilon_{ij} \quad (4)$$

In equation (4), the γ represents the constant term; Bor is a dummy variable measuring whether the two countries share a common border adjacent physically, taking the value of 1 if the two countries share a common border and 0 otherwise.

b) Data processing

The dataset for infrastructure trade modeling is constructed by collecting relevant historical data between China and ASEAN countries. Trade data is sourced from the UN Comtrade, while GDP data for each country is obtained from the World Bank's public database. The lengths of China's roadway and railway networks are provided by the National Bureau of Statistics, and the corresponding data for the ten ASEAN countries is collected from the official ASEAN website. The distances between the countries are calculated as the straight-line distances between the capitals of the two trading partners. Additionally, for the missing data of ASEAN countries, we use the average value of historical data to replace. All data are processed by maximum-minimum normalization, the maximum-minimum normalization equation is shown in equation 5 and the resulting statistical table of the trade model variables is presented in Table 1.

$$X_{norm} = \frac{X - X_{MIN}}{X_{MAX} - X_{MIN}} \tag{5}$$

Table 1. Statistics on trade model variables

Variant	Maximum value	Minimum value	Average value
GDP	0.785	0.01	0.428
D_{ij}	0.814	0.261	0.487
TRI_{ij}	0.114	0.01	0.050
Roadway	0.977	0.041	0.525
Railway	0.940	0.039	0.553

2) Analysis of results

By combining the relevant variables from Table 1, the gravity model of trade between China- ASEAN was fitted, resulting in the regression table of each variable, as shown in Table 2. When considering only the GDP and distance between the trading partners in the standard gravity model, as presented in column 2 of Table 2, the GDP of the trading countries exerts a significant positive influence on trade volume. In contrast, the geographical distance (D_ij) between the countries has a negative, though moderate, effect on trade. Comparing the results in columns 2, 3, and 4 of Table 2 with the standard model, the analysis demonstrates that the impact of GDP on trade volume remains consistently significant, showing a strong positive effect. Similarly, distance exerts a consistent negative influence on trade volume, with a moderate inhibiting effect. Transport infrastructure also shows a moderate influence on trade volume, with roadway infrastructure having a more pronounced impact on trade between China and the ASEAN countries. However, the effect of railway infrastructure is weaker and largely insignificant in influencing trade between China-ASEAN countries.

The influencing factors of gravity model is shown as Fig. 1, and the model impact diagram of roadway and railway are shown as Fig. 2 and Fig. 3, respectively.

Table 2. Table of regression results for the gravity model

Variant	Standard	TRIi	Roadway	Railway
GDP	4.2672	4.183	4.074	4.27
	(9.343)	(7.202)	(6.330)	(7.311)
Dij	-0.8551	-1.027	-0.801	-0.852
	(-1.588)	(-1.351)	(-1.372)	(-1.307)

TRIij		0.35		
		(0.423)		
Roadway			0.285	
			(0.456)	
Railway				0.01
				(0.012)
Constant term	13.543	13.622	13.469	13.54
	(40.957)	(31.211)		(21.685)
R2	0.927	0.911	0.938	0.927

Note: The t value at the 5% significance level is shown in parentheses.

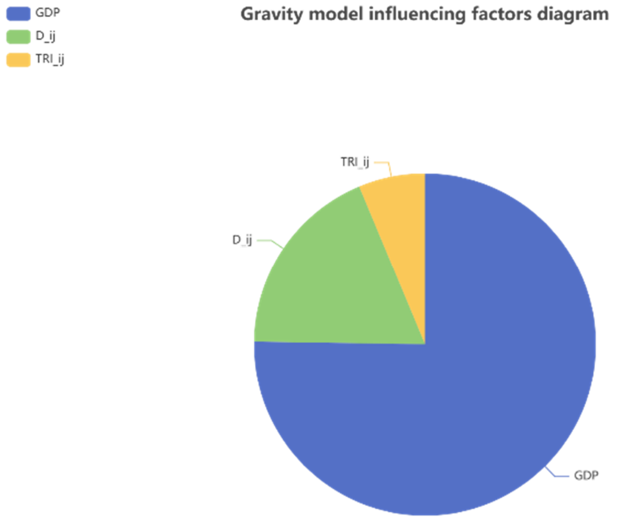

Fig. 1. Influencing factors of gravity model

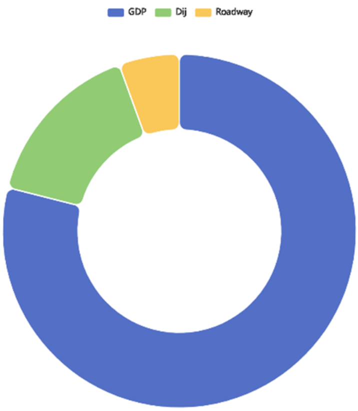

Fig. 2. Roadway impact diagram of gravity model

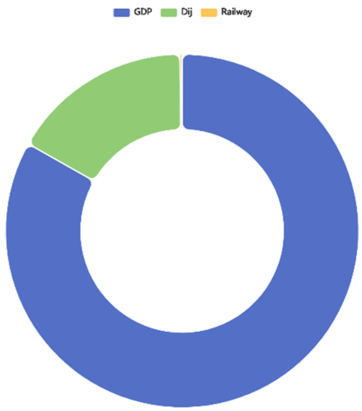

Fig. 3. Railway impact diagram of gravity model

Table 3. Table of regression results for the boundary effect model

Variant	Standard	TRIij	Roadway	Railway
GDP_i	1.25	1.0	1.0	1.35
	(1.252)	(0.966)	(0.919)	(0.708)
GDP_j	4.32	4.321	3.623	4.235
	(4.231)	(3.83)	(2.651)	(2.535)
D_{ij}	-0.541	-0.579	-0.156	-0.525
	(-0.341)	(-0.288)	(-0.347)	(-0.683)
TRI_{ij}		2.795e-15		
		(1.670e-15)		
Roadway			1.001	
			(0.710)	
Railway				0.01
				(0.003)
Bor	0.108	0.119	-0.01	0.101
	(0.106)	(0.918)	(-0.01)	(0.074)
Constant term	12.772	12.90	12.749	12.717
	(10.154)	(8.61)	(10.009)	(7.841)
R^2	0.752	0.798	0.828	0.731

Incorporating the effect of shared borders adjacent physically between China-ASEAN, and applying the boundary effect model, the regression results for each variable are presented in Table 3[9]. The findings indicate that both China's GDP and the GDP of ASEAN countries have a significant influence on trade cooperation. Notably, the GDP of ASEAN countries exerts a stronger impact on trade than that of China. The study further reveals that the distance between the countries has a significant inhibitory effect on trade volume. However, when considering the effect of roadway infrastructure, the negative impact of distance on trade volume decreases[10]. Overall, transport infrastructure moderately enhances trade, with roadway infrastructure having a more pronounced positive effect on trade between China and ASEAN countries, while the contribution of railway infrastructure to trade remains relatively weak.

The weak railway connection between China and ASEAN may be due to the fact that most of the terrains in ASEAN countries are tropical mountainous and hilly areas, such as Indo China Peninsula, where the terrains are complex and the mountains and rivers criss-cross, which greatly increases the difficulty and cost of railway construction, while the construction period is relatively long. The railway infrastructure of ASEAN countries is backward, and there are great differences in rail standards, transportation technology, and operation modes, which need to be coordinated and unified. Additionally, the railway systems of some countries are relatively old and have limited carrying capacity, which is difficult to meet the needs of cross-border railway transport.

4 Conclusions

In the context of close trade cooperation between China-ASEAN, this study analyzes the impact of transport infrastructure in the two regions by constructing a gravity trade model and a boundary effect model, using public databases such as UN Comtrade and the World Bank. The analysis concludes that transport infrastructure has a moderate impact on enhancing trade between China and ASEAN, with roadway infrastructure playing a notably stronger role in promoting trade, while railway infrastructure has a relatively weaker effect. The inclusion of the boundary effects show that, apart from roadway infrastructure, there is a facilitative impact on trade between the two regions. Based on these findings, the following recommendations are proposed:

(1) Enhance transport infrastructure connectivity to promote trade cooperation

Accelerating the development of cross-road railway projects will create a comprehensive railway transport corridor, reducing trade barriers between China-ASEAN. Furthermore, under the "Belt and Road" initiative, expanding maritime transport corridors will help form an efficient and integrated transport network.

(2) Maintain the advantages of roadway transport and upgrade the quality of the transport network

It is essential to maintain and expand existing roadway infrastructure to ensure accessibility to major trade routes. Roadway transport efficiency can be improved by reducing border barriers and simplifying procedures. Strengthening diplomatic ties between China and ASEAN countries will also reduce delays at customs and enhance the overall efficiency of trade-related transport.

(3) Develop railway facilities

China's railway transport is greatly developed, and the cost of railway transport is lower than that of road transport. Thus, railway transport in ASEAN countries has certain potential to promote trade between the two regions through the development of railway facilities in ASEAN countries.

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