How to Increase the Locational Value of Free-Trade Ports: Measurement of Boundary Effects in International Trade

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Abstract. Free-trade ports (FTPs) have become a means for China to promote economic upgrading, expand international trade, and attract foreign capital. Based on the variables of GDP, distance, language synergy, border conditions, and the exchange rates of trading countries, hypotheses are proposed regarding the influence of Chinese FTPs on the total import and export volume of foreign trade. The gravity model and convergence analysis are established based on the variables, and regression results are obtained using a varying coefficient model with panel data. The Levin–Lin–Chu test is used to test the hypotheses. Based on the results, it is concluded that the GDP, geographical distance, language synergy, and border conditions of Chinese FTPs and target countries significantly affect the import and export volume of foreign trade. Based on the findings, we make five suggestions for increasing the locational value of FTPs.

Keywords: Locational value · Free-trade port · Gravity model · Boundary effect · Bilateral trade

1 Introduction

China's economy has developed rapidly since the "reform and opening up," and many developed countries now regard China as a main competitor [1]. The free-trade zone (FTZ) initiative was proposed as part of a new round of reform and opening up. The previous work [2] showed that the locational value of FTPs can serve to promote economic integration. As artificial geographical elements, boundaries have significant effects on regional economic development as well as integration into the global economy. According to the principle of relative interests, countries produce goods with comparative interests based on different resource endowments. Considering the gaps between countries in terms of resource endowments and various costs, coupled with ongoing economic liberalization and reduced transportation costs, the manufacturing of various commodities is no longer limited to a single country. By leveraging the advantages of global supply chains, manufacturers can find the best combinations of production processes through

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multi-country participation and develop a production mode dominated by intermediate trade. This form of production facilitates economic integration between both developed and developing countries.

Convergence analysis and gravity models are normally used to measure boundary effects. With changes in the international industrial division of labour, the prosperity of intermediate trade means that traditional regional economic growth statistics do not truly reflect trade relations between countries. There is more duplication of accounting and overestimates of the amount of trade. Meanwhile, the foreign trade import and export volume of bilateral trade objects can more accurately reflect value creation in the value chain. Accordingly, gravity models and convergence analysis have been used to analyse the locational value of free-trade port areas (FTPAs). This study uses convergence analysis and a gravity model to measure boundary effects and identify ways to enhance the locational value of FTPAs.

2 Literature Review

The border effects between the cities and regions of different countries have attracted research attention. Borders can have a sizable negative effect on trade flow [3], and they have been repeatedly observed in various economies since 2001 [4]. Coughlin and Novy [5] estimate border effects in terms of spatial aggregation and find that aggregation leads to border effect heterogeneity. Kashiha et al. [6] find that border effects are nontrivial and asymmetric, even within the European free-trade zone. Campling et al. [7], meanwhile, evaluate the effects of EU bilateral free-trade agreements in terms of trade-labor linkages. Li et al. [8] find that the FTA relationship is associated with more bilateral cross-border mergers and acquisitions.

The gravity model has long been successfully used in economics research [9, 10]. The gravity model is probably best known in the context of international trade and capital flows between countries to analyze boundary effects between different countries. While economic factors such as tariffs and nontariff barriers have been included in gravity models, "noneconomic" factors have been used as well, such as cultural differences, religious differences, language similarities, colonial ties, institutional differences, and differences in technological development [11]. Kepaptsoglou et al. [12] review the recent literature on gravity models and provide an overview of FTA effects on international trade with gravity model-based analyses.

Okubo [13] revealing how biased interregional trade is compared with international trade. Kien [14] investigates the determinants of trade flows among ASEAN Free-Trade Area member countries and finds that export flows increase proportional to GDP. Yao et al. [15] examine the effect of FTAs on bilateral carbon emissions using a gravity framework. Gamassa and Chen [16] use a gravity model and the Hausman test to determine the important variables affecting bilateral trade between Côte d'Ivoire and China. Yuan [17] analyzes the double threshold of financial agglomeration affecting regional economic development.

Wan et al. [18] discusses the background of the Shanghai FTZ, while Yao and Whalley [19] use data from the Shanghai FTZ to investigate its objectives and why China introduced it. With the development of pilot FTZs, ports now have new opportunities to achieve high-quality development. With its geographical location, economic foundation, development support, and industrial services, Shanghai has the potential to display institutional innovation in the construction of pilot FTZs and FTPs [20]. Using a modified Delphi method, Deng, Wang, and Yeo [21] investigate the determinants of in-vestment in FTPAs from an enterprise perspective and find that the Shanghai Yangshan FTPA is the most preferred FTZ for investment. Liu, Wang, and Guo [22] use a super-SBM (slacks-based measure) model to analyze the technical efficiency of ports in six typical Chinese FTPAs from 2010 to 2017 to reveal their development status. Chen et al. [23], meanwhile, select six typical FTPAs in China's coastal areas to evaluate their development performance and propose measures for upgrading them.

From the perspective of service trade efficiency, Wang, Jiang, and Shan [24] compare the efficiency of Shanghai Port, Singapore Port, and Busan Port to identify ways to achieve the strategic goals of FTPs. Hsu, Huang, and Huynh [25] use fuzzy analytic hierarchy process to analyze the foreign direct investment performance of FTPAs. Huang et al. [26] evaluate the service quality of FTPAs using multilayer quality function deployment. Using panel data for 16 listed port companies in China during 2010–2016, Li, Liu, and Kong [27] study the influence and regional heterogeneity of FTZ policy. Tang et al. [2] proposes to enhance the locational value of the Ningbo–Zhoushan FTP. Fan et al. [28] select four Chinese seaports to explore the role of FTZs in promoting high-quality port development and boosting the coordinated development of ports and urban economies. He explores policies for promoting the growth of the Hainan FTP. He find that the economic fragmentation of the Yangtze River Economic Belt diverges significantly from the intention of the central government.

3 Model Analysis

3.1 Variable Selection

The gravity model is widely used to estimate static effects. Many variables affect locational value based on boundary effect measurement. Based on the gravity model and convergence analysis [9], the variables listed in Table 1 are chosen for this study. The outliers need to be processed, and the data need to be logarithmically calculated in the gravity model used to ensure the validity of the data.

3.2 Hypotheses

It is assumed that FTPAs, the economy, trade-target country GDP, geographical distance, language synergy, border situation, and exchange rate changes will affect foreign trade import and export volumes. Specifically, we propose the following:

H1: The larger the economic scale and total economic output of the trade-target country, the greater the comprehensive import capacity; the foreign trade import and export volume of the Chinese FTPA relative to the trade-target country will correspondingly become larger.

H2: Geographical distance, to some extent, reveals the effect of transport costs on bilateral trade. Based on the assumption of the gravity model, an increase in distance will hinder the growth of bilateral trade.

H3: Language and culture synergy refers to the common language and culture of two trade objects, which will reduce the cost of trade. This variable is conducive to increasing the foreign trade import and export of a certain trade-target country for China's FTPAs.

H4: Sharing borders will reduce transportation and communication costs and increase value-added services in the trade areas, which is conducive to increasing the foreign trade import and export of a certain trade-target country.

H5: Exchange rate changes will affect the flow of international funds. Exchange rate changes have a reverse effect on China's foreign trade import and export volume relative to a certain trade-target country.

3.3 Data Statistics

The explanatory variable of this study is the foreign trade import and export volume of Chinese FTPs relative to trade objects. Explanatory variable data are derived from data from 2002 to 2017. The data involve five variables and seven bilateral trade objects, mainly as panel data. In terms of similar language and culture, the value for synergy is 1; otherwise, 0. In terms of border connectivity, a shared border equals 1; otherwise, 0.

The US, Germany, Macao, Russia, South Korea, India, and Japan are selected as trade objects because China has frequent economic exchanges with them, and the likelihood of contact with China's main FTPAs is high. The distribution range is wide, spanning Asia, Europe, North America, and others. The dispersion is fairly open, and the distances and differences are large, indicating diverse representativeness.

3.4 Gravity Model

When measuring the flow of two trade objects, the gravity model needs to pay attention to the operability and rationality of the model's variable setting and sample screening. In a gravity model, the trade quota between countries is positively correlated with their economic development levels and negatively correlated with the distance between the two countries. The gravity model aims to fit the relationship between member countries, whether they belong to a free-trade area together based on the setting of virtual variables and whether the trade-creation effect between member countries and the effect size can be reflected by the virtual variable coefficients. The equation for the gravity model is as follows:

$$X_{ij} = \alpha \cdot Y_i^{\alpha_1} \cdot Y_j^{\alpha_2} \cdot D_{ij}^{\alpha_3} \tag{1}$$

where X_{ij} is the trade volume between countries i and j, Y_i is the domestic GDP, Y_j is the GDP of the trading countries, D_{ij} is the distance between China and the trading countries, and α_1, α_2, and α_3 are the corresponding coefficients.

More factors are taken into account. Specifically, language synergy, border situation, and exchange rate are added to the variables to explore the variables influencing port locational value with the modified gravity model.

To form the final gravity model, we integrate and simplify the employed models and merge or delete some unnecessary variables. Since the index of GDP product and of per capita GDP product have repeatability, we combine the two. The new variable is the GDP of bilateral trade countries. Thus, the gravity model is finally set as

$$\begin{aligned} lnFV_{ijt} &= \beta_0 + \beta_1 \ln\left(Y_{jt}\right) + \beta_2 \ln\left(Dist_{ij}\right) \\ &+ \beta_3 Comlang_{ij} + \beta_4 ComBorder_{ij} + \beta_5 VolatilityEx_{ijt} + \mu \end{aligned} \tag{2}$$

where FV denotes the import and export volume of foreign trade, i denotes China's FTPA, j denotes different import objects, t denotes time, Y_{jt} denotes the GDP of trade objects, $Dist_{ij}$ denotes the distance between the two trade objects, $Comlang_{ij}$ denotes common language and culture between the two trade objects, $ComBorder_{ij}$ denotes a common border between two trade objects, and $VolatilityEx_{ijt}$ denotes the change in exchange rate.

3.5 Convergence Analysis

As one method for measuring boundary effects, convergence analysis is based on the framework of conditional β convergence analysis and is carried out using the Barro regression equation. Conditional β convergence can be understood as follows: the development speed of different regions is roughly proportional to the distance. Through variable substitution, longitudinal and transverse comparisons within the same framework can be realized. The Barro regression equation is as follows:

$$g_{i,t,t+T} = \alpha_i + \beta_i \ln\left(y_{i,t}\right) + \psi_i X_{i,t} + \mu \tag{3}$$

where β is the coefficient; $\beta < 0$, t are, respectively, the growth rate of foreign trade import and export volume of China's FTP and bilateral trade object countries at expiration from t to $t + T$; α_i is a constant term; Ψ_i is a set of coefficients; μ is an error term; and $y_{i,t}$ is the GDP scale of China's FTP at time t.

Then, we have the following:

$$\begin{aligned} \left[\mathrm{In}(y_{t+T}) - \ln(y_t)\right] &= a_0 + a_1(\ln(y_{i+T}) - \ln(y_i)) \\ &+ \alpha_2 CL + \alpha_3 distance + \alpha_4 CB + \mu \end{aligned} \tag{4}$$

where $\ln(y_{t+T}) - \ln(y_t)$ denotes the growth rate of foreign trade import and export, $\ln(y_{i+T}) - \ln(y_i)$ notes the logarithmic difference of GDP, distance is the distance variable, the virtual variable CL represents language synergy, CB represents the boundary condition, μ is the error term, and α_1, α_2, and α_3 are the coefficients to be measured.

4 Empirical Analysis of China's FTPAs

4.1 Regression Results

We use panel variable coefficient estimation and Stata 15 software to analyze the panel data samples of seven trade-object countries or regions from 2002 to 2017. Five related variables of China's trade import and export to bilateral trade objects are also statistically analyzed. Table 1 shows the regression results. Because of the discovery of self-related benefits in the analysis process, we use the panel data analysis method to analyse the data.

Table 1. Variable coefficient regression results for the panel data

Explanatory variable	Coefficient	t-value	Prob.
GDP of target countries	0.8586987	13.22	0.000
Geographical distance	−71.73953	−4.22	0.004
Language synergy	101.8043	3.89	0.006
Boundary situation	−10.42635	−1.54	0.167
Exchange rate	−0.0393599	−1.19	0.274
Canada.id	8.363057	4.25	0.004
India.id	57.62005	3.14	0.016
Korea.id	−52.14901	−3.90	0.006
Germany.id	−29.89025	−6.51	0.000
Japan.id	0		
Australia.id	0		
USA.id	0		
Canada.lngdp	0.727822	11.88	0.000
India.lngdp	0.0277423	17.18	0.000
Korea.lngdp	0.1041626	5.40	0.001
Germany.lngdp	0.1045347	13.58	0.000
Japan.lngdp	0.960787	6. 72	0.000
Australia.lngdp	0.344041	22.55	
USA.lngdp	0.1354909	8.65	0.000
Year	0.036893	3.54	0.009
Cons	550.2002	3.26	0.014
R-squared	0.983		
Sample number	128		

4.2 Analysis of Panel Data Variable Coefficient Regression

As indicated by the regression analysis result of the gravity model, R2 = 0.983, the pruned gravity model fits the study samples very well. Under the significant condition of 1%, trade target GDP, geographic distance, and language synergy have significant effects on the added value of the foreign trade imports and exports of FTPAs relative to other trade-target countries. For every 1% increase in GDP, the foreign trade import and export volume will increase by 0.86%. For every 1% difference in distance, the import and export volume of foreign trade will decrease by 71%. Countries with high language synergy are 100 times more remarkable than those with low language synergy. Borders are 1 to 0, and the volume of foreign trade import and export is smaller. Non-borders are 10 times higher than borders, but they are not significant. The higher the exchange rate, the smaller the volume of foreign trade imports and exports; however, it is not significant.

For every dollar increase in the exchange rate, the value of foreign trade imports and exports will decrease by 3.9%. Assuming other variables are fixed, the foreign trade import and export volume of China's FTPs relative to a certain trade-target country has a certain positive correlation with the GDP and language synergy of the trade-target country, but it is also related to the distance between the country and the exchange rate. The variables have a negative correlation. Then, the formula can be written as:

$$\begin{aligned} V_{ijt} &= 3.26 + 0.86\ln\left(Y_{jt}\right) - 71.74\ln\left(Dist_{ij}\right) \\ &+101.80\ln\left(CL_{ij}\right) - 10.43\ln\left(CB_{ij}\right) - 0.04\ln\left(VE_{ijt}\right) + \mu \end{aligned} \tag{5}$$

In the same way, we can get the variable coefficient regression results for the convergence analysis panel data.

4.3 Analysis of Panel Data Variable Coefficient Regression

The regression analysis result of the convergence analysis is R2 = 0.7111. This verifies that the sample fitting effect is very good after pruning. In the significant case of 1%, the logarithmic difference of trade-target GDP, geographic distance, language synergy, and borders have a significant effect on the added value of the foreign trade imports and exports of FTPAs relative to other trade-target countries. For every 1% increase in differential economic growth, the growth rate of foreign trade imports and exports increases by 0.83%. For every 1% increase in distance, the growth rate of foreign trade imports and exports decreases by 0.53%. The growth rate of foreign trade imports and exports with high language synergy increases by 0.80%. The growth rate of foreign trade imports and exports near the border drops by 0.28%. Assuming other variables are fixed, the increase in the foreign trade import and export volume of China's FTPAs relative to a certain trade partner country is proportional to the logarithmic difference of the trade partner country's GDP and language synergy. This is proportional to the distance between the two trade partners and the borders. Changes in exchange rates are inversely proportional. Thus, the formula can be written as:

$$\begin{aligned} &\left[\ln(y_{t+T}) - \ln(y_t)\right] = 58.07 + 0.83(\ln(y_{i+T}) - \ln(y_i) \\ &+0.80CL + 0.53distance + 0.28CB + \mu \end{aligned} \tag{6}$$

4.4 Test

To ensure the reliability of the panel data calculations, it is necessary to perform stationarity verification on the sequence on the panel. Following Zhang et al. (2013), we test the main panel root using the Levin–Lin–Chu (LLC) test. The LLC formula is

$$\Delta y_{it} = \rho_i y_{i,t-1} + \sum\nolimits_{L=1}^{Pi} \theta_{iL} \Delta y_{i,t-L} + \alpha_{mi} d_{mt} + \varepsilon_{it}, m = 1, 2, 3 \tag{7}$$

where m = 1,2,3, pi ≤ 0. The t-statistics obey the distribution N(0,1).

5 Conclusion

The rise of China's economy has attracted investment from many developed countries, resulting in rapid industrial progress. In recent years, the production supply chain has seen shifts from partnerships to competitive relationships with certain developed countries. The economic competition and cooperation relationships between Japan, South Korea, and China have quietly changed. With the form of the international industrial division of labor having changed significantly, the prosperity of intermediate trade has made traditional regional trade statistics unable to truly reflect trade relations between countries. As a result, there are problems of repeated accounting and the overestimation of trade amounts. Meanwhile, the import and export volume of foreign trade can more accurately reflect the value creation of a region in the value chain. Based on the gravity model in the boundary effect measurement method, convergence analysis has become a tool for analysing the value promotion of FTPs.

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