

Study on the Impact of Trade Facilitation on China's Exports in BRICS Member Countries

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Abstract: Under the guidance of the BRICS spirit of openness, inclusiveness, and win-win cooperation, BRICS economic and trade cooperation has flourished at , has completed the historic expansion of its membership at , and has attracted many partner countries to deepen deal of their collaboration at , which has attracted a great attention from the international community. This paper constructs and measures the trade facilitation index of based on the 2010-2019 data of BRICS member countries, and further explores the impact of trade facilitation index of each country on China's exports by extended gravity model. It is found that the overall level of is not high and the differences are significant, and trade facilitation of BRICS member countries has a significant promotion effect on China's exports, and there is heterogeneity in the promotion effect of on China's exports, among which the quality of infrastructure and the customs efficiency of have the most significant impact. services Lower income level member countries have a higher marginal gain for China's exports by improving their trade facilitation index.

Keywords: BRICS, Trade Facilitation, Expanding Trade Gravity Model, Export Trade

1. Introduction

General Secretary Xi Jinping pointed out at the 16th meeting of the leaders of the BRICS countries that “the BRICS cooperation mechanism is the most important platform for solidarity and cooperation among emerging market countries and developing countries in today's world, and is a pillar force in promoting the realization of an equal and orderly multipolarization of the world and a universal and inclusive economic globalization.” On January 1, 2024, with Saudi Arabia, Egypt, the UAE, Iran and Ethiopia becoming full members, BRICS achieved a historic expansion of its membership. In January, 2025, Indonesia formally joined the BRICS Cooperation Mechanism, further expanding the number to 11 of member countries. It has established a new and more inclusive pattern of “Greater BRICS Cooperation” and established its status as a core international mechanism representing countries of the Global South. The expansion has significantly enhanced the representation and voice of BRICS countries in global economic governance, and strengthened their economic influence and radiation effects in key regions such as the Middle East, Africa and Latin America, marking the entry of South-South cooperation into a new stage of more in-depth and comprehensive cooperation. As the core promoter of BRICS cooperation, China's trade with other member countries continues to grow. In 2024, China's exports to other BRICS countries amounted to 3.92 trillion yuan, a year-on-year increase of 10.86 %, accounting for 15.4 % of China's total foreign trade.

This paper empirically examines the differential impact of trade facilitation on China's exports under the heterogeneity of BRICS member countries by constructing a composite index of trade facilitation covering four aspects: quality of infrastructure, efficiency of customs services, judicial regulatory environment, and the degree of digital financial inclusion and incorporating it into an extended gravity model. The study aims to answer the following questions: How is the index of trade facilitation measured in BRICS member countries? How does trade facilitation promote China's exports in the expanded BRICS framework? Does its effect on China's export promotion show heterogeneity due to the differences in the economic structure of the member countries? The findings of this paper will provide empirical support for China's promotion of BRICS economic and trade cooperation and optimization of regional cooperation paths, and provide differentiated strategy suggestions for the new pattern of "Greater BRICS Cooperation", so as to promote the synergistic development of trade facilitation in BRICS countries.

2. Literature review

At present, economic globalization continues to drive global economic and trade demand upward, but traditional tariff and non-tariff barriers remain high, countries are still faced with backward infrastructure construction, cumbersome customs procedures, differences in the regulatory environment and the digital divide and other hidden obstacles, international trade is faced with many challenges. Against this background, countries around the world are actively promoting the process of, seeking to promote the trade facilitation of factors of production international. Trade facilitation has become a hotspot of academic attention, providing theoretical support and practical guidance for solving global trade problems.

2.1. Study on the measurement of trade facilitation levels

Regarding the measurement of the index of trade facilitation, the academic community has not yet formed a unified standard. The construction of trade facilitation indicator system can be traced back to the pioneering study by Wilson [1, 2], which firstly systematically quantified the trade facilitation index of APEC countries by constructing a four-dimensional indicator system covering port efficiency, customs environment, government regulation and e-commerce. In recent years, related studies have been deepening and expanding. Kong Qingfeng [3] and Li Baomin [4] integrate indicators of customs efficiency, logistics infrastructure, regulatory environment and financial support in the study of "the Belt and Road", while Cheng Huifang [5] combine the needs of digital trade facilitation and systematic openness to construct an evaluation system that better adapts to the high standards of trade and economic rules. Meanwhile, scholars at home and abroad have constructed trade facilitation index measurement models based on their respective frameworks using different methods, such as principal component analysis [6], entropy value method [7], and OECD standardized index application [8].

2.2. Study on the trade effects of trade facilitation

The trade effect of trade facilitation is a hot area of research at home and abroad, and most scholars have concluded the positive effect of trade facilitation on trade through different methods and models. In macro country studies, scholars such as Liao Jia [9], Kang Wenmei [10] and Ren Wei [11] found through empirical studies that the increase in the index of trade facilitation has a significant positive impact on the international trade and economic cooperation of the countries along the "Belt and Road". Li Jialin [12], Hao Hanyu [13] and Yan Nan [14] use the gravity model to study RCEP member countries and find that improving trade facilitation can promote economic and trade cooperation between China and other RCEP member countries. In the study of specific industries or indicators ,

Fang Yue [15] found that trade facilitation can significantly promote agricultural export by reducing transaction costs and institutional barriers the growth of trade ; Zheng Yueming [16] found that trade facilitation is conducive to promoting the enhancement of export technological sophistication ; Tang Rui [17] pointed out that the of trade facilitation balanced development has a significant effect on the coordinated development of the international tourism industry .

To summarize, academics have not yet formed a unified view measurement of trade facilitation index. Existing studies mainly focus on “the Belt and Road” countries along the route, RCEP and other regions, and the trade facilitation of the BRICS countries, especially after the expansion of the membership to 11 countries is not sufficiently explored. Based on the inheritance of existing research, this paper constructs for the first time a trade facilitation indicator system covering the new member countries, and adopts the extended gravity model to quantify the impact of heterogeneity, so as to provide data support for the trade cooperation policies of BRICS countries after the expansion of their membership, and to provide theoretical reference for developing countries to promote the upgrading of their export structure and integration into the global value chain through trade facilitation, so as to help the high quality development under the framework of “South-South Cooperation”.

3. Construction and measurement of trade facilitation indicators

In accordance with the principles of scientific, systematic and operability, and taking into account the specific economic and trade development characteristics of the BRICS countries and the core provisions of WTO Trade Facilitation Agreement, this paper, based on the research framework of Wilson[1, 2], selects four first-level indicators of quality of infrastructure(P), efficiency of customs services (C), judicial and regulatory environment (R), and digital financial inclusion (F) , which are further refined into 16 second-level indicators. See Table 1 for details.

Table 1: Trade facilitation indicator components and data sources

First-level indicators	Second-level indicators	Range	Data sources
Quality of infrastructure	Quality of port infrastructure	1-7	GCR
	Quality of air transportation infrastructure	1-7	GCR
	Quality of rail transportation facilities	1-7	GCR
	Quality of road transport facilities	1-7	GCR
Efficiency of customs services	Prevalence of non-tariff barriers	1-7	GCR
	Burden of customs procedures	1-7	GCR
	Illegal expenses and bribes	1-7	GCR
	Customs clearance efficiency	1-5	WDI
Judicial and regulatory environment	Burden of government regulations	1-7	GCR
	Legal efficiency	1-7	GCR
	Judicial independence	1-7	GCR
	Dispute resolution efficiency	1-7	GCR
Digital financial inclusion	Number of Internet users	1-100	GCR
	Availability of state-of-the-art technology	1-7	GCR
	Availability of financial services	1-7	GCR
	Affordability of financial services	1-7	GCR

Note: Due to the fact that clearance efficiency data are only published in even-numbered years and the Global Competitiveness Report was revamped between 2010-2019, some data are missing and have been replaced by linear interpolation.

Due to the different dimension of the second-level indicators, in order to eliminate the influence, this paper adopts the extreme value standardization method to process the data, the formula is as follows. X_i refers to the original value of the second-level indicator, X_{min} refers to the minimum value of the indicator, X_{max} refers to the maximum value of the indicator, and X^* is the value after standardization.

$$X^* = (X_i - X_{min}) / (X_{max} - X_{min}) \quad (1)$$

In order to accurately construct trade facilitation indicators for in-depth research, this paper uses principal component analysis to downsize and assign weights to the data. First KMO and Bartlett's test of sphericity are performed, and the calculation yields a KMO value of 0.877 and $P > 0.001$, indicating that there is a significant correlation between the variables, which is suitable for principal component analysis. Following the principle of principal component extraction with eigenvalue greater than 1, the first two principal components are selected, and the cumulative variance contribution rate reaches 77.3%, followed by dividing the contribution rate of the two principal components by the cumulative contribution rate, then multiplying the value by the two coefficients corresponding to each secondary indicator and summing them up, and finally carrying out the normalization process, the comprehensive evaluation system of trade facilitation obtained is as follows:

$$TFI = 0.0775P_1 + 0.0613P_2 + 0.0534P_3 + 0.0736P_4 + 0.0728C_1 + 0.0795C_2 + 0.0729C_3 + 0.0628C_4 + 0.0682R_1 + 0.0609R_2 + 0.0630R_3 + 0.0665R_4 + 0.0477F_1 + 0.056F_2 + 0.037F_3 + 0.0471F_4 \quad (2)$$

Summing the values of the secondary indicators included in each first-level indicator yields the weights of the five first-level indicators as 0.2658, 0.2880, 0.2585, and 0.1877, respectively, thus obtaining the evaluation system of the level 1 indicators as follows:

$$TFI = 0.2658P + 0.288C + 0.2585R + 0.1877F \quad (3)$$

The secondary indicators of the 11 BRICS member countries were brought into the TFI formula calculation respectively to obtain the trade facilitation index and the ten-year average value of BRICS member countries, which are shown in Table 2.

Table 2: Trade Facilitation Index (TFI) of BRICS member countries

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
China	0.501	0.511	0.495	0.504	0.507	0.495	0.534	0.564	0.554	0.554	0.522
United Arab Emirates	0.851	0.828	0.876	0.902	0.917	0.919	0.932	0.933	0.848	0.885	0.889
Egypt	0.408	0.365	0.322	0.288	0.325	0.348	0.366	0.426	0.441	0.474	0.376
Ethiopia	0.297	0.256	0.208	0.204	0.201	0.244	0.304	0.268	0.266	0.228	0.248
Brazil	0.289	0.286	0.276	0.265	0.237	0.214	0.183	0.197	0.195	0.18	0.232
Russia	0.198	0.178	0.177	0.232	0.292	0.297	0.306	0.344	0.382	0.397	0.28
South Africa	0.602	0.606	0.63	0.66	0.642	0.632	0.677	0.541	0.494	0.509	0.599
Saudi Arabia	0.682	0.744	0.704	0.651	0.608	0.617	0.602	0.594	0.61	0.675	0.649
Iran	0.246	0.242	0.278	0.262	0.226	0.26	0.287	0.314	0.306	0.253	0.267
India	0.454	0.425	0.434	0.443	0.387	0.434	0.542	0.543	0.548	0.524	0.473
Indonesia	0.38	0.356	0.365	0.409	0.443	0.416	0.424	0.469	0.484	0.489	0.424

Currently, it is generally recognized that the index of trade facilitation is graded as follows: $TFI > 0.8$ is very facilitative, $0.7 < TFI < 0.8$ is relatively facilitative, $0.6 < TFI < 0.7$ is generally facilitative, and $TFI < 0.6$ is not facilitative.

The study found that among the BRICS members, only the ARE has reached the very convenient level, and Saudi Arabia is in the average convenient range. The other member countries are in the unfavorable trade facilitation index. China is at the top of the list of BRICS member countries, but there is still a lot of room for improvement. From the perspective of development, different countries show different trade facilitation development due to different economic development conditions, Russia's growth is the strongest, China, India, and Indonesia and other countries have also achieved varying degrees of increase in trade facilitation index; however, Brazil and Saudi Arabia have seen a relatively large decrease; African countries, such as Egypt and Ethiopia, are hovering at a relatively low level, fluctuating and fluctuating. It can be seen that the index of trade facilitation in BRICS countries is generally low and there are large differences, some countries have achieved phased improvement through active reform, but some countries continue to decline or maintain a low level of fluctuations due to structural problems. In the face of this situation, the BRICS countries urgently need to strengthen cooperation and jointly promote the improvement of trade facilitation through the BRICS cooperation mechanism.

4. Impact of trade facilitation in other BRICS member countries on China's exports

4.1. Construction of trade attraction models and data sources

In order to empirically test the impact of trade facilitation index of BRICS member countries on China's exports, this paper introduces indicators such as trade facilitation (TFI), population size (POP), and trade dependence (DFT) on the basis of the classic gravity model, and constructs an extended trade gravity model as follows:

$$\ln EXP_{it} = \beta_0 + \beta_1 TFI_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln POP_{it} + \beta_4 \ln DISCAP_i + \beta_5 \ln EXCH_{it} + \beta_6 RG_{it} + \beta_7 RL_{it} + \beta_8 HDI_{it} + \beta_9 DFT_{it} + \varepsilon_{it} \quad (4)$$

Among them, EXP_{it} is the explanatory variable, denoting the volume of China's export trade to country i in period t ; TFI_{it} is the core explanatory variable, referring to the index of trade facilitation in country i in period t ; control variables include country i 's GDP in period t (GDP_{it}), the total population (POP_{it}), the efficiency of regulation (RG_{it}), the rule of law (RL_{it}), the human development index (HDI_{it}), and the degree of trade dependence (DFT_{it}), $DISCAP_i$ denotes the geographic distance of the capital city of country i to Beijing, and $EXCH_{it}$ denotes the exchange rate of country i 's currency to RMB in period t . β_0 is the constant term and $\beta_i (i=1,2,\dots,9)$ is the regression coefficient of each explanatory variable, and ε_{it} is the random error term. The expected signs of specific variables, data sources and descriptive statistics are shown in Table 3.

Table 3: Description of variables and descriptive statistics of the trade attraction model

variable name	Expected Symbol	average value	standard deviation	minimum value	maximum values	Data sources
export		2.58E+10	1.7E+10	885000000	7.67E+10	UN COMTRADE
tfi	+	0.44	0.21	0.18	0.93	The preceding calculation yields
gdp	+	9.37E+11	7.91E+11	2.99E+10	2.84E+12	WDI
pop	+	230000000	372000000	6870000	1.39E+09	WDI
discap	-	7745.5	3692.58	3782	16934	CEPII
exchange	+	571.5	1345.27	0.26	6176.63	Calculated from WDI data
rg	+	-0.29	0.63	-1.71	1.1	WGI

Table 3: (continued)

rl	+	-0.26	0.46	-1.05	0.82	WGI
hdi	+	0.72	0.12	0.41	0.92	UNDP
dft	+	57.93	36.97	22.77	170.98	WDI

4.2. Empirical testing and analysis of results

Based on the trade gravity model, this paper constructs a random effects model for empirical testing. Firstly, we regress China's export volume with the trade facilitation index (TFI) as the core explanatory variable to test whether trade facilitation has a significant positive effect on exports; next, we regress each first-level indicator as the core explanatory variable respectively to test whether there is heterogeneity in the effect on exports. The specific results are shown in Table 4.

The results of model 1 show that the coefficient of trade facilitation is significantly positive, the development of trade facilitation significantly contributes to the increase of China's exports. The coefficient of control variables such as GDP, population, exchange rate, regulatory efficiency, human development index and trade dependence is significantly positive, shows that the factors of consumption capacity, market size, the relative price advantage of China's products, and the propensity to export are the important influencing factors of China's exports. The coefficient of the legal system is significantly negative, referring to the viewpoint of Wang Mingjin [18], it may be due to the overprotection of intellectual property rights of enterprises, resulting in the leading excessive monopoly effect of the market of the enterprises, inhibiting the innovation momentum of other enterprises, resulting in the reduction of the potential exporters, impeding the sustained growth of the foreign exports. The positive coefficient of geographic distance between capitals is mainly due to the unprecedented development of logistics and transportation technology at , which has led to a significant drop in international transportation costs, and the influence of distance on exports has been declining.

The results of Model 2-5 show that the regression coefficients of all four first-level indicators are significantly positive. The quality of infrastructure and the efficiency of customs services have significant export promotion effects at the 1% confidence level, suggesting that the host country's strengthening of infrastructure and simplifying the customs process will be conducive to the growth of China's exports. The coefficient of digital financial inclusion is significant at the 5% level, indicating that the improvement of digital financial inclusion in the host country will promote the further growth of China's foreign exports. The coefficient of on the regulatory environment is significant at the 10% level, and has a positive effect on China's exports.

Table 4: Model regression results

variant	Model 1 (TFI)	Model (P)	Model 3 (C)	Model 4 (R)	Model 5 (F)
tfi	0.9261 ***				
tfi_p		2.5637 ***			
tfi_c			2.6433 ***		
tfi_r				1.5673 *	
tfi_f					2.7123 **
lngdp	0.5251 ***	0.3701 ***	0.4385 ***	0.4315 ***	0.4894 ***
lnpop	0.3562 ***	0.3601 ***	0.2776 ***	0.3295 ***	0.3023 ***
lndiscap	0.1764	-0.05281	-0.0506	0.02466	0.08977
lnexch	0.03877 ***	0.02627 ***	0.03231 ***	0.03641 ***	0.04409 ***
rg	0.1902 **	0.2457 ***	0.2016 ***	0.2098 **	0.1673 *

Table 4: (continued)

rl	-0.3111**	-0.06029	-0.04176	-0.03873	-0.01032
hdi	2.1293***	3.4236***	2.7233***	2.7446***	2.5920***
dft	0.009905***	0.005435***	0.004389**	0.007827***	0.007866***
constant					
term	-5.7073***	-1.4678	-0.6303	-2.2253	-3.3026**
(math.)					
sample					
size	100	100	100	100	100

Note: t-statistics are in parentheses, * indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$.

4.3. Model robustness tests

To alleviate the potential endogeneity problem, this paper introduces the lagged term as an instrumental variable for robustness testing. As the inter-annual variation of TFI values is small, this paper selects the four-period lagged values of TFI values for regression, and the results are significantly positive at the 5% level, indicating that the positive impact of trade facilitation on exports is robust. To further ensure the reliability of the estimation results, this paper uses the lagged terms of each level of indicators for regression. The results show that the coefficients of the lagged terms of each level of indicators are basically consistent with the original model estimation results, indicating that the endogeneity problem has a limited impact on the model estimation results, and the random effect model is more robust.

Table 5: Robustness test results

Variant	Model 1	Model 2	Model 3	Model 4	Model 5
L4.tfi	0.7670**				
L.tfi_p		1.9512**			
L.tfi_c			2.3860***		
L.tfi_r				0.266	
L.tfi_f					2.2107*

Note: * indicates $p < 0.1$, ** indicates $p < 0.05$, *** indicates $p < 0.01$

In order to further verify the robustness of the model, this paper conducts two sets of alternative tests. First, the regression analysis is re-conducted by replacing exports with trade volume as the explanatory variable, and the results show that the coefficient of TFI is still significantly positive and the estimation results of other related indicators have not changed significantly, indicating that the model estimation results are robust to the selection of explanatory variables. Secondly, this paper replaces TFI with Logistics Performance Index (LPI) for regression analysis. The results show that the coefficient of the LPI index passes the test at the 1% significance level, further confirming the robustness of the model in this paper. In summary, through the above alternative tests, the research conclusions of this paper are fully verified, and the model has high robustness and reliability.

4.4. Heterogeneity test

Due to the large differences in the level of economic development among the BRICS countries, this paper further explores the impact of heterogeneity of trade facilitation indicators in countries with different income levels. According to the World Development Indicators (issued by the World BankWDI) standard, this paper categorizes high-income countries and upper-middle-income countries into the higher-income country group, and low-income countries and lower-middle-income

countries into the lower-income country group, and carries out the regression analysis for the two groups of countries separately, and the results are shown in Table 6. The results show that the impact of trade facilitation on China's exports is significantly positive in countries of different income levels, but the degree of influence varies. Specifically, lower-income countries have on China's exports a greater impact by improving trade facilitation, which may be due to the fact that lower-income countries have a relatively lagging infrastructure at, and non-tariff barriers at are more complex at , so that the marginal gains from improving trade facilitation index are higher.

Table 6: Results of heterogeneity test

Variant	Higher income countries	Lower-income countries
tft	0.8026*	1.7278*
lngdp	0.6349 ***	2.3880 ***
lnpop	-0.02883	-5.6695
lndiscap	0.6505 ***	-12.033
lnexch	0.1410***	1.2087
rg	0.9145 ***	-0.2564
rl	-1.0148 ***	-0.1094
hdi	3.9935 ***	-11.327*
dft	0.004611**	0.003961
cons	-6.3264**	191.16

Note: t-statistics are in parentheses, * indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$.

5. Conclusions and insights

5.1. Conclusions of the study

This paper constructs a trade facilitation index system and measures its level using principal component analysis based on 2010-2019 panel data of BRICS member countries, analyzes its impact on China's exports by expanding the gravity model, finds:(1) The index of trade facilitation varies in BRICS member countries greatly, with most of them at a lower stage. However, the overall effect on China's exports is significant. When other conditions remain unchanged, for every 1% increase in the trade facilitation index of the host country, China's exports to it will increase by 0.9261%.(2) There is heterogeneity in the impact of each index of trade facilitation indicators on China's exports. Among them, the efficiency of customs service (C) and the degree of digital financial inclusion (F) have the most significant promotion effect.(3) The impact of trade facilitation on China's exports is also heterogeneous across different economic countries at levels of development . The effect of trade facilitation on China's exports is greater in lower-income countries than in higher-income countries.

5.2. Policy implications

(1) Deepen cooperation in multilateral mechanisms to promote trade facilitation construction

Against the backdrop of the current headwinds of economic globalization, BRICS economic and trade cooperation, as a "ballast" and "propellant", should be further deepened on the basis of the existing cooperation mechanism. On the one hand, we should make every effort to promote the deepening of BRICS cooperation, deepen the strategic partnership, jointly build an open world economy, promote the liberalization and facilitation of trade and investment, and make joint efforts to build a new global value chain. On the other hand, we will strengthen in-depth cooperation on trade facilitation, regularly assess the progress of member countries in infrastructure, customs efficiency

and other key indicators, explore the interconnection of electronic ports, strengthen policy coordination and realize efficient connectivity of the industrial chain and supply chain.

(2) Strengthening regional cooperation among BRICS countries, with a focus on supporting low-income member countries

Within the framework of BRICS, there are significant differences in the development status of member countries. On the basis of shared resources, complementary advantages and synergistic development, support for trade facilitation in lower-income member countries should be emphasized. Through the BRICS and New Development Bank, we should expand low-interest loans to low-income countries, promote the flow of technology, capital, human capital and other factors of production, and help Egypt, Ethiopia and other countries to raise the index of trade facilitation and reduce trade costs, so as to enhance the overall efficiency and competitiveness of the BRICS countries.

(3) Refine the direction of BRICS cooperation and implement precise measures in areas.

With regard to the trade facilitation system, we will enhance the index of trade facilitation in member countries at different levels. In the field of infrastructure, we will jointly carry out the upgrading of the Eurasian Railway trunk line with Russia, take advantage of China's infrastructure to build regional logistics centers, and accelerate the construction of BRICS land corridors. In the area of customs efficiency optimization, we will promote China's "Single Window" model, accelerate the interconnection of data at the ports of member countries, and implement fast customs clearance for enterprises of member countries that meet the AEO mutual recognition standard. In terms of digital financial inclusion, we will promote the development of BRICS Pay and expand the use of RMB in bulk trade settlement in member countries.

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