ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

Efficiency and Potential of China's Timber and Wood Products Exports to RCEP Members: A Stochastic Frontier Gravity Analysis

Jionglin Li

College of Economics and Management, South China Agricultural University, Guangzhou, 510642, China

Abstract: *This study employs a stochastic frontier gravity model to examine the export efficiency of China's timber and wood products trade with Regional Comprehensive Economic Partnership (RCEP) member countries from 2012 to 2021. The analysis provides insights into the market potential and trade prospects for China's timber and wood products exports. The results indicate that the average export efficiency of China's timber and wood products trade with RCEP partners is 0.18 over the sample period. Significant heterogeneity exists in trade efficiencies across countries, suggesting substantial untapped export potential. China's timber and wood products exports are positively associated with the economic mass of RCEP members as well as China, but negatively correlated with differences in population and per capita forest resources between trade partners.*

Keywords: *RCEP member countries; Timber and wood products; Export efficiency; Export potential; Stochastic; frontier gravity model*

1. Introduction

The Regional Comprehensive Economic Partnership (RCEP) is a free trade agreement between the 10 ASEAN countries, China, Japan, South Korea, Australia and New Zealand, comprising a total of 15 countries that aims to promote economic integration and development in the Asia-Pacific region. Timber and wood products exports are an important component of China's economic growth, with RCEP countries representing major export markets. The timber and wood products trade is significant in RCEP member negotiations. In 2021, RCEP members accounted for 0.882 billion people, comprising 10.9% of the global population, and US$23 trillion in GDP, constituting 27.2% of the world economy. China's total timber and wood products exports reached US$18.613 billion, of which exports to RCEP partners were US$5.528 billion, making up 29.7%.

The implementation of the RCEP will provide a platform for further strengthening cooperation and elevating trade development among member states. Thus, evaluating China's timber and wood products export efficiency with RCEP members and future potential offers value in promoting export channel diversification and trade facilitation with partner countries. This study seeks to quantify the China's timber and wood product's industry export efficiency issues and calculates trade potential with the RCEP members through a stochastic frontier gravity model.

2. China's Timber and Wood Products Exports to RCEP Member Countries

In recent years, the proportion of China's timber and wood products exports to RCEP member countries relative to total Chinese timber and wood products exports has steadily increased. As shown in Table 1, the share of China's timber and wood products exports to RCEP partners in total global timber and wood products exports rose from 25.8% in 2012 to 31.4% in 2020, before slightly decreasing to 29.7% in 2021. The proportion has remained relatively stable over the period.

From 2012-2021, China's average annual growth rate of timber and wood products exports to RCEP members was 6.8%, higher than the 5.4% growth in total global timber and wood products exports. This indicates China's timber and wood products export volumes to RCEP partners have expanded year-on-year. As RCEP members are predominantly developing countries with relatively low industrial levels, Chinese timber and wood products possess certain comparative advantages and pricing power in these markets. Additionally, the short transportation distance can save export costs,

ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

improve the level of export foreign exchange, and it should expand the export scale of timber and wood products to RCEP member states.

Table 1 Analysis of China's timber and products export data for RCEP member countries and global markets

Year	China's Exports of timber and Products to RCEP member countries (US $100 million)	China's exports of timber and products to the world (US $100 million)	Proportion of the former in the latter (%)
2012	31.72	123.15	25.8
2013	33.89	127.48	26.6
2014	37.72	144.70	26.1
2015	35.94	141.99	25.3
2016	35.24	135.44	26.0
2017	37.79	136.40	27.7
2018	41.93	148.44	28.2
2019	40.29	133.87	30.1
2020	42.46	135.41	31.4
2021	55.28	186.13	29.7

data source: UN Comtrade data base

3. Model construction and data source

3.1 Model construction

The stochastic frontier approach addresses limitations of the traditional trade gravity model by incorporating random disturbance term ν and non-efficiency term μ. The non-efficiency term μ measures export efficiency issues and calculates trade potential. The basic form of the stochastic frontier gravity model is:

$$T_{ijt} = f(X_{ijt}, \beta)\exp(v_{ijt})\exp(-\mu_{ijt}) \quad (1)$$

$$T_{ijt}' = f(X_{ijt}, \beta)\exp(v_{ijt}) \quad (2)$$

$$TE_{ijt} = T_{ijt}/T_{ijt}' = \exp(-\mu_{ijt}) \quad (3)$$

Take the logarithm of equation (1) to get

$$\ln T_{ijt} = \ln f(X_{ijt}, \beta) + v_{ijt} - \mu_{ijt}, \mu_{ijt} \geq 0 \quad (4)$$

where T_{ijt} and T_{ijt}'represent the actual and optimal trade levels between country i and j at time t, respectively. X_{ijt} denotes other explanatory variables like GDP, population, distance, etc. β is the estimated parameters. v_{ijt} is the random disturbance term and μ_{ijt} is the non-efficiency term, independent of each other.$TE_{ijt} = T_{ijt}/T_{ijt}'$ represents trade efficiency. If $\mu_{ijt} = 0$, trade reaches the optimum and efficiency is 1. If $\mu_{ijt} > 0$, trade is below optimal level due to non-efficiency, with TE_{ijt} between 0 and 1.

In panel data, explanatory variables and non-efficiency term may change over time. A time-varying model is:

$$\mu_{ijt} = \{exp[-\eta(t - T)]\}\mu_{ij} \quad (5)$$

where t denotes year and T is the number of periods. η is the estimated parameters.μ_{ijt} remains unchanged when η=0 (time-invariant model).μ_{ijt} decreases over time and efficiency increases when η>0.μ_{ijt} increases over time and efficiency decreases when η<0.

The classic gravity model includes only economic size and geographic distance, representing economic development and trade costs. Subsequent models incorporated additional variables. Linnemann (1968) added population, closely related to trade volume and characterize domestic market demand[1]. Armstrong (2007) suggested including time-invariant factors like economic size, distance, landlocked status in the stochastic frontier model, and infrastructure, institutions in the non-efficiency term[2]. Cai et al. (2020) incorporated differences in per capita forest resources in stochastic frontier gravity model of forest products trade[3].

ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

Based on the above theoretical background, the stochastic frontier gravity model used in this study is:

$$\ln T_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{jt} + \beta_4 \ln D_{ij} + \beta_5 \ln DFA_{ijt} + v_{ijt} - \mu_{ijt} \quad (6)$$

The explained variable T_{ijt} represents the export level of country i to country j in period t. In this paper, country i is China and country j is importing country.T_{ijt}represents China's actual exports to country j during period t.

Explain the explanatory variables as follows:

(1)GDP_{it} represents China's GDP in year t, related to economic size, and also reflects a country's production capacity and export supply capacity. Higher GDP_{it} implies more tremendous export potential, with an expected positive effect on T_{ijt}.

(2)GDP_{jt} is per capita GDP of importer j in year t, representing import demand and purchasing power. Higher demand and purchasing power indicates greater trade flows, with expected positive impact.

(3)POP_{jt} is total population of importer j in year t. Higher POP_{jt} leads to greater import demand, with expected positive effect.

(4)D_{ij} indicates the trade distance between China and the importing country j. The farther the distance between the trading countries is, the greater the cost required to carry out trade, which is not conducive to the realization of the export of products, and the expected impact has a negative impact. Since the spatial distance variable is fixed and takes the distance between the capitals of two countries as an indicator, Peng et al. (2022) used the actual distance multiplied by the geographical distance of the international crude oil price index in that year in order to eliminate the collinearity problem in the data calculation process, which can eliminate the collinearity problem[4].

(5)DFA_{ijt} represents differences in per capita forest resources between China and importer j in year t. $DFA_{ijt}=\left|\frac{FA_{it}}{POP_{it}}-\frac{FA_{jt}}{POP_{jt}}\right|$,where FA_{it} and FA_{ijt} respectively represent the forest area of China and the importing country j during the period t, and POP_{it} and POP_{jt} represent the total population of the two countries during the period t.Forests provide the resource base for China's timber and wood products exports. The difference significantly affects bilateral timber and wood products trade flows. If China's per capita forest resources exceed importer j's, greater difference implies higher export potential. If importer j has more per capita forest resources, the difference reduces China's export potential. So DFA_{ijt} may have positive or negative impact.

3.2 Sample and data source

This study uses data from 2012-2021 to estimate export efficiency and analyze export potential using Stata 17.0. China's timber and wood products export data to RCEP members are from the UN COMTRADE database. GDP, POP and DFA data are calculated from the World Bank database.D_{ij} data are compiled from the CEPII-GRAVITY database. The international crude oil price index is from the International Monetary Fund. Export value and GDP are in USD at 2015 constant prices. Summary statistics of the main variables are shown in Table 2.

Table 2 Descriptive statistics of main variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ln Value of exports	140	18.383	1.957	13.235	21.165
ln China's GDP	140	30.121	0.182	29.820	30.391
ln GDP of trading country	140	26.184	1.727	23.172	29.153
ln Population of trading country	140	17.067	1.645	12.916	19.428
ln Trade distance	140	13.168	0.652	11.429	14.705
ln Differences in forest resources per capita	140	-6.107	2.057	-13.581	-2.881

ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

4. Empirical analysis on the efficiency and potential of China's export of timber and products from RCEP member countries

4.1 Regression analysis of time-varying stochastic frontier gravity model

Regression analysis is conducted using OLS, time-invariant and time-varying models, with results shown in Table 3. Except for trading countries' population and trade distance, the coefficient signs of other explanatory variables are consistent across the three models. γ represents the proportion of trade non-efficiency term in the random error term. In time-invariant and time-varying models, γ values are 0.560 and 0.908, respectively, and γ is significant at 1% level in the time-varying model. This indicates the gap between China's timber and wood products trade development with RCEP members and trade potential is mainly caused by trade non-efficiency. In the time-varying model, η is significantly nonzero, suggesting trade non-efficiency changes over time, further confirming the time-varying model is more suitable than the time-invariant model. The negative coefficient of η implies trade non-efficiency has slightly increased, highlighting the need to improve efficiency of China's timber and wood products exports.

Table 3 Estimated results of stochastic frontier gravity model

Estimation method	OLS model		Time-invariant model		Time-varying model	
Variable	Coef.	t	Coef.	t	Coef.	t
_cons	-50.465***	13.729	-39.473***	11.592	-136.199***	17.579
ln China's GDP	1.343***	0.430	1.062***	0.339	4.2198***	0.540
ln GDP of trading country	0.860***	0.057	0.991***	0.163	1.393***	0.149
ln Population of trading country	0.034***	0.065	-0.007	0.164	-0.562***	0.159
ln Trade distance	0.282*	0.149	0.053	0.188	0.106	0.155
ln Differences in forest resources per capita	-0.263***	0.050	-0.161*	0.096	-0.258***	0.065
σ^2	0.814		0.785	0.216	2.481*	1.156
γ	—	—	0.560	0.127	0.908***	0.046
μ	—	—	1.623*	0.835	3.347***	0.622
η	—	—	—	—	-0.089***	0.015
log likelihood		-142.211	-122.839	log likelihood		-142.211

Note: *, ** and *** represent significant levels of 10%, 5%and 1%, respectively.

Based on the time-varying stochastic frontier gravity model, GDP, population, and differences in per capita forest resources significantly affect China's timber and wood products exports to RCEP members. The specific analysis is as follows:

(1)China's GDP is significant at 1% level with a positive coefficient as expected, indicating China's economic expansion increases timber and wood products production and supply capacity, facilitating timber and wood products exports to RCEP markets. 1% rise in China's GDP enlarges timber and wood products exports to RCEP by 4.21%.

(2)Trading countries' GDP is significant at 1% level with an expected positive sign, suggesting higher economic development increases demand for China's timber and wood products, with greater imports to meet domestic needs.1% increase in trading countries' GDP expands China's timber and wood products exports to RCEP members by 1.39%.

(3) Trading countries' population is significant at 1% level with a negative coefficient, possibly because larger populations provide abundant labor, reducing domestic production costs for wood product firms.

(4)The positive yet insignificant distance coefficient indicates that with improvements in China's transportation, such as new ocean shipping routes, distance is not an obvious barrier for timber and wood products exports to RCEP markets.

(5)The negative and significant coefficient on differences in per capita forest resources implies that greater differences hinder China's timber and wood products exports to RCEP partners. 1% increase reduces timber and wood products exports by 0.26%.

ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

4.2 Efficiency measurement of China's export of timber and products to RCEP member countries

Trade efficiency of China's timber and wood products exports to RCEP members is calculated and shown in Table 4. Overall, export efficiency to RCEP members exhibits a declining trend, with significant differences across countries. Efficiency of exports to Cambodia has remained high over the years, relatively stable with the highest average among RCEP partners. This indicates fewer trade barriers enabling efficient Chinese timber and wood products exports to Cambodia, but also less room to improve bilateral efficiency and limited untapped export potential.

In 2021, efficiency was below 0.2 for all countries except Cambodia and the Philippines, with small fluctuations. This suggests serious impediments still exist for China's timber and wood products exports to most RCEP members, with tremendous export potential and underdeveloped markets. Hence, while ensuring steady export growth, China should attach greater importance to these countries' timber and wood products markets, gradually improving efficiency.

Table 4 Trade efficiency of China's exports of timber and products to RCEP member countries from 2012 to 2021

Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average export efficiency 2012-2021
Australia	0.181	0.155	0.130	0.108	0.088	0.070	0.055	0.042	0.031	0.023	0.088
Brunei	0.096	0.077	0.061	0.047	0.035	0.026	0.018	0.013	0.008	0.005	0.039
Cambodia	0.917	0.910	0.902	0.894	0.885	0.875	0.865	0.854	0.842	0.829	0.878
Indonesia	0.163	0.138	0.115	0.094	0.075	0.059	0.046	0.034	0.025	0.018	0.077
Japan	0.120	0.098	0.079	0.063	0.049	0.037	0.027	0.019	0.013	0.009	0.051
Laos	0.176	0.150	0.125	0.103	0.084	0.067	0.052	0.039	0.029	0.021	0.085
Malaysia	0.337	0.304	0.273	0.242	0.212	0.184	0.157	0.132	0.110	0.090	0.204
Burma	0.405	0.373	0.340	0.308	0.276	0.245	0.216	0.187	0.160	0.135	0.265
New Zealand	0.116	0.095	0.077	0.060	0.046	0.035	0.026	0.018	0.013	0.008	0.049
Philippines	0.495	0.464	0.432	0.400	0.367	0.335	0.303	0.271	0.241	0.211	0.352
South Korea	0.117	0.096	0.077	0.061	0.047	0.035	0.026	0.018	0.013	0.008	0.050
Singapore	0.131	0.109	0.088	0.071	0.055	0.042	0.031	0.023	0.016	0.011	0.058
Thailand	0.270	0.240	0.210	0.182	0.155	0.131	0.108	0.088	0.070	0.055	0.151
Vietnam	0.318	0.286	0.255	0.224	0.195	0.168	0.143	0.119	0.098	0.079	0.189

4.3 Estimation of China's export potential of timber and products from RCEP member countries

Using China's timber and wood products export efficiency values to RCEP members, the trade potential (optimal export frontier) can be calculated as the ratio of actual exports to efficiency. This represents the maximum achievable export value without trade non-efficiency. The export increase potential is then (Trade potential/Actual exports - 1)*100%. Analyzing China's 2021 timber and wood products export potential to individual RCEP members gives the results in Table 5.

Table 5 China's export potential of timber and products to RCEP member countries in 2021

Country	Export efficiency	Actual exports (millions of US dollars)	Export potential Value (millions of US dollars)	Export improvement space (%)
Australia	0.023	75.95	3367.15	4333.1
Brunei	0.005	0.12	21.44	18276.3
Cambodia	0.829	21.00	25.32	20.6
Indonesia	0.018	18.97	1065.87	5517.5
Japan	0.009	140.02	15600.03	11041.5
Laos	0.021	0.45	21.36	4647.1
Malaysia	0.090	39.66	442.33	1015.3
Burma	0.135	2.97	21.92	638.0
New Zealand	0.008	9.09	1083.56	11815.2
Philippines	0.211	57.45	271.83	373.1
South Korea	0.008	52.18	6175.51	11735.5
Singapore	0.011	10.80	982.86	8997.4
Thailand	0.055	32.55	591.48	1717.4
Vietnam	0.079	91.58	1159.92	1166.6

ISSN 2616-5902 Vol. 5, Issue 17: 127-132, DOI: 10.25236/AJBM.2023.051720

Table 5 shows Cambodia was the only RCEP member with export efficiency above 0.8 in 2021, at 0.829, indicating fewer trade barriers but less value in tapping potential. China's timber and wood products export potential to Cambodia was $25.32 million, while actual exports were $21 million, reaching 82.93% of potential. The relatively narrow scope for expanded timber and wood products exports contrasts with the Philippines, with 2021 efficiency between 0.2-0.4, signifying greater market potential and space for export growth. For other RCEP members with efficiency below 0.2, the huge trade potential signifies untapped markets needing development. Leveraging the RCEP, China should seize opportunities to promote efficient timber and wood products exports to these countries.

5. Conclusion and suggestion

This study selects panel data on China's timber and wood products exports to RCEP members from 2012-2021 and uses a stochastic frontier gravity model to estimate export efficiency and potential, yielding the following conclusions:

First, among the main influencing factors, traditional factors remain key determinants of China's timber and wood products exports–bilateral economic development facilitates trade growth, while differences in per capita forest resources and importers' population expansion hinder exports.

Second, the overall efficiency of China's timber and wood products exports to RCEP members is moderate. The average efficiency is just 0.18, with most countries below average. Efficiency is highest for Cambodia and lowest for Brunei.

Third, China's timber and wood products export potential to RCEP members is substantial, with broad room for increased trade. Aside from Cambodia, other RCEP countries have sizable export potential.

To promote diversification of China's timber and wood products export channels and trade facilitation with partners, the following recommendations are proposed based on the conclusions:

First, earnestly enhance trade facilitation with Belt and Road countries, build an efficient business environment, and continue deepening timber and wood products trade with RCEP members.

Second, focus on domestic development and actively advance transformation of China's timber industry, enhancing core competitiveness especially in high-end wood products through managerial and technological innovation.

Third, Chinese government departments should strengthen financial support, improve public services, and smooth the way for forestry companies to "go global", eliminating obstacles.

References

[1] Linnemann, H. An Econometric Study of International Trade Flows [J]. Econometrica. Volume 36, Issue 2. 1968. PP 432-432 (Amsterdam: North-Holland).
[2] Armstrong S. Measuring Trade and Trade Potential: A Survey [R]. Asia Pacific Economic Paper, 2007.
[3] Cai Yuqiu, Liu Chenyang. Research on the export efficiency and potential of China's forest products to RCEP member countries-From the perspective of Asia-Pacific economic integration [J]. Price Monthly, 2020. (In Chinese)
[4] Peng Hong, Zhang Yantang and Qing Feng. Analysis of influencing factors and optimization path of Sino-Fiji bilateral trade: Based on the background of "China-Oceania Blue Economic Channel" [J]. Technology and Industry across the Straits, 2022. (In Chinese)