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The Impact of Forest Certification on the Ternary Margins of China's Forest Product Export

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Abstract: Forest certification as a typical green trade measure has been gradually adopted by developed countries. Although it can promote the upgrading of forest products' trade structure, it also threatens the stability of export growth. However, most studies have focused on the impact of forest certification on the total volume of forest product exports, but less on the impact on the growth structure. This study used the cross-country panel data and an extended gravity model to empirically analyze the impact of forest certification on the ternary margins of China's forest products export to 39 countries that have introduced green trade measures from 2006 to 2019. The results show that the growth of China's export of forest products is primarily driven by the quantitative margin, followed by the price margin. Forest certification in the trading partner countries has a significant positive impact on the price margin and a significant negative effect on the quantitative margin of China's forest products. Furthermore, the effect on the quantitative margin is greater than that on the price margin, while the impact on the extensive margin is not significant. The study provides a scientific basis for responding to the forest certification measures, deepening cooperation with trading countries on forest products, and strengthening the mutual recognition and coordination of forest certification systems.

Keywords: green trade measures; forest certification; forest products; export ternary margins

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1. Introduction

Forest products play a crucial role in China's forestry development because of their green and environmentally friendly properties. In recent years, driven by domestic and foreign markets, China's import and export trade in forest products has been developing rapidly, with an overall upward trend. In 2006, China's total trade in forest products amounted to USD 39.663 billion, and even with the impact of the coronavirus disease 2019 (COVID-19) epidemic in 2020, the total trade still reached USD 97.122 billion, with a 144.87% cumulative growth rate. Although the total volume of exports is increasing, the structure of exports shows that China's forest products are still at the lower end of the global value chain [1,2]. The products lack technological innovation and independent brand, and the high-end link is still firmly controlled by developed countries, making China's forest products trade have the risk of "low-end lock" [3]. In addition, China's forest product export experienced negative growth in many years, indicating the vulnerability and instability of export. With uncertainties in the international market increasing in the post-COVID-19 era, determining how to make China's forest product export develop smoothly is a crucial research issue.

Inspired by the concept of sustainable development, countries are gradually paying attention to the balance of economic growth and environmental protection, and are actively exploring the sustainable development model of forestry [4]. For this reason, some countries have even established strict green trade measures and formed green trade barriers [5]. Scholars have conducted extensive explorations on whether green trade barriers have

trade protection effects. Studies pointed out that some developed countries protected their domestic markets by introducing higher-level environmental technology standards [6,7]. These green trade measures have two-fold effects on the exporting countries. In the short term, as the importing countries raise the requirements and standards of imported products, they will increase the costs of the products, thus impeding the development of international trade of the exporting countries [8]. In the long term, the green trade measures can help improve the quality of products and promote the industrial transformation and upgrading of trade structures in the exporting countries [9,10], thus improving the environment for their international trade.

For forest products, developed countries such as European countries and the United States have introduced green trade measures represented by forest certification and chain-of-custody certification [11]. Currently, forest certification has become one of the important criteria for setting forest management standards [12] and represents a commitment to environmental responsibility [13]. Although countries have different comparative advantages in forest products due to their different resource endowments [14], trade measures in target markets, such as tariff and non-tariff trade barriers, weaken the international competitiveness of forest products [15]. The green trade measures represented by forest certification brought both opportunities and challenges for China's export of forest products. Some scholars argued that although forest certification cannot be able to increase the amount of participation in forest management, it still had a possible positive effect on sustainable forest management [10,16]. Forest certification not only helped the exporters of forest products to break through international green trade barriers [17], but also motivated them to improve the quality of the products, thus increasing the competitive advantage. Therefore, forest certification has a competitive export effect [18]. On the other hand, some scholars argued that various certification systems and testing measures not only increased the cost of forest products but also seriously undermined the international competitiveness of the products [19]. For countries involved in the international trade of forest products, forest certification would affect the trade flows of forest products from developing countries, owing to their inability to meet the requirements of forest certification. Therefore, forest certification became a trade barrier for the export of forest products by developing countries [18]. Although China has established its forest certification system, it is difficult to gain consumer support without the recognized forest product certification marks such as Forest Stewardship Council (FSC) in the face of the importing countries with strong environmental awareness, even if the quality of Chinese forest products is high and the price is low [20] Therefore, Chinese forest products would lose their competitive advantage or eventually be excluded from the international market [21]. Damette and Delacote [22] affirmed the negative effects of forest certification on the export of forest products, as they argued that the higher the level of forest certification, the more deforestation would gradually decrease, which would make companies produce and export fewer forest products. Therefore, if China can grasp the development trend of forest certification, make good use of its positive effects, and reduce its adverse effects, it will be conducive to the stable development of forest product export and the innovation and upgrading of the export growth structure.

From the existing studies, there is no consensus on the impact of forest certification on the export of forest products. The paper's contributions to the existing literature are shown as follows. Firstly, most studies focused on the impact of forest certification on the total volume of wood forest product exports, but less on the impact on the growth structure. This study analyzed the impact of forest certification on the growth structure of China's forest product export from the perspective of the ternary margins. Secondly, there are many qualitative studies on the impact of forest certification as a green trade measure on the export of forest products, but quantitative studies are limited. This study established an extended gravity model to quantitatively analyze the impact of forest certification as a green trade measure on the ternary margins of China's forest product export. The study further explored the possible paths to improve the quality of China's forest products and to transform and upgrade the growth structure of forest product exports. Thirdly,

studies on the structure of China's forest product export primarily focused on the growth structure of countries in a certain region, and the research regions were mostly divided by geographical scopes, such as Regional Comprehensive Economic Partnership (RCEP) member countries, countries along the "Belt and Road", Northeast Asia, and Association of Southeast Asian Nations (ASEAN) countries. In this study, the research area was not divided by geographical scope, but by countries that introduced green trade measures, which was more representative. This study provides a scientific basis for responding to the forest certification measures of trade partner countries, deepening cooperation on forest products, and strengthening the mutual recognition and coordination with international forest certification systems.

2. Methodology

Forest certification has been gradually used as a new type of green trade barrier by developed countries such as European countries and the United States. These environmentally sensitive countries require imported forest products to have a certified eco-label and a set of green criteria [23,24]. Widespread forest certification will stimulate consumer demand for green forest products [25], which will promote the substitution between certified forest products and their competitors. As a result, non-certified forest products will have more difficulty entering environmentally sensitive markets [26]. In addition, although countries regulate the production and processing of forest products through forest certification to reduce environmental damage [13], it also has an adverse impact on the types of traded forest products [18]. Thus, forest certification has become a market access condition for forest products, which can decrease the diversity of forest product export categories. It is reflected as an impact on the extensive margin of forest products.

H1. *Forest certification reduces the variety of exported forest products, and the impact on the extensive margin is negative.*

Forest certification as a green trade measure can force enterprises to improve their technology [27], thus increasing the international competitiveness of exported forest products and enterprises. It makes a change in the cost and profit of production and operation of enterprises [28]. Therefore, with the popularity of the green consumption concept, the increase in the price of certified products, and the expansion of certified products, the profits of companies will rise to high levels [29,30]. Government support is known to significantly upgrade the ability of domestic producers by improving access to backbone services [31]. Therefore, the government's subsidies and support for certified products can offset part of the profit losses of enterprises [32], thereby enhancing the competitiveness of enterprises. In addition, influenced by the green trade measures, the producers and exporters of forest products autonomously promote technological change [33], which enhances the quality, technology, and added value of exported products. Thus, it is observed that forest certification improves the technology and added value of forest products exported from China, making a dramatic change in the quality of the exported products. This is reflected in the impact on the price margin.

H2. *Forest certification enhances the technology and added value of exported forest products and has a positive impact on the price margin.*

Forest certification, once overused by countries that thrive on protectionism, can become a green barrier [34] and hinder trade liberalization. Therefore, forest certification can hinder the export of forest products from China [30]. In addition, for companies that produce and operate forest products, a series of standards and fees for forest certification can increase the cost and export price of forest products [10]. The increase in the price of exported forest products has two implications. On the one hand, the price competitiveness of forest products in the international market is weakened, which in turn reduces the quantity of exported forest products. On the other hand, although consumers' environmental awareness is increasing, purchasing expensive certified products may be beyond

their spending power. Even though they have the desire to purchase certified products, they may still be constrained by their income level and choose non-certified products [20]. This causes a decrease in market demand for certified forest products, which ultimately results in a decrease in the number of exported products. Thus, it is observed that forest certification reduces the quantity of forest products exported from China, as reflected by the effect on the quantitative margin.

H3. *Forest certification decreases the quantity of exported forest products and negatively affects the quantitative margin.*

3. Methods and Data

3.1. Extended Trade Gravity Model

Based on the law of gravity in physics, Tinbergen [35] applied the gravity model to the field of international trade and concluded that the volume of trade between two economies was positively related to the size of the economy and negatively related to distance. The basic form of the gravity model of trade is shown below.

$$T_{ij} = A\frac{Y_i \times Y_j}{D_{ij}} \tag{1}$$

where T_{ij} denotes the trade flow between i and j; A is the gravitational constant; and Y_i and Y_j represent the economic size of i and j, respectively. D_{ij} denotes the geographical distance between i and j. Equation (2) converts all variables in Equation (1) to natural logarithmic form.

$$\ln T_{ij} = \alpha_0 + \alpha_1 \ln Y_i + \alpha_2 \ln Y_j + \alpha_3 \ln D_{ij} + \mu_{ij} \tag{2}$$

where α_0 is the constant term; α_1, α_2, and α_3 are the regression coefficients of each variable; and μ_{ij} is the random error term. The remaining variables are the same as in Equation (1). Equations (1) and (2) are the classical expressions of the gravity model.

With the development of the gravity model, some scholars added factors other than distance and economic size, such as population [36], exchange rate [37], and common border [38], to the model to investigate the impact of these factors on trade flow. At present, the gravity model has become a widely used and relatively mature model in analyzing international trade issues.

Based on the standard gravity model, this study established an extended gravity model by introducing forest certification, forest area per capita, trade openness, exchange rate, etc. To avoid heteroskedasticity, some variables were logarithmicized. The final gravity model is shown in Equation (3).

$$\begin{aligned} lnY_{ijt} = {} & \beta_0 + \beta_1 lnBR_{jt} + \beta_2 lnGDP_{ijt} + \beta_3 lnPOP_{ijt} + \beta_4 lnDIS_{ij} + \beta_5 lnOPEN_{jt} \\ & + \beta_6 lnER_{jt} + \beta_7 lnAF_{ijt} + \beta_8 Border + \beta_9 FTA + \beta_{10} Culture \\ & + u_{ij} + \varepsilon_{ijt} \end{aligned} \tag{3}$$

where i denotes China and j denotes the 39 destination countries. Y_{ijt} denotes the extensive margin (EM_{ijt}), the intensive margin (IM_{ijt}), the price margin (PM_{ijt}), and the quantitative margin (QM_{ijt}) of China's forest product export. BR_{jt} denotes the proportion of certified forest area in country j in year t to its total forest area. GDP_{ijt} denotes the economic size of the two countries, calculated by the product of the GDP of the two countries ($GDP_{it} \times GDP_{jt}$). POP_{ijt} denotes the population size of the two countries, calculated by the product of the domestic population numbers in the two countries ($POP_{it} \times POP_{jt}$). DIS_{ij} denotes the geographical distance between country i and country j. $OPEN_{jt}$ denotes the openness of the economy in country j in period t. ER_{jt} denotes the ratio of the exchange rate to the Chinese exchange rate in country j in period t. AF_{ijt} denotes the absolute value of the difference in forest area per capita between country i and country j. *Border* denotes whether the two countries have a common border. FTA denotes whether the two countries

have signed a free trade agreement, and Culture denotes whether the two countries have a common cultural language. β_0 is a constant term. u_{ij} is the unobservable random variable and ε_{ijt} is the random error term.

3.2. Variable Descriptions

3.2.1. The Core Dependent Variable

The ternary margins of China's forest product export (Y_{ijt}). Based on the work of Hummels and Klenow [39], this study adopted the approach of Shi [40] to decompose China's export growth of forest products into the extensive margin, quantitative margin, and price margin. The extensive margin reflects the diversity of export products, while the price and quantitative margins capture the changes in the quality and quantity of export products, respectively. When a country's export growth is primarily driven by the quantitative margin, its fragile growth pattern can cause a deterioration in the terms of trade; conversely, this can be avoided if a country's export growth relies mainly on the extensive margin or price margin [41]. The specific calculation process is as follows.

First, this study defines the extensive margin (*EM*) and the intensive margin (*IM*):

$$EM_{jm} = \frac{\sum_{i \in I_{jm}} (Q_{rmi} \times P_{rmi})}{\sum_{i \in I_{rm}} (Q_{rmi} \times P_{rmi})} \tag{4}$$

$$IM_{jm} = \frac{\sum_{i \in I_{jm}} (Q_{jmi} \times P_{jmi})}{\sum_{i \in I_{jm}} (Q_{rmi} \times P_{rmi})} \tag{5}$$

where j represents the exporting country (China), m represents the importing country, and r represents the reference country (world). The condition for choosing the reference country is that the categories and quantities of forest products exported from China to the importing country are less than or equal to those exported from China to the reference country. Therefore, the world is usually used as the reference country. i denotes a certain category of forest products. P represents unit price. Q represents the export quantity. I_{rm} and I_{jm} represent the forest products exported from the world and China to the importing countries, respectively. The extensive margin is the ratio of a country's forest product imports from the world in the categories it imported from China, compared to total forest products it imported from the world. It reflects the overlap of forest product categories exported by China and the world. The intensive margin is the ratio of a country's forest product import from China compared to that from the world, inside the categories it imported from China. It reflects China's share in the markets of these categories.

Then, this study further decomposes the intensive margin into the quantitative margin and the price margin.

$$IM_{jm} = P_{jm} \times Q_{jm} \tag{6}$$

The price margin (or quantitative margin) represents the weighted product of the ratio of China's forest product export price (or quantity) to that of the world. The calculation formulas of the price margin and the quantitative margin are as follows:

$$Q_{jm} = \prod_{i \in I_{jm}} \left(\frac{Q_{jmi}}{Q_{rmi}}\right)^{w_{jmi}} \tag{7}$$

$$P_{jm} = \prod_{i \in I_{jm}} \left(\frac{P_{jmi}}{P_{rmi}}\right)^{w_{jmi}} \tag{8}$$

$$w_{jmi} = \frac{\frac{s_{jmi} - s_{rmi}}{\ln s_{jmi} - \ln s_{rmi}}}{\sum_{i \in I_{jm}} \frac{s_{jmi} - s_{rmi}}{\ln s_{jmi} - \ln s_{rmi}}} \tag{9}$$

$$s_{jmi} = \frac{Q_{jmi} \times P_{jmi}}{\sum_{i \in I_{jm}} Q_{jmi} \times P_{jmi}} \quad (10)$$

$$s_{rmi} = \frac{Q_{rmi} \times P_{rmi}}{\sum_{i \in I_{jm}} Q_{rmi} \times P_{rmi}} \quad (11)$$

where w_{jmi} stands for the weight and s_{jmi} and s_{rmi} represent the share of China's and the world's forest products in the target market, respectively. The average price in the world is usually set as 1. When the price margin is lower than 1, it signifies that technology content and added value of the forest products lag behind the world average, and there is a great potential for future industrial upgrading.

3.2.2. The Core Independent Variable

The proportion of certified forest area (BR_{jt}). There are three types of forest certification systems that are commonly used: global systems, regional systems, and national systems. The global forest certification system mainly consists of the Programme for the Endorsement of Forest Certification Schemes (PEFC) and the Forest Stewardship Council (FSC). The FSC is a global certification scheme with a set of principles and standards, while the PEFC is a mutual recognition framework [42]. Therefore, compared to the PEFC system certification, the FSC system is more complete because of its uniform performance standards. PEFC is an international certification body created in 1999 by European small forest owners to focus on the characteristics and needs of small forests. By 2022, there will be 20,000 PEFC Chain of Custody certified companies, with 55 countries worldwide being PEFC members. The FSC system covers more companies and countries than the PEFC system and has a broader coverage.

To investigate the impact of forest certification on the ternary margins of China's wood forest product export, this study introduced forest certification as a variable which was calculated by the share of FSC-certified area in the importing country to its total forest area [43,44]. With the continuous improvement of the trade policy system and the increasing awareness of protecting the domestic forest product market, countries will gradually pay more attention to forest certification. Green consumption has become a global consumer trend, with more and more consumers preferring forest products with a "green label" and buying certified forest products, and more and more countries are gradually placing more emphasis on green ecology. Therefore, the percentage of certified forest area in the importing country is used to indicate the level of development of forest certification in the importing country and to characterize the characteristics of green trade measures. Because the more the importing countries develop forest certification, the more importance they attach to forest certification, they will also pay more attention to whether the products imported into their countries are forest certified, which will have an impact on China's exports of forest products. The higher this proportion is, the more importance the importing countries attach to forest certification. As the importance of forest certification increases, it signifies that people's awareness of environmental protection will increase, which will force Chinese wood forest product companies to improve the technology and added value of exported forest products. Therefore, forest certification is expected to be negatively correlated with the extensive margin and the quantitative margin and positively correlated with the price margin.

3.2.3. Control Variables

Economic size (GDP_{ijt}). This study used the product of gross domestic product (GDP) of the importing and exporting countries ($GDP_{ijt} = GDP_{it} \times GDP_{jt}$) to measure the size of the overall economy which reflects the socioeconomic development [45]. A larger product of the GDP of the two countries represents a larger total economy size, indicating that the two countries are more capable of producing and exporting forest products. The units of GDP_{it} and GDP_{jt} are trillions of USD.

Population size (POP_{ijt}). The population size was expressed as the product of the population of the importing and exporting countries ($POP_{ijt} = POP_{it} \times POP_{jt}$). A larger product of the two countries' populations indicates a larger consumer market, a higher consumer demand for forest products [46], and thus a greater variety and quantity of forest products exported from China. However, an increase in population size also reflects an increase in labor and supply capacity. The deepening domestic division of labor in the importing countries may also be detrimental to the growth of China's export of forest products. The units of POP_{it} and POP_{jt} are billions of people.

Distance (DIS_{ij}). The distance, as one of the basic variables of the gravity model, captures the transportation costs of commodities between the two countries [47]. The greater the distance between the two countries, the higher the transportation cost of trade between the two countries. Therefore, the importing country will import fewer forest products to China, which reduces the categories and quantities of China's forest products and increases the price.

External openness ($OPEN_{jt}$). This variable was calculated by the ratio of exports of goods and services to GDP, which represents the level of external openness of the importing country [48]. A higher level of external openness is conducive to promoting the growth of the extensive margin and the quantitative margin of export. However, it may also have an adverse impact on the growth of China's export of forest products because of the substitution effect of forest products from an increasing number of countries.

The per capita forest resource (AF_{ijt}). The difference in forest resources per capita was expressed as the absolute value of the difference in forest area per capita between the importing country and the exporting country [49]. The greater the difference in per capita forest resources between the two countries, the more likely it is that trade exchanges will occur and thus may significantly contribute to the growth of China's export of forest products, with the per capita forest resources variable given by the following formula:

$$AF_{cg} = \left|\left(forest_c / pop_c\right) - \left(forest_g / pop_g\right)\right| \quad (12)$$

c denotes China and g denotes the trading country. $forest_c$ and $forest_g$ refer to the forest area of China and the trading country. pop_c and pop_g refer to the population of China and the trading country, respectively. Absolute values were taken for the formulas to unify the notation to facilitate comparison.

Exchange rate (ER_{jt}). The variable was calculated by the ratio of the exchange rate of the importing country to the exchange rate of China in the current year [50]. The smaller the ratio, the higher the price of China's forest products in the international market, which has a positive impact on the price margin, making it more difficult for China's forest products to be exported to the target market, which may be detrimental to the export growth of China's forest products. However, the appreciation also indicates that China's economy is expected to gradually strengthen, which will promote the production and export of forest product enterprises.

Common border (*Border*). This variable was a dummy variable, which is 1 if the importing country has a common border with China and 0 otherwise [51]. If a common border exists between China and trading countries, it will allow China to fully exploit its local advantages to neighboring countries, further expand its opening and improve its economy and trade [48], which will facilitate the growth of China's export of forest products.

Free trade agreement (*FTA*). This variable was a dummy variable, which is 1 if the importing country has signed an agreement with China and 0 otherwise, distinguished by the effective date of the agreement [49]. Signing a free trade agreement can enhance the economic and trade exchanges between the two countries and help to enrich the categories and increase the quantity of China's forest product exports [50].

Cultural distance (*Culture*). This variable was a dummy variable, taking the value of 1 if the official language of the importing country is the same as China and 0 otherwise. If the two countries share a common language, it is easier for them to trade with each other, and conversely, if there is a cultural conflict between the two countries, the additional communication cost hinders the growth of forest product export [18].

3.3. Sample Selection and Data Sources

3.3.1. Country Selection

This study selected 39 countries that introduced green trade measures, namely Japan, Korea, Malaysia, Indonesia, Singapore, and India (6 countries in Asia); Norway, the United Kingdom, and 27 countries of the European Union (29 countries in Europe); and the United States, Canada, New Zealand, and Australia (4 countries in North America and Oceania). These countries are members of the FSC, and forest certification is mentioned in the forest product acts introduced by the United States, Japan, the European Union, and Australia. Forest certification also reflects, to some extent, the concept of green ecology and environmental protection, by which the importing countries protect their own markets. The fact that forest certification is also mentioned in the relevant forest product acts ever introduced by the importing countries not only shows that these countries are more sensitive to environmental issues, but also shows that there is an aim to use forest certification as an institutional measure to influence other countries to send forest products to their own countries.

3.3.2. Definition of Forest products

This study focused on wood forest products, including logs, sawn timber, other raw timber, man-made boards (veneer, particle board, fiberboard, plywood), wood pulp, paper and paper products, wood products, and wood furniture. The data were obtained from the 6-digit Harmonized System (HS6) of the CEPII-BACI database of France's International Research Center. Other scholars' classifications of forest products were also referred to when defining forest products in this study [14,50,52].

3.3.3. Data Sources

The data used to calculate ternary margins of export growth came from the HS96 code in the CEPII-BACI database [53]. The database contains a large and complete volume of import and export data for more than 5000 products from more than 200 countries or regions. Specifically, it includes the value, quantity, and unit value (thousands of USD and tons) of each category of forest products. The data for the variables of distance, common border, and cultural distance were also from the CEPII-BACI database [53]. In addition, the data for the variables of economic size, population size, forest area, and exchange rate were from the World Bank database [54]. The data for the variable of external openness were from the World Bank database [54] and the UN Comtrade database [55]. The data of forest certification variables were obtained from the FSC official website [56] and the World Bank database [54]. The data for the variable of free trade agreement were from the China Free Trade Zone Service website [57].

3.4. Descriptive Statistical Analysis of Variables

In order to set up the extended gravity model, this study conducted descriptive statistical analysis of the variables, and the results are shown in Table 1. It can be seen that the standard deviations of the economic and population sizes are much larger than the values of the other variables, indicating that there are large differences in the size of the economy and consumer market in the sample countries. To reduce the heteroskedasticity problem, all non-dummy variables were treated logarithmically in this study.

Table 1. Descriptive statistical analysis of variables.

Variables (Units)	Sample Size	Average Value	Standard Deviation	Minimum Value	Maximum Value
EM_{ijt}	546	0.84	0.13	0.35	1.00
IM_{ijt}	546	0.08	0.08	0.00	0.39
PM_{ijt}	546	1.21	0.32	0.53	4.89
QM_{ijt}	546	0.07	0.07	0.00	0.37
BR_{jt} (%)	546	18.28	24.94	0.00	106.10
GDP_{ijt}	546	11.00	29.10	0.02	306.00
POP_{ijt}	546	9.14	28.00	0.05	192.00
DIS_{ij} (kilometers)	546	7407.00	2104.00	999.30	11,100.00
$OPEN_{jt}$ (%)	546	58.27	40.85	10.64	229.00
AF_{ijt} (square kilometers per 10,000 people)	546	90.80	187.00	0.02	1050.00
ER_{jt}	546	49.00	270.70	0.04	2152.00
Border	546	0.03	0.16	0.00	1.00
FTA	546	0.11	0.32	0.00	1.00
Culture	546	0.05	0.22	0.00	1.00

Data source: CEPII-BACI database, World Bank database, UN Comtrade database, FSC official website, and China Free Trade Zone Service website.

4. Results and Analysis

4.1. Ternary Margin Measurement Results and Analysis

Overall, the extensive margin and intensive margin of China's forest product export to 39 countries maintained an increasing trend from 2006 to 2019, while the export growth was mainly driven by the intensive margin (see Table 2). Specifically, the average annual growth rate (AAGR) of extensive margin exported to the United Kingdom was the lowest (−0.53%), while that to Luxembourg was the highest (7.17%). Meanwhile, the intensive margin exported to Estonia had the lowest average annual growth rate (−4.8%), while that to Malaysia was the highest (9.26%).

China's extensive margin of forest products was high, with values mostly greater than 0.9, and with little potential to increase. Smaller fluctuations in the extensive margin imply that external economic shocks have a relatively slight impact on the extensive margin. According to the definition of the ternary margins, the larger the extensive margin, the greater the variety of export products. Therefore, the forest products exported from China to these countries were diversified.

Furthermore, the high growth in the intensive margin for China's forest products signifies that the export of forest products from China to these countries is increasing rapidly. Among them, the intensive margins exported to Malaysia, Singapore, and New Zealand were ranked the top three, with high average annual growth rates of 9.26%, 8.05%, and 7.75%, respectively. This indicates that China is rapidly expanding the market share of forest products in these countries. The negative growth rate of the intensive margin exported to seven countries—Cyprus, Malta, Estonia, Croatia, Latvia, Slovakia, and Lithuania—indicates that the export of forest products from China to these countries is decreasing.

According to Shi [40], the intensive margin can be further decomposed into the price margin and the quantitative margin. The results show that the average annual growth rate of the quantitative margin is larger than that of the price margin. This signifies that the quantitative margin plays a more significant role in forest product export than the price margin. In particular, the price margin of China's forest products exported to Finland had the highest average annual growth rate of 7%, while the lowest was −1.42% for Canada. Additionally, the quantitative margin to Malaysia had the highest average annual growth rate of 8.78%, while the lowest was for Estonia at −9.47%.

Table 2. Average annual growth rate of ternary margins for forest products exported from China to 39 countries during the period 2006 to 2019.

Regions	Countries	Extensive Margin			Price Margin			Quantitative Margin		
		2006	2019	AAGR	2006	2019	AAGR	2006	2019	AAGR
Asia	Japan	0.75	0.93	1.87	1.03	1.13	0.80	0.19	0.20	0.38
	Korea	0.93	1.00	0.59	0.96	1.10	1.14	0.18	0.18	−0.12
	Malaysia	0.85	0.99	1.21	1.14	1.32	1.20	0.09	0.27	15.28
	Indonesia	0.69	0.85	1.81	1.00	1.10	0.79	0.09	0.19	8.92
	Singapore	0.94	1.00	0.47	0.97	1.51	4.33	0.10	0.19	6.85
	India	0.75	0.82	0.69	0.84	1.29	4.03	0.10	0.12	1.78
Europe	Denmark	0.89	0.94	0.39	1.32	1.31	−0.06	0.03	0.03	0.27
	Sweden	0.74	0.78	0.44	1.18	1.45	1.75	0.03	0.03	0.31
	United Kingdom	0.96	0.89	−0.51	1.08	1.14	0.43	0.06	0.12	7.65
	France	0.84	0.97	1.14	1.21	1.30	0.62	0.02	0.04	6.75
	Ireland	0.89	0.96	0.53	0.95	1.15	1.56	0.04	0.04	−0.65
	Netherlands	0.68	0.92	2.64	1.05	1.26	1.59	0.03	0.05	5.04
	Belgium	0.82	0.89	0.73	1.11	1.70	4.09	0.03	0.03	0.34
	Germany	0.95	0.95	−0.02	1.25	1.45	1.27	0.02	0.03	6.18
	Poland	0.74	0.85	1.07	1.26	1.43	1.07	0.02	0.03	5.56
	Italy	0.90	0.88	−0.11	1.39	1.36	−0.17	0.02	0.03	4.83
	Spain	0.88	0.90	0.18	1.11	1.25	0.94	0.04	0.05	2.83
	Finland	0.68	0.83	1.71	1.11	2.67	10.85	0.02	0.01	−4.03
	Norway	0.89	0.95	0.49	1.06	1.17	0.78	0.02	0.02	2.37
	Austria	0.69	0.84	1.71	1.60	2.18	2.81	0.00	0.01	4.34
	Portugal	0.80	0.83	0.27	0.85	1.24	3.51	0.01	0.02	4.52
	Cyprus	0.75	0.89	1.52	0.95	1.20	2.03	0.05	0.04	−2.79
	Luxembourg	0.35	0.85	11.24	0.98	1.12	1.10	0.01	0.01	6.30
	Malta	0.78	0.91	1.35	0.91	0.86	−0.42	0.08	0.05	−2.67
	Greece	0.84	0.86	0.20	0.88	1.05	1.48	0.05	0.07	2.60
	Croatia	0.77	0.78	0.07	0.97	1.16	1.49	0.03	0.02	−1.54
	Bulgaria	0.82	0.90	0.75	0.82	1.19	3.46	0.06	0.04	−1.56
	Czech Republic	0.80	0.94	1.32	1.36	2.02	3.68	0.01	0.01	−2.06
	Estonia	0.50	0.65	2.28	1.25	2.29	6.39	0.03	0.01	−5.58
	Hungary	0.58	0.86	3.67	1.13	2.03	6.13	0.01	0.01	−3.06
	Latvia	0.51	0.53	0.35	1.08	1.24	1.15	0.03	0.02	−2.72
	Lithuania	0.51	0.81	4.45	1.05	1.27	1.65	0.03	0.01	−4.28
	Romania	0.80	0.87	0.68	0.82	1.21	3.71	0.02	0.04	5.99
	Slovak Republic	0.66	0.86	2.28	1.32	1.77	2.64	0.01	0.01	−2.20
	Slovenia	0.51	0.63	1.93	1.09	1.22	0.93	0.02	0.03	3.75
North America	United States	0.78	0.94	1.64	1.04	1.05	0.04	0.18	0.21	0.97
	Canada	0.90	0.94	0.38	1.11	0.92	−1.31	0.07	0.13	7.28
Oceania	New Zealand	0.93	0.95	0.15	0.96	1.07	0.88	0.09	0.24	11.93
	Australia	0.94	0.99	0.41	0.90	1.00	0.83	0.17	0.37	9.12

Data source: Calculations based on the CEPII-BACI database.

In summary, the growth rate of the extensive margin of forest products exported from China to 39 countries was relatively stable with values around 1. This implies that the export of forest products from China to these countries is diversified and saturated. Simultaneously, the price margin showed a steady upward trend. This may be attributed to the strong environmental awareness in these countries, such as forest certification, forcing China to improve the technology and added value of its products. However, the quantitative margin was more volatile and sensitive to external shocks, such as the negative growth trend in the quantitative margin for South Korea and 12 countries in the EU. In addition, the small and rapidly growing value of the quantitative margin indicates that China's forest product export has great potential for growth.

4.2. Regression Results and Analysis

4.2.1. Analysis of Empirical Results

This study used the cross-country panel data and an extended gravity model to empirically analyze the impact of forest certification on the ternary margins of China's forest product export. The Hausman test result of the extensive margin showed that the p-value was greater than 0.1, and thus the random effects model was chosen. In contrast, the test results of the intensive margin, price margin, and quantitative margin had p-values less than 0.05, so the fixed effects models were chosen and the time effects were controlled.

The regression results of forest certification on the extensive margin, the intensive margin, the price margin, and the quantitative margin are shown in Table 3. It can be seen that forest certification had a significant negative effect on the intensive margin and quantitative margin, whereas it had a significant positive effect on the price margin. Meanwhile, forest certification had a negative effect on the extensive margin, but the impact was not significant.

Table 3. The regression results of forest certification on the ternary margins.

Variables	$lnEM_{ijt}$	$lnIM_{ijt}$	$lnPM_{ijt}$	$lnQM_{ijt}$
$lnBR_{jt}$	−0.0006	−0.0279 **	0.0120 **	−0.0400 ***
	(−0.004)	(−0.0111)	(−0.0061)	(−0.0129)
$lnGDP_{ijt}$	0.0440 ***	0.0514	0.0364	0.0151
	(−0.0081)	(−0.1036)	(−0.0569)	(−0.1206)
$lnPOP_{ijt}$	0.0051	3.5893 ***	−0.4166 *	4.0059 ***
	(−0.0217)	(−0.4176)	(−0.2294)	(−0.4864)
$lnDIS_{ij}$	0.028			
	(−0.0523)			
$lnOPEN_{jt}$	−0.0570 *	0.2510 *	0.0931	0.1579
	(−0.0326)	(−0.1332)	(−0.0731)	(−0.1551)
$lnAF_{ijt}$	−0.0285 ***	0.1722 ***	−0.0650 ***	0.2373 ***
	(−0.0091)	(−0.0426)	(−0.0234)	(−0.0496)
$\ln ER_{jt}$	−0.0093	0.0734 ***	−0.0198	0.0931 ***
	(−0.0085)	(−0.0277)	(−0.0152)	(−0.0323)
FTA	0.0064	0.0031	−0.0088	0.0119
	(−0.0293)	(−0.0777)	(−0.0427)	(−0.0905)
Border	−0.0709			
	(−0.136)			
Culture	0.2365 *			
	(−0.1299)			
Constant	−3.0834 ***	−140.7727 ***	12.9587	−153.7317 ***
	(−0.8403)	(−16.7652)	(−9.2092)	(−19.5268)
Observations	487	487	487	487
Whether the time effect is controlled		Yes	Yes	Yes

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.

The results showed that forest certification reduced the export category of China's forest products, but this effect was not significant. This is primarily because as a major exporter of forest products, China already has a considerably wide range of exported products which basically include a variety of forest products [3]. Thus, the effect of forest certification on the extensive margin was not significant. Concurrently, every 1% increase in the percentage of the certified forest area was associated with a 0.0279% decrease in export under a given export product category. The reason is that the more importance the importing country attaches to forest certification, the stronger the environmental awareness of consumers in the importing country, which will discourage the export of non-certified forest products and hinder trade liberalization. Furthermore, as the importing countries attach importance to forest certification, the production and operation costs for forest product exporters will also increase significantly, which will cause changes in the export market structure of China's forest products, thus reducing the export value. Therefore, forest certification had a significant negative impact on the intensive margin of forest products.

Further decomposing the intensive margin into the quantitative margin and the price margin, the study indicates that forest certification had a significant effect on both the

price margin and the quantitative margin, and the effect on the quantitative margin was greater. For every 1% increase in the percentage of the certified forest area, the number of forest products exported decreased by 0.04%. This suggests that forest certification reduces the number of forest products exported from China. Once forest certification is overused by countries where protectionism is prevalent, it can become a green barrier and hinder the liberalization of trade in forest products [34]. For enterprises that produce and operate forest products, a series of standards and fees for forest certification, including the application for the Green Mark, increase the cost of raw material production [18], thus increasing the selling price of products. The increased price will have two effects: On the one hand, the price competitiveness of exported products is weakened [10], which decreases the export quantity of China's forest products. On the other hand, although consumers' environmental awareness is increasing, the expensive certified products may be unaffordable for them. Even if they prefer to purchase the certified products, they are still constrained by their income and end up choosing non-certified ones. This makes the market demand for certified products decrease, which is detrimental to the export of certified forest products from China. Moreover, the complicated import procedures of forest certification will also prolong the life cycle of China's forest products [58], which will also greatly weaken the international competitiveness of forest products. Therefore, forest certification had a significant negative impact on the quantitative margin of forest product exports.

Furthermore, for every 1% increase in the percentage of the certified forest area, the price margin of forest products will increase by 0.012%. The reason is that as the importance of forest certification increases, the awareness of consumers for environmental protection increases, which will force China's forest product exporters to make improvements in the technology and quality of exported products [27]. Simultaneously, under the influence of the green concept of forest certification, forest product manufacturers and exporters in China will also standardize the technical standards related to production and trade, thus improving the quality and added value of their export products [33]. Therefore, forest certification had a significant positive effect on the price margin, promoting the upgrade of forest products' trade structure and the improvement of quality.

Meanwhile, the economic size had a significant positive impact on the extensive margin, indicating that the higher the economic level, the more the two countries can afford to purchase or export forest products. Therefore, the more frequently China trades with the importing country, the more categories of forest products will be exported to it. The population size had a significant positive impact on the intensive margin and the quantitative margin, indicating that the larger the population, the more the market demand and the stronger the consumption capacity, and therefore the larger the export value and the number of products exported by China in the same forest product categories. In contrast, the population size had a significant negative effect on the price margin, primarily because the larger the population, the larger the market size for forest products, and then the more intense competition China's forest products encounter in the international market. Therefore, companies have to reduce prices to gain more market share.

The per capita forest resources had a significant negative impact on the extensive margin of China's forest product export, indicating that per capita forest resources had an adverse effect on enriching the variety of China's forest product export. Countries with greater differences in per capita forest resources from China may produce a greater variety of products with potentially less overlap and therefore may reduce the variety of forest products exported from China. However, the per capita forest resources had a significant positive impact on the intensive and quantitative margin. The greater the difference in per capita forest resources between the two countries, the more demand for forest products from the importing countries, thus increasing the quantity and value of China's forest product export. As the export volume increases, the export price of forest products will also decrease to some extent. Thus, the per capita forest resources had a significant negative effect on the price margin.

The economic openness had a significant negative effect on the extensive margin. The more open the trading partners, the more countries will be able to replace China as the source of forest product imports. Therefore, the import substitution effect will reduce the variety of forest products exported by China. However, the more open the importing countries, the more it will boost the volume of forest product export, which is reflected as a significant positive effect on the intensive margin.

In addition, the exchange rate had a significant positive effect on the intensive margin and the quantitative margin. The increased exchange rate represents a devaluation of the Chinese currency, which is conducive to enhancing the motivation of exporters and thus expanding the export of China's forest products. The cultural distance had a significant positive effect on the extensive margin. This shows that using a common language between the two countries facilitates the stable export of products and allows trade with fewer barriers, thus promoting an increase in the variety of China's forest product export.

4.2.2. Robustness Test

In this study, the robustness of the model results was tested by changing the core independent variable. The share of the FSC-certified area of the importing country in its total forest area was replaced with the number of Forest Management certificates (FM_{jt}) obtained by the importing country. The results of the robustness test are shown in Table 4. It can be found that the regression results of the number of Forest Management certificates (FM_{jt}) on the ternary margins were consistent with those in the initial model. This indicates that the results of this study are robust. In particular, the number of certificates obtained by the importing country had a negative effect on the extensive margin and the quantitative margin. The more certificates obtained by the importing country, the more importance the importing country attaches to forest certification, which will hinder the growth of China's forest product export. Additionally, the number of certificates obtained by the importing countries had a significant positive effect on the price margin. The increased number of certificates obtained by the importing countries signifies stronger environmental awareness, which will force forest product enterprises to improve the technology and added value of their export products.

Table 4. Robustness test results.

Variables	$lnEM_{ijt}$	$lnIM_{ijt}$	$lnPM_{ijt}$	$lnQM_{ijt}$
$lnFM_{jt}$	−0.0113	−0.0740 ***	0.0440 ***	−0.1180 ***
	(−0.0086)	(−0.0238)	(−0.013)	(−0.0276)
$lnGDP_{ijt}$	0.0487 ***	0.0869	0.0029	0.0841
	(−0.0083)	(−0.1056)	(−0.0579)	(−0.1224)
$lnPOP_{ijt}$	0.0063	3.3414 ***	−0.2776	3.6190 ***
	(−0.0208)	(−0.4228)	(−0.2317)	(−0.4899)
$lnDIS_{ij}$	0.0339			
	(−0.0521)			
$lnOPEN_{jt}$	−0.0557 *	0.2905 **	0.0722	0.2183
	(−0.0322)	(−0.1311)	(−0.0718)	(−0.1519)
$lnAF_{ijt}$	−0.0271 ***	0.1580 ***	−0.0580 **	0.2159 ***
	(−0.0091)	(−0.0423)	(−0.0232)	(−0.0491)
$lnER_{jt}$	−0.008	0.0781 ***	−0.0237	0.1018 ***
	(−0.0084)	(−0.0277)	(−0.0152)	(−0.0321)
FTA	0.0026	−0.002	−0.0024	0.0003
	(−0.0293)	(−0.0775)	(−0.0425)	(−0.0898)
Border	−0.0906			
	(−0.1364)			
Culture	0.2407 *			
	(−0.1291)			
Constant	−3.4223 ***	−133.5719 ***	9.6346	−143.2068 ***
	(−0.8731)	(−16.7902)	(−9.2005)	(−19.4525)
Observations	484	484	484	484
Whether the time effect is controlled		Yes	Yes	Yes

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in parentheses.

5. Conclusions and Policy Implications

This study used cross-country panel data and an extended gravity model to empirically analyze the impact of forest certification on the ternary margins of China's forest products exported to 39 countries that have introduced green trade measures from 2006 to 2019. The results show that the growth of China's forest product export to the 39 countries is mainly driven by the intensive margin, and the quantitative margin plays a more crucial role than the price margin. Furthermore, forest certification has a significant negative effect on the quantitative margin, while it has a significant positive effect on the price margin, and the effect on the quantitative margin is greater than that on the price margin. Meanwhile, forest certification has a negative effect on the extensive margin, but the impact is not significant. As a result, this study proposes the following policy implications.

First, China should deepen trade cooperation in the existing markets and develop trade with partners in the emerging markets. China's forest product export shows a rapid growth in quantitative margins and has great potential for future development. Therefore, China should further explore the potential international demand on the existing cooperation platform for forest products. On the one hand, China should deepen the current cooperation agreements and expand the establishment of FTAs with trading countries to provide facilitation services for the bilateral trade in forest products. On the other hand, China should actively expand trade markets with potential countries, such as Africa and the Middle East, and adjust the structure of export markets to promote the steady growth of forest product export [49]. Particularly, it can target the Asia-Pacific region and seize the opportunities in markets that are not fully mature, especially in some non-developed countries and regions. China should also make use of its competitive advantage of labor-intensive forest products with high quality and low price to strengthen mutually beneficial cooperation with these countries.

Second, it is crucial to implement product differentiation strategies and to build green and innovative product markets. The contribution of the extensive margin to the growth of China's export of forest products is limited. In order to improve export growth patterns and achieve sustainable development of forest products, attention must be paid to the growth of the extensive margin. To this end, China should consider expanding the range of export products to form differentiated competition. The export market for China's forest products is regionally heterogeneous, so enterprises can produce differentiated products according to the characteristics of different regions in order to meet the consumer demand in the international market. In addition, attention should be paid to the growth of price margins. As labor-intensive manufacturing products, the production of man-made boards, paper products, and wood furniture has been resisted by some countries, owing to environmental pollution and wood scarcity. Therefore, in order to meet the environmental standards of products in the importing countries, enterprises should take the initiative to improve their technology, actively carry out green technological innovation, implement clean production, and vigorously improve the quality of forest products.

Finally, China should develop forest certification and promote the international convergence of the certification system. The results show that forest certification has a positive impact on the price margin of China's forest products. Specifically, forest certification can strengthen the environmental awareness of enterprises and force the quality upgrade of products, thus improving the quality of China's forest product export. Therefore, China should respond to forest certification and other related policy measures with a positive attitude and take the initiative to expand the scope of forest certification. In addition, forest certification has a significant negative impact on the quantitative margin of China's forest product export, indicating that forest certification still has an adverse effect on the export volume of China's forest products. Therefore, China should accelerate the mutual recognition between its own forest certification system and those of other countries to further enhance the internationalization of the forest certification system. Meanwhile, China's forest certification system should be consciously aligned with FSC and other internationally

recognized certification systems, and extended to Laos, Cambodia, and other non-certified countries with rich forest resources, so as to expand the export market for forest products.

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