Research Article

Integration Level and Influencing Factors’ Analysis of Forest Product Market Based on the Mathematical Model

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This paper uses Python programming to improve the existing price index method and calculate the integration level of the forest products market in China. Based on the model, the influencing factors of domestic forest product market integration were examined empirically. The results show that the integration degree of the forest product market in recent years lags behind the average level in China. In this paper, the improvement of the existing price index method can calculate the level of market integration more quickly and accurately, and this improvement has obvious advantages in the case of a large amount of data. In terms of development, the overall pattern shows an increasing trend, and the eastern, central, and western provinces are gradually converging, although the differences between provinces continue to expand. In terms of influencing factors, the coefficient of the local government’s emphasis on forestry, the prosperity of international trade in forest products, and highway density were significantly positive factors, while the number of foreign investors and the railway density had no significant effects. In this paper, the optimization of the measurement method of market integration makes it easier for scholars to obtain the data on the level of market integration and promote in-depth research in the field of market integration.

1. Introduction

Under the strategy of an export-oriented economy and globalization, China’s economy has developed into the largest in the world in terms of production, consumption, and trade in forest products. However, China’s forestry industry could be described as “large but not strong” compared with the forestry industries of developed countries. Although the domestic wood and wood product trade by unified purchasing and marketing to market-oriented reform has proceeded for nearly 30 years, the entire forestry industry has yet to form an effective and unified domestic market. This has led to weak circulation ability and high dependence on foreign markets. Related to this, research on the domestic market system of forestry products is also relatively insufficient; topics such as the composition of the domestic forestry market system, the degree of integration of the domestic forest product market, efficiency evaluation, and other theoretical and practical issues have not been clearly examined.

From the perspective of the development needs of the forestry industry, the construction of a unified and efficient forest product market is not only related to the improvement of the income of stakeholders and the economic development of mountainous areas but is also involves one of the major raw materials for building and construction. A highly integrated market is also the basis for ensuring the stable operation of the domestic supply systems important in all walks of life. At the same time, as the main component of ecologically sound construction, a unified and efficient forest product market can give full play to the role of market forces in the supply of ecological products and make up for the inherent defects in the inefficient supply system of ecological products implemented by the government.

From the perspective of economic theory, if a country does not have a comparative advantage or if its comparative advantage is decreasing, it can promote trade development and enhance its trade position by boosting domestic demand [1]. As the basis for expanding domestic demand, a unified domestic market can rationally optimize the allocation of
social resources at a macroscopic level and provide important guarantees for sustainable development.

Given the need for the reform of forestry marketing, what is the trend of the integration process of China’s forest product market? What is the current level of market integration? What factors hinder the formation of a unified market for domestic forest products? To answer these questions, in this study, we used the concepts of market integration and forestry marketization to measure the degree of integration of the forest product market in China from 2002 to 2018 based on the annual price data of wood products in each province. Based on the analysis framework constructed in this paper, the factors influencing the formation of an integrated forest product market are empirically tested.

2. Literature Review

Market integration means that the behaviors of market subjects at different places within a region are regulated by the same supply and demand relationship [2]. Forestry marketization refers to the process in which forestry economic activities are increasingly dependent on a market mechanism, and the forestry market system, operation mechanism, market relationship norms, market competition order, and macro-control mechanisms are constantly improved and allowed to mature [3]. Based on the above definitions of market integration and forestry marketization, this paper defines the concept of forest product market integration: forest product market integration refers to the state and process in which forest product market subjects in different places, under the influences of a market mechanism, policies, and regulations, gradually break the original market and trade barriers between regions, thus forming a unified market in which commodities and factors can flow freely.

As for the measurement of market integration, a consensus on the trend and status quo of domestic market integration has been reached in current academic circles, that is, the degree of integration of China’s domestic market is generally low, but there is an increasing trend toward integration [4, 5]. In terms of measuring methods of market integration, currently, mature methods include the trade flow method, output method, and price index method. Considering the availability of data, academics mainly use Excel programming and iterative calculation methods to obtain market integration data based on the principle of the price index method. However, due to the complex calculation logic of this method, the workload of calculation will increase exponentially with each additional dimension of data, resulting in the small scale of data used in existing research on market integration, and the pertinence of research conclusions is not strong. In terms of the influencing factors of market integration, according to the existing literature, China’s domestic market integration is most strongly affected by local government behavior, local foreign economic and trade situations, infrastructure level, and other factors. The local government’s protection of the regional economy will intensify the segmentation of the market, a process that is not conducive to the integration of the entire domestic market [5]. The impacts of the international economy and trade are relatively complex. At present, the academic community has reached a consensus on the impact of opening trade: with the gradual improvement of the degree of opening up, the degree of segmentation of the domestic market will be further intensified in the initial stages; there will be an inflection point, and finally, the market will develop in the direction of integration [6, 7]. Infrastructure construction can reduce transportation costs and facilitate the integration of domestic product markets [8–11]. In addition, researchers have also discussed the extent of economic nationalism [12], international trade [13], and distance to a harbor [14] on the level of market integration.

The existing literature on the measurement and theoretical research of domestic market integration is quite sufficient, but the literature concerning the application of “market integration” in the field of forestry is scarce and out of date. In this paper, Python programming software is used to improve the existing price index method, and combined with the situation of China’s forest product market, the “Forest product Market Integration Index” evaluation model is constructed to measure and analyze the level of forest product market integration in China and all regions from 2002 to 2018. Based on the above factors, an econometric model is constructed to empirically test the influencing factors of domestic forest product market integration, thereby providing an empirical basis for the design of forest product market policies.

3. Forest Product Market Integration Index: Calculations

3.1. Calculation of the Market Integration Index. In this paper, Spyder (Python 3.6) software was used to calculate a degree of integration index for the Chinese forest product market based on the principle of price index, and a first-order difference equation method is adopted to calculate the relative price variance [15, 16], that is,

\[ \Delta Q_{ijt}^k = \ln \left( \frac{P_{it}^k}{P_{jt}^k} \right) - \ln \left( \frac{P_{it-1}^k}{P_{jt-1}^k} \right) = \ln \left( \frac{P_{it}^k}{P_{it-1}^k} \right) - \ln \left( \frac{P_{jt}^k}{P_{jt-1}^k} \right), \]

where \( i \) and \( j \) represent the \( i \)th and \( j \)th regions, respectively; \( k \) represents the commodity; \( t \) represents time; \( P_{it}^k \) and \( P_{jt}^k \) represent the price of commodity \( k \) in regions \( i \) and \( j \) at \( t \); \( P_{it-1}^k \) and \( P_{jt-1}^k \) refer to the price of commodity \( k \) in regions \( i \) and \( j \) at \( t - 1 \); and \( P_{it}^k / P_{jt}^k \) and \( P_{it-1}^k / P_{jt-1}^k \) are the sequential indices of commodity retail prices.

In this study, 23 provincial administrative regions were paired according to whether they were bordering, and 51 pairs of bordering provinces and regions were formed. By referring to formula (1), 6,996 (=51 × 17 × 8) relative price variances of 51 pairs of bordering provinces and regions in each year were obtained, and the absolute value of price variances can be obtained as \( |\Delta Q_{ijt}^k| \). Then, \( |\Delta Q_{ijt}^k| \) was used to subtract the data mean \( \bar{|\Delta Q|^k} \) of the same forest product category in the same year, marked as \( q_{ijt}^k \):
Using this method, a total of 6,936 observations were obtained; the variance is marked as \( \text{Var}(q_{ij}^{k}) \). This represents the variance of relative price fluctuations of eight types of forest products in neighboring provinces in a given year. As the data related to the characteristics of forest products have been removed from the calculation of formula (2), the fluctuation range of the relative price of forest products in neighboring provinces in each year can be intuitively expressed as \( \text{Var}(q_{ij}^{k}) \).

After all \( \text{Var}(q_{ij}^{k}) \) is calculated, the 17-year time series of 51 groups of neighboring provinces and regions can be obtained, with a total of 867 (51 \( \times \) 17) observation values, which can be used to intuitively characterize the degree of market segmentation between different neighboring provinces.

Next, the inverse of the arithmetic square root of the relative price fluctuation variance of the eight forest products in the neighboring provinces is taken as \( \text{Var}(q_{ij}^{k}) \) [17], and the forest product domestic market integration index is then constructed as follows:

\[
\text{Index}_a = \frac{1}{\sqrt{\text{Var}(q_{ij}^{k})}} = \frac{1}{\sqrt{\text{Var}(q_{ij}^{k})}}.
\]  \( \text{(3)} \)

Using Equation (3), 867 indices representing forest product market integration between bordering provinces were obtained. For each province's forest product market integration index, 51 sets of observations were combined for the provinces as units. The degree of forest product market integration can be calculated by means of pairwise values; for example, for the Guangxi region, we have indices for Guangxi and Yunnan, Guangxi and Guangdong, Guangxi and Hunan, and Guangxi and Guizhou; the mean index of the four indices is obtained. The full forest product market integration index for the 23 provinces can be written as Index_a.

According to equations (1)–(3) above, the relevant results of the forest product market integration index of all provinces, regions, and the entire country were calculated. The detailed operation methods, data format processing, and program files of this method in Python are detailed in the attachment.

3.2. Data Sources and Descriptive Statistics. The annual average price data of 8 types of forest products in 23 provinces of China from 2001 to 2018 were selected for analysis. The data of Tibet, Qinghai, Xinjiang, Gansu, Ningxia, Beijing, Tianjin, Shanghai and Hong Kong, Macao, and Taiwan were not included in the sample. The data are from the China Forestry and Grassland Statistical Yearbook over the years, and the descriptive statistics are shown in Table 1.

3.3. Results. The forest product market integration index of each province was obtained by taking provinces as the regional subjects of measurement, and the dynamic change of market integration data of each province was analyzed by kernel density estimation. Figure 1 shows the kernel density diagram of the forest product market integration index of 23 provinces in China. It can be seen that from 2002 to 2018, except in 2010, the kernel density distribution in all years showed a single peak, and the peak value had a downward trend; the curve gradually flattened and also had a rightward trend. This indicates that the degree of integration of the forest product market in each province increased as a whole but also with the gradual expansion of differences.

Considering the regional differences in the development of the national forestry industry, the forest product market integration index of each province was calculated, and then the integration index of each province was combined according to the corresponding regional distribution, and the average value was calculated. The forest product market integration index of each region was thus obtained. According to the regional grouping data of the eastern, central, and western regions, the degree of the forest product market in the three regions showed an increasing trend, and the differences among regions gradually converged. However, during most of the period from 2002 to 2008, the degree of market integration in the three regions was higher in the Midwest than in the east (see Figure 2). This is consistent with the calculation results of the degree of integration of the whole domestic commodity market by researchers such as Gui et al. [18]. This result also confirms the conclusion of Lu Ming and Chen [5] that the degree of economic openness has an inverted U-shaped impact on market segmentation [5]. The results of this study indicate that before 2002, the export-oriented economic development model of the forestry industry in eastern China aggravated the segmentation of the forest product market. At the end of 2001, China formally acceded to the WTO, opening trade to a new height. Combined with the forestry industry center of gravity accelerating since 2000 from the northeast to the southwest, this eased the forest product market segmentation in the east. Afterward, three regions gradually converged (Figure 2).

The averages of the forest product market integration index for the 23 provinces in China were used to obtain 17 time series representing the degree of national forest product market integration. The change trend of domestic forest product market integration level from 2002 to 2018 is shown in Figure 2. The integration level of China’s domestic forest product market showed an overall upward trend in other years, except for a clear decline during the international financial crisis of 2008–2009. From the perspective of horizontal comparison, the forest product market integration index of China in recent years was roughly between 5 and 10; compared with the national average commodity market integration index between 80 and 100; clearly, there is a significant gap [14].

4. Analysis of Factors Influencing the Integration Level of Forest Product Market

4.1. Theoretical Analysis of Influencing Factors. Forestry, as a resource-based and ecological public welfare industry, involves externalities; the relevant theories of market failure
Table 1: Descriptive statistics of panel data.

| Variable                          | Containing righteousness | Number of samples | The mean | The standard deviation | The minimum value | The maximum value |
|----------------------------------|--------------------------|-------------------|----------|------------------------|------------------|------------------|
| A Wood (yuan/m³)                 |                          | 358               | 666.170  | 212.332                | 180              | 1,389            |
| B Converted timber (yuan/cubic meter) |                          | 358               | 1,165.489 | 459.691                | 52               | 3,625            |
| C Wood chips (yuan/solid volume cubic meter) |                          | 358               | 712.690   | 372.634                | 21               | 2,387            |
| D Wooden floor (yuan/square meter)  |                          | 358               | 182.696   | 212.489                | 18               | 2,945            |
| E Plywood (yuan/m³)              |                          | 358               | 1,966.536 | 668.476                | 109              | 4,935            |
| F Hardboard (yuan/cubic meter)   |                          | 358               | 1,454.930 | 490.606                | 200              | 3,042            |
| G Medium density fiberboard (yuan/m³) |                         | 358               | 1,386.869 | 358.457                | 204              | 2,952            |
| H Particleboard (yuan/m³)        |                          | 358               | 1,188.534 | 414.902                | 299              | 3,116            |

Figure 1: Kernel density map for the forest product market integration index of 23 provinces in China.

Figure 2: Trend of forest product market integration in China and in eastern, central, and western regions (2002–2018).
show that the effective allocation of resources can be realized only with the assistance of a competent government [19, 20]. Therefore, when market forces are exogenous, the more attention the local government departments pay to forestry, the more conducive to the development of local forestry and the construction of a forest product market. In reality, the Chinese government not only pays attention to the forestry industry through tree planting and prevention of disasters such as forest fires and related infrastructure investment but also implements various policies and regulations designed to support economic development and promote the reform of the forestry system. These measures in theory will have positive effects on the forest product market in China. Based on the above discussion, we propose several hypotheses:

(i) H1: The importance of local governments to forestry has a positive impact on the level of forest product market integration.

Infrastructure such as transportation, trading venues, and the Internet is the material basis for market transactions to be realized, and its degree of perfection determines the trade cost between domestic regions [21]. With the continuous improvement of infrastructure level, the influence of geographical segmentation between regions is gradually reduced, and this, in turn, improves the liquidity of commodities and factors, thus promoting the integration of markets. As far as forestry is concerned, the infrastructure level of roads and railways has a more direct impact on the domestic trade cost because the value of forest products per unit weight is relatively low and intraregional trade is mainly by land.

(ii) H2: The level of local infrastructure has a positive impact on the level of forest product market integration.

In terms of foreign economy and trade, China has become the world's largest trading country in forest products, and its dependence on foreign timber resources has remained above 50% since 2001. This is because the forestry industry, especially the forest product processing industry, has been following the development model of "both outside and outside" in which resources and the market have become more dependent on the international market; this led to a rapid rise and the formation of a high degree of dependence on the foreign market [22]. Therefore, the international economic and trade situation has an important impact on the development of China's forestry industry and forest product market.

(iii) H3: Foreign economic and trade conditions have a positive impact on the level of forest product market integration.

4.2. Model Setting and Data Description. To test the above three hypotheses, the research methods of Cui and Liang [14] were used for reference [14], were used for empirical study of forest product market integration factors. The model variables were set as follows: laws and regulations concerning forestry are introduced to reflect the government’s emphasis on local forestry. The state of roads and railways was used to characterize the development situation of domestic forest products trade costs in different areas. International trade in Chinese forest products is booming, and the number of registered foreign investors was used to represent China’s foreign economic relations and trade.

The econometric model was as follows:

\[
\text{Index}_{it} = \alpha + \beta_1 \text{Trade}_{it} + \beta_2 \text{Gov}_{it} + \beta_3 \text{Foreign}_{it} + \beta_4 \text{Rail}_{it} + \beta_5 \text{Road}_{it} + \epsilon_{it},
\]

where subscript \(i\) represents the province, \(t\) represents time, Index represents the forest product market integration index of different provinces in China, and \(\text{Gov}\) represents the importance each local government attaches to local forestry. The index data were calculated and sorted out using the Beida Legal database. Foreign refers to the number of foreign investors registered in each province, representing the degree of local foreign trade openness. The data are from the China Statistical Yearbook. Rail and Road represent the railway density and highway density of each province in China, respectively. The estimated data are from China Traffic Yearbook and China Tertiary Industry Statistical Yearbook. Trade is a dummy variable representing the prosperity of China’s international trade in forest products represented by whether the growth rate of China’s total import and export of major forest products (calculated in dollars) in past years is positive, and the data are from the Statistical Yearbook of China’s Forestry and Grassland in past years. From 2002 to 2018, the total import and export trade of China’s forest products was negatively affected by the international economic and trade environment in 2009 and 2016, respectively, showing a significant negative growth trend. The growth trend was unclear in 2012 and 2015, with the growth rate close to zero, and the other years showed significant positive growth. According to the actual growth rate of the total import and export of major forest products, the international trade prosperity degree in 2009 and 2016 was assigned 0, and the remaining years were assigned 1; the values of each province are the same. The meanings and characterization indices of the main variables of the model are shown in Table 2.

4.3. Analysis of Empirical Results. The descriptive statistics of panel data from 2002 to 2018 of 23 provinces, autonomous regions, and municipalities are shown in Table 3.

Columns (1) to (3) in Table 4 consider the prosperity of international trade in forest products, the emphasis of local governments on local forestry, and highway density, while columns (4), (5), and (6) are the regression results after incorporating the number of foreign registrations and railway density into the model. In the six regression results, the prosperity of international trade in forest products in China, the importance of local governments to forestry, and the density of roads had the same impact on the integration level of the domestic forest product market and were
positively correlated with the integration level of the domestic market.

In the regression results of the two groups of models containing three explanatory variables and five explanatory variables, the $P$ values from the Hausman test were all 0, indicating that the regression coefficients in the two groups were systematically different, that is, the effect of FE regression is better than RE regression. In addition, the $P$ values of the fixed effect regression results of the two groups of models were significant at the 1% level, indicating that the regression effect of the fixed effect model was better than that of the mixed OLS and thus of the two groups of models; we finally chose fixed effect regression for estimation. Subsequent analysis will be based on FE regression results.

As listed in Table 4 columns (2) and (5), the results showed that the degree of Chinese forest products international trade, the local government, and the construction of highways had positive effects, and forest products international trade and road density were always significant at the 1% level.

In order to solve the endogeneity problem of explanatory variables, this study draws lessons from Sheng and Mao [17]. The proximity of the international market and the share of the total import and export volume of foreign investment

| Table 2: Meanings of main variables. |
|-------------------------------------|
| **Variables** | **Meaning** | **Characterization of indicators** |
| Index | Forest product market integration index | Based on the segmentation index, see formula (3) |
| Trade | Whether forest product international trade boom | If the growth rate of forest product trade is significantly negative, the value is assigned to 0; otherwise, it is 1 |
| Gov | Local preference for forestry by local government | Number of local regulations related to forestry (pieces) |
| Foreign | Number of registered foreign investors | Number of foreign-invested enterprises registered at year-end (PCS) |
| Rail | Railway density | Railway density (km/100 km²) |
| Road | Road density | Road density (km/100 km²) |

| Table 3: Descriptive statistics of main variables. |
|-------------------------------------|
| **Variable** | **Containing righteousness** | **Number of samples** | **Mean** | **Standard deviation** | **Minimum value** | **Maximum value** |
| Index | Forest product market integration index | 330 | 4.44 | 1.77 | 0.97 | 11.87 |
| Trade | Whether forest product international trade boom | 330 | 0.86 | 0.34 | 0 | 1 |
| Gov | Local preference for forestry by local government | 330 | 286.08 | 163.82 | 22 | 929 |
| Foreign | Number of registered foreign investors | 330 | 12,983.58 | 21,031.72 | 595 | 170,968 |
| Rail | Railway density | 330 | 1.91 | 0.84 | 0.52 | 4.47 |
| Road | Road density | 330 | 81.46 | 42.21 | 6.14 | 191.35 |

| Table 4: Results of mixed OLS (ordinary least squares), FE (fixed effect), and RE (random effect) regression for the population sample using Stata15.0 software. |
|-------------------------------------|
| **Estimation method** | **Mixed OLS** | **FE** | **RE** | **Mixed OLS** | **FE** | **RE** |
| **Explanatory variables** | (1) | (2) | (3) | (4) | (5) | (6) |
| Trade | 0.6490*** | 0.7210*** | 0.6612** | 0.6489** | 0.7266*** | 0.6614** |
| Gov | 0.0033*** | 0.0005 | 0.0032*** | 0.0034*** | 0.0001 | 0.0032*** |
| Road | 0.0027 | 0.0364*** | 0.0047* | 0.0028 | 0.0287*** | 0.0043 |
| Foreign | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Rail | 0.0118 | 0.4708 | 0.0358 | 0.0018 | 0.4708 | 0.0358 |
| Constant term | 2.7026*** | 0.7238 | 2.5639*** | 2.7122*** | 0.2890 | 2.3966*** |
| $R^2$ | 0.3380 | 0.4708 | 0.3547 | 0.3601 | 0.5158 | 0.3795 |
| Hausman test | 32.341*** | 39.181*** |
| $P$ values | 0.0000 | 0.0000 |
| Observations | 330 | 330 | 330 | 330 | 330 | 330 |

Note. OLS = ordinary least squares, FE = fixed effect, and RE = random effect. In () is the t statistic. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.
companies in the total GDP of each province were used as instrumental variables reflecting the degree of foreign trade openness. Since China's foreign trade is mainly carried out by sea, this study assigns a value of 0 to the international market proximity of coastal provinces and assigns a value to the nearest distance of inland provinces to large port cities (Tianjin, Shanghai, and Guangzhou). Relevant data are from the China Statistical Yearbook.

At the same time, this study also considered the endogeneity of local government's emphasis on the forestry industry. The proportion of the government's investment in forestry and the leading position in the formulation of forestry policies and regulations were used as instrumental variables. The formulation of forestry policies and regulations was based on the average number of forestry policies and regulations issued by each province in China every year as the benchmark, and then the number of forestry policies and regulations issued by each province was subtracted from the average value to obtain the leading degree of forestry policies and regulations issued by each province. In addition, given that one of the motives of local governments is to win in the GDP bidding competition, the greater the proportion of forestry output value in local GDP, the stronger the motivation of the local government's forestry preference. Therefore, in this paper, we used the proportion of forestry output value to GDP as the third instrumental variable of local government preference for local forestry. Relevant data are from the China Statistical Yearbook, the China Forestry and Grassland Statistical Yearbook, and the Peking University Legal database. The results are shown in Table 5.

Table 5 shows the results of 2SLS regression using instrumental variables. Columns (1) to (3) and (4) to (6) in the table are the models containing four and five explanatory variables, respectively. All the regression results confirmed that the local government's attention to local forestry, the prosperity and development of international trade of Chinese forest products, and the construction of roads had positive impacts on the integration of the domestic forest product market in China.

Column (1) lists the regression results of the instrumental variables that the government considers important to forestry, including the proportion of government investment in forestry in the total government investment, the leading degree of forestry policy and regulation issuance, and the share of forestry GDP in local GDP. The statistical results for the minimum eigenvalues show that the three selected instrumental variables pass the test of "weak instrumental variables." Column (2) lists the regression results of the international market proximity of each province and the share of the total import and export volume of foreign-invested companies in the local GDP as instrumental variables affecting the degree of opening up, and the results showed that the two instrumental variables pass the test of "weak instrumental variables." Column (3) shows the results of simultaneous regression using the above five instrumental variables. In the regression results of columns (1) to (3), the influence of the local government's emphasis on forestry and the prosperity of China's international trade in forest products on the integration level of the domestic forest product market always remains significant at the 5% level.

Column (4) lists the regression results of the five explanatory variables of the model, where the proportion of the government's investment in forestry in the total government investment, the leading degree of issuing forestry policies and regulations, and the share of forestry GDP in GDP are instrumental variables for the local government's emphasis on local forestry. Column (5) shows the regression results based on the proximity of the international market and the share of the total import and export volume of foreign-invested companies in the GDP of each province as the instrumental variable of the degree of opening to the outside world. Column (6) lists the regression results using five instrumental variables simultaneously. The regression results of columns (4) to (6) all passed the test of "weak instrumental variables." In the above regression results, the prosperity degree of China's international trade in forest products and the importance of each province to forestry, the two core variables, always remain significantly positive. Although the degree of foreign trade openness and infrastructure development were not significant in individual regression results, this does not affect the basic conclusion that the prosperity degree of China's international trade in forest products and the importance of local governments to forestry have significant positive impacts on the level of domestic forest product market integration.

5. Robustness Analysis of Regression Results

In order to test the robustness of the regression results, in this study, we conducted the following three tests for the panel regression results of 23 provinces in China from 2002 to 2018.

5.1. Replacement of Instrumental Variables. We referred to the literature for general practice [14]. First, we replace all instrumental variables in the model with the lagged phase of explanatory variables (Gov, Foreign, Rail, and Road) for regression to test the robustness. In the regression results after the replacement of instrumental variables, the significance of each variable did not change substantially. The regression coefficient signs of Trade, Gov, and Road were all positive, consistent with the previous values, and both Trade and Gov remained significant at the level of 1%. The specific results are shown in columns (1) and (2) of Table 6.

5.2. Eliminating the Extreme Values in the Samples. Based on the 2018 data, the provinces whose forest product market integration values were within the top 10% of the highest and lowest levels in China were selected and eliminated, with Jiangsu (10.08) and Yunnan (9.07) the highest and Heilongjiang (2.48) and Shaanxi (2.28) the lowest successively deleted. Then, the data for the remaining 19 provinces, autonomous regions, and municipalities were regressed again. The coefficient symbols of all variables were unchanged; the influence of the prosperity degree of China's international trade in forest products remained significant. The results are shown in columns (3) and (4) of Table 6. This indicates that the existence of extreme samples in the data did not affect the robustness of the conclusions in this paper.
5.3. Adjusting the Valuation of the International Trade Boom.
Different from the previous values of 0 for the trade prosperity degree in 2009 (−2.38%) and 2016 (−2.00%) and 1 for the remaining years, this part also assigned 0 to 2012 (0.25%) and 2015 (−0.83%) when the growth rate of China’s import and export trade of forest products (calculated in dollars) was close to zero. The value remained 1 for the rest of the years. The results are shown in columns (5) and (6) of Table 6. The estimation results show that the indicators of the estimated coefficients of the variables such as the prosperity of international trade in forest products, the importance of local governments to forestry, and the density of roads were unchanged, and the prosperity of international trade in forest products and the density of roads were significant at least at the 5% level. This indicates that in the current development stage, the prosperity of international trade of forest products in China is highly correlated with the integration degree of the domestic forest product market. The prosperity of the international forest product trade is conducive to the integration of the domestic forest product market in various provinces, and the estimated results are relatively robust. Since the year in which the trade prosperity degree is assigned as 0 is expanded from the year in which the trade volume significantly grows negatively to the year in which the growth rate is close to zero, the explanatory power of the international trade prosperity degree of forest products on the integration of domestic forest product market has decreased. Therefore, the explanatory power of the full model has decreased slightly, in line with expectations.

6. Conclusion
In this paper, we use the Python programming method to improve the price index method and calculate the integration level of the forest products market in China and then introduce variables that can reflect the local government, infrastructure, and foreign economic and trade situation to conduct an empirical analysis on the influencing factors of

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Table 5: Regression results of instrumental variables.

| Explanatory variables | Gov (1) | Foreign (2) | Gov and Foreign (3) | Gov (4) | Foreign (5) | Gov and Foreign (6) |
|-----------------------|---------|------------|---------------------|---------|------------|---------------------|
| Trade                 | 0.5803**| 0.6701**   | 0.8186***           | 0.5836**| 0.6697***  | 0.6143**            |
| Gov                   | 0.0017**| 0.0034***  | 0.0071***           | 0.0017**| 0.0034***  | 0.0020**            |
| Road                  | 0.0055**| 0.0056**   | 0.0024              | 0.0050  | 0.0059*    | 0.0084**            |
| Foreign               | 0.0000  | 0.0000**   | 0.0000              | 0.0000  | 0.0000**   | 0.0000              |
| Rail                  |        |            | 0.0447              | 0.0250  | 0.0238     |                     |
| Constant term         | 2.9918***| 2.6337***  | 1.9990***           | 2.9436***| 2.6546***  | 2.8540***           |
| $R^2$                 | 0.1056 | 0.0934     | 0.0209              | 0.0163  | 0.0928     | 0.0676              |
| Minimum eigenvalue statistics | 156.4810 | 141.1740 | 8.5729              | 167.4530| 140.9940   | 45.4897             |
| Observations          | 330    | 330        | 330                 | 330     | 330        | 330                 |

Note. The value in parentheses is the t statistic; *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively. The minimum eigenvalue statistic [ ] is the critical value of the 2SLS Wald test at the 10% significance level. Gov and Foreign are endogenous variables.

Table 6: Results of robustness analysis.

| Explanatory variables | (1)      | (2)      | (3)      | (4)      | (5)      | (6)      |
|-----------------------|----------|----------|----------|----------|----------|----------|
| Trade                 | 0.6073***| 0.6971***| 0.5334** | 0.5362** | 0.4651** | 0.4679** |
| Gov                   | 0.0033***| 0.0033***| 0.0000   | 0.0000   | 0.0000   | 0.0000   |
| Road                  | 0.0028   | 0.0030   | 0.0416***| 0.0390***| 0.0364***| 0.0288***|
| Foreign               | 0.0000   | 0.0000   | 0.0000   | 0.0000   | 0.0000   | 0.0000   |
| Rail                  | 0.0177   | 0.2260    | 0.4997   | 0.5194   | 0.5194   | 0.5194   |
| Constant term         | 2.7200***| 2.7340***| 0.02869  | 0.0694   | 0.9598** | 0.5194***|
| $R^2$                 | 0.0985   | 0.0985   | 0.2929   | 0.2954   | 0.1921   | 0.2033   |
| Observations          | 322      | 322      | 264      | 264      | 330      | 330      |

Note. In () is t statistic; *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.
forest product market integration. The main conclusions are as follows: (1) the improvement of the price index method can calculate the market integration level more quickly and accurately, which has obvious advantages in the case of a large amount of data. (2) The degree of forest product market integration in China is between 5 and 10, lagging behind the national average. (3) For the temporal trend, the degree of integration of China’s forest product market shows an overall upward trend. (4) In terms of spatial trend, the degree of integration of the forest product market among east, central, and west regions gradually converges, but the differences among provinces continue to expand. (5) In terms of influencing factors, the coefficients of local government’s emphasis on forestry, the prosperity of international trade in forest products, and highway density are significantly positive, while the number of foreign investors registering and railway density have no significant positive effects.

Inspired by the above conclusions: (1) the optimization of the market integration measurement method in this paper makes it easier for scholars to obtain data on various market integration levels and promote in-depth research in the field of market integration. (2) The international economic environment fluctuations have become a major factor influencing the Chinese forest products production and trade. This is because China’s forest product processing industry is highly dependent on foreign markets, and the deeper reason is the lack of an effective integrated forest product market in China. Therefore, it is necessary to establish a unified, high-standard domestic forestry market system as soon as possible, where the forestry industry adapts to the new development pattern of ‘mainly internal circulation; internal and external circulation promote each other’. (3) The forestry industry as a resource-based ecological public welfare industry and as local government departments plays an important and irreplaceable role in improving the efficiency of market resource allocation. Therefore, the government should participate in the development of the forestry industry together with market subjects and accelerate the integration of the domestic forest product market by strengthening the aspects including the government’s system guarantees, financial support, and scientific research support. (4) Infrastructure construction is the material basis of a high-standard integrated domestic forest product market system, especially the improvement of transportation conditions supporting modern logistics of forest products, a factor that is of great significance to the construction of a unified high-standard domestic forest product market. China’s domestic forest product trade depends on road transportation. Under the condition that the backbone road network has been relatively efficient, paying attention to the construction of transportation infrastructure in mountainous areas and forest areas can significantly reduce the cost of forest product transportation and further promote the integration of the domestic forest product market.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors’ Contributions

Linshu Song and Hao Wang are co-authors of the article.

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Supplementary Materials

Python software code for calculating the level of market integration. Adjacent conditions of each region. Detailed operation method description of computing market integration using Python. (Supplementary Materials)

References

[1] P. Krugman, “Scale economies, product differentiation, and the pattern of trade,” The American Economic Review, vol. 70, no. 5, pp. 950–959, 1980.
[2] Research group of development Research Center of The State Council, “The impact of domestic market integration on China’s regional coordinated development and its enlightenment,” Study on China Administration for Industry & Commerce, no. 12, pp. 22–25, 2005.
[3] F. Kong, Y. Zheng, and D. Li, Evaluation Theory and Empirical Study on the Process of Forestry Marketization in China — Based on the Relevant Statistical Data of 15 Provinces (Autonomous Regions) from 2002 to 2006, The Fifth China Forestry Technology Economic Theory and Practice Forum, Beihai, China, 2010.
[4] B. J. Naughton, How Much Can Regional Integration Do to Unify China’s Markets?, The Conference for Research on Economic Development and Policy Research, California, USA, 1999.
[5] M. Lu and Z. Chen, Market Integration and Industrial Agglomeration in China’s Regional Economic Development, Shanghai People’s Publishing House, Shanghai (China), 2006.
[6] A. Young, "The razor’s edge: distortions and incremental reform in the people’s Republic of China,” Quarterly Journal of Economics, vol. 115, no. 4, pp. 1091–1135, 2000.
[7] M. Chen, Q. Guil, M. Lu, and Z. Chen, How will China’s economic growth continue to generate economies of scale — an empirical study on economic openness and domestic commodity market segmentation Economic, Beijing, China, no. 1, pp. 125–150, 2007.
[8] E. Javier and V. s. Arturo, Market Integration for Agricultural Output Markets in Peru: The Role of Public Infrastructure, University Library of Munich, (Germany), 2005.
[9] L. J. Bachmeier and J. M. Griffin, “Testing for market integration: crude oil, coal, and natural gas,” Energy Journal, vol. 27, no. 2, 2006.
[10] A. Virmani and S. Mittal, Domestic Market Integration, Indian Council for Research on International Economic Relations, New Delhi (India), 2006.
[11] P. Brenton, A. Portugal-Perez, and J. Régolo, Food Prices, Road Infrastructure, and Market Integration in central and
[12] G. Liu, "Does economic opening aggravate domestic market segmentation? An empirical test on provincial panel data in China," *Finance and Trade Research*, vol. 29, no. 1, pp. 16–26, 2018.

[13] C. Vithessonthi and S. Kumarasinghe, "Financial development, international trade integration, and stock market integration: evidence from Asia," *Journal of Multinational Financial Management*, vol. 35, pp. 79–92, 2016.

[14] Q. Cui and S. Liang, "The empirical analysis on the influence factors of the domestic market integration in China — an test based on panel data," *Industrial Technology Economics*, vol. 35, no. 1, pp. 26–35, 2016.

[15] P. K. Goldberg and F. Verboven, "Market integration and convergence to the Law of One Price: evidence from the European car market," *Journal of International Economics*, vol. 65, no. 1, pp. 49–73, 2005.

[16] O. Ogrokhina, "Market integration and price convergence in the European Union," *Journal of International Money and Finance*, vol. 56, pp. 55–74, 2015.

[17] B. Sheng and Q. Mao, "Trade opening, domestic market integration and China’s inter-provincial economic growth: 1985-2008," *The Journal of World Economy*, vol. 11, pp. 44–66, 2011.

[18] Q. Gui, M. Chen, M. Lu, and Z. Chen, "Is China’s domestic goods market disintegrated or integrated: an analysis based on the relative price," *The Journal of World Economy*, vol. 29, no. 2, pp. 20–30, 2006.

[19] Y. Zhu, "On market failure in forestry," *Journal of Beijing Forestry University*, vol. 21, no. 6, pp. 77–83, 1999.

[20] Y. Lin, "Chinese experience: effective market and effective government are indispensable in economic development and transformation," *Administrative Reform*, no. 10, pp. 12–14, 2017.

[21] S. Phousai and S.-W. Jang, "A study on the determinants of trade costs and exports in Laos," *The Journal of Eurasian Studies*, vol. 17, no. 2, pp. 83–108, 2020.

[22] S. Poncet, "Measuring Chinese domestic and international integration," *China Economic Review*, vol. 14, no. 1, pp. 1–21, 2003.