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# Dynamic Decomposition of Factors Influencing the Export Growth of China's Wood Forest Products

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Received: 10 July 2018; Accepted: 4 August 2018; Published: 6 August 2018



**Abstract:** Wood forest products (WFPs) are globally important environmental products, with economic, ecological, and renewable characteristics. China is the world's largest WFP exporter. However, many factors, such as the downturn of traditional major export markets and the rise of the price of production factors, have generated great challenges and uncertainties for China's WFP export market. This study improves the product scope of WFPs. The category of WFPs has been expanded to 14 categories and 30 sub-categories, which is more detailed and more developed than in previous literature. Based on the United Nations' Comtrade Database (COMTRADE), this paper uses the revised constant market share (CMS) model to measure and analyze empirically the factors affecting the export growth of China's WFPs from the perspective of market, structure, and competitiveness. It is found that (1) the competitive effect exerts the biggest influence on export growth, followed by market size effects, with the effects of market distribution and product structure both being small; (2) wooden furniture, wooden products, plywood, paper, and its products play a main role in enhancing the competitive effect in China's WFPs; and (3) China's WFPs have a strong market competitiveness in other markets such as the USA, China Hong Kong, United Kingdom, Japan, Australia, Malaysia, and Singapore. Therefore, it is crucial for China's WFP market to improve its product structure effects and market distribution effects in order for it to participate in international competition. On the other hand, considering that China's exports of WFPs mainly consist of resource- and labor-intensive products, the improvement of standards such as the technology level, environmental protection and sustainable development, must not be ignored.

**Keywords:** wood forest products; export; revised constant market share (CMS) model; China

## 1. Introduction

Wood forest products (WFPs) are forest wood-based products with economic, ecological, and renewable characteristics that are widely used in the home, in papermaking, for decorations, and in many other fields. As a result, global demand for WFPs is growing rapidly. Additionally, due to their sustainable and environmentally-friendly nature, WFPs have been recognized as an environmental product, and have received preferential tax policies for international trade. The Organization for Economic Cooperation and Development (OECD) divides environmental products into 10 categories, the seventh of which is "Sustainable Forestry". Asia-Pacific Economic Cooperation (APEC) also incorporates forest products such as "Bamboo Flooring" into environmental products [1]. Therefore, the trade potential of WFPs in the world is huge, and China has played an important role in this regard.

Statistics show that the export value of China's forest products in 2017 exceeded \$150 billion, and it continues to maintain its status as the world's largest exporter [2]. The export of China's forest products mainly consists of WFPs, accounting for 63.25% of China's forest products in 2016 [3].

What are the characteristics of the evolution of China's WFPs? This study analyzed data from 2007 to 2016. (1) China's WFP exports are growing rapidly, but they are also fluctuating. The export value increased from \$7.35 billion in 2002 to \$50.75 billion in 2016, an increase of 5.91-fold (Figure A1). Research showed that the average annual export growth rate of China's WFPs from 1993 to 2014 reached 13.56%, which is much higher than the 4.54% annual growth rate of the world's average exports over the same period (Zhang et al., 2017) [4]. China is also the world's largest exporter of wooden furniture, with its export share accounting for 31% of the world's share (Shi et al., 2015) [5]. It is worth noting that from 2007 to 2009, China's WFPs even experienced a slight decline in exports. After 2010, the export value of China's WFPs showed steady growth. In 2015, the export value reached the highest historical record of \$53.7 billion, but in 2016, the value of exports fell drastically by \$3 billion (Figure A1). (2) China's WFP export products are highly concentrated. Paper and its products, wooden furniture, wooden products, and plywood rank among the top four WFP exports in China. The proportion of exports of four categories accounted for 37.91%, 28.03%, 15.54%, and 10.57%, respectively, which totaled 92.06% (Table A1). (3) The share of the traditional export market showed a downward trend, and the export share of emerging markets showed a growth trend. China's WFP export markets are mainly concentrated in the USA, Japan, China Hong Kong, and four European countries (United Kingdom, Germany, France, and The Netherlands). The average annual shares of the four major export markets in 2007–2016 were 27.62%, 10.71%, 10.16%, and 9.75%, respectively (Table A2). However, from the perspective of development trends, China's WFPs have gradually declined in dependence on exports from USA, Japan, China Hong Kong. The cumulative share of the three major markets fell rapidly from 69.32% in 2002 to 38.72% in 2016 (Table A2). At the same time, China's WFPs increased rapidly in emerging markets such as Australia, Saudi Arabia, India, Vietnam, and Singapore. Calculations from the trade potential model found that the financial crisis had a huge impact on the import of major developed economies (Gu et al., 2009) [6]. In short, China's WFP export growth is also full of ups and downs, and the high product concentration and the decline in the traditional export market share are not conducive to future development. Therefore, it is of great importance to find out which factors affect the growth of China's WFP exports, the impact of different export target markets on China's WFP exports, and the impact of changes in the size of international market demand, and so on. In response to these problems, this study will decompose dynamically the drivers of China's WFP export growth from the perspectives of the market, its structure, and its competitiveness. The research in this paper is based on previous foundations, so that the relevant literature is first reviewed and analyzed.

Firstly, free trade has had a great impact on WFP exports, and many scholars are concerned about this. According to global trade analysis project (GTAP) simulation, China's entry into the World Trade Organization (WTO) has greatly increased the size of its import of foreign WFPs, and the price of wood, wooden products, pulp, and newsprint in China has decreased. The Association of Southeast Asian Nations (ASEAN) and emerging economies in Asia will benefit greatly, and the world trade in WFPs will change. At the same time, the size of China's WFP processing trade exports is also growing rapidly (Gan, 2004) [7]. Luo et al. (2018) [8] believe that WFP is a water-intensive product, and its trade has effectively alleviated the pressure of global water shortages. At present, China's virtual water trade, based on forestry products, is growing rapidly. Under the background of economic globalization, China has attracted a lot of foreign direct investment (FDI) to develop its export-oriented forest products processing industry and its service industry. Its production materials are mainly imported from abroad, which is conducive to China's forest ecological recovery (Li et al., 2015) [9]. Overall, free trade has promoted the development of WFP trade in the world. China's role in the global value chain is more of a model of "importing logs, then processing them into consumer goods, and finally exporting them to the world", which has contributed to the effective allocation and utilization of global forestry resources.

Secondly, the factors affecting WFP exports are also important research hotspots. Bertrand et al. (2016) [10] studied the relationship between forest resource endowment and the trade

of WFPs in the European Union (EU) from 1995 to 2007. It was found that forestry resource endowment has a significant impact on the international trade of wood pulp, paper products, and wooden furniture in Europe. Zhang et al. (2009) [11] used the gravity model to calculate the export trade of China's WFPs from 1995 to 2004. The study identifies the characteristics of China's own forest resources and that cutting restrictions affects its export trade model of WFPs. China has imported a large number of WFPs for processing and production, and its low-value WFPs are exported to foreign countries. But in the context of a stronger currency (RMB) and higher logistics costs, China's imports and exports of WFPs are likely to fall. Additionally, Xiong et al. (2017) [12] find that the rising trade costs have led to declining profit margins for China's producers and exporters of WFP. At present, many of China's WFP manufacturers have already moved their factories abroad, and Vietnam is one of the main destinations [13]. Vietnam has become Asia's second largest exporter of WFPs, and it is highly competitive with China's exports of WFPs in USA and European countries [14,15]. Gu et al. (2010) [16] undertook an empirical analysis of the export of China's WFPs in 10 markets from 1992 to 2006. It was found that the export growth of China's WFPs is mainly driven by the effect of improving competitiveness, and that the effect on market structure is negative. During this period, China's export share of WFPs to 10 markets reached 84%. Today, China's WFP export markets are further dispersed, and its share of exports to 10 markets has fallen to less than 70%. Additionally, China has begun to tap the trade potential of emerging economies and "The Belt and Road" countries. This study will use the latest data to analyze the reasons for the export growth of China's WFPs.

Third, research on the constant market share (CMS) model and its applications has also made a lot of progress. The model assumes that the international market share is constant if the export competitiveness of one or more products of a country (region) does not change. In fact, product export and market share are changing, which must be caused by the change in international market demand, the demand structure of the importing country, and the competitiveness of the exporter's products (Xiao et al., 2010) [17]. Tyszynski (1951) [18] was the first to introduce this model to the empirical study on the global manufacturing trade in manufacturing industry from 1899 to 1950. Jepma C. (1986), Milana C. (1988), and Fredoun Z. (2006) [19–21] further summarize the application domain, the limitations, and the prospects of the CMS model, and the model construction is perfected. Additionally, Shane et al. (1993), Drysdale et al. (1996), and Edwards et al. (2008) [22–24] respectively analyzed the trade growth factors of Australia, New Zealand, and South Africa based on the CMS model. At present, the CMS model has been analyzed and applied in a series of fields, such as environmental products and renewable energy products. The size of China's WFP exports is growing in volatility, while the distribution of its export markets and its product structure indicators are also constantly changing. It is important to know the extent of how these changes affect China's WFP export growth, and which indicators have more influence. This requires the introduction of analytical tools, by which the CMS model can solve this problem. Considering the wide application and maturity of the method [25,26], this study uses the modified CMS model for empirical analysis.

Reviews show that scholars are concerned about China's WFP export trade. It is worth pointing out that the existing literature on the factors influencing China's WFP exports have some problems, such as old data and incomplete classification of the export WFPs. This study will adopt the modified CMS model to make an empirical analysis on the causes of the growth of China's WFP exports from 2002 to 2016, in order to identify the problems. The category on WFPs has been supplemented, and is related here in more detail and with greater volume than in previous literature.

## 2. Data and Methods

### 2.1. Definition of the Wood Forest Product(WFP) Category

Presently, the definition and statistical standards of WFPs are not uniform. The United Nations Food and Agriculture Organization (FAO) defines the category of WFP as comprising seven categories of industrial logs, sawn timber, wood pulp, wood-based panels, wood fuels,

paper products, and recycled paper [27], but no statistics have been compiled for wooden products and wooden furniture. However, the “China Forestry Statistical Yearbook” defines WFPs in 14 categories, including logs, sawn timber, veneer, special-shaped materials, particle board, fiberboard, plywood, wooden products, wooden furniture, wood chips, wood pulp, waste paper, charcoal, and paper and its products [28]. Moreover, the product codes of the United Nations’ Comtrade Database (COMTRADE) do not correspond to the above two categories. For example, the name of the wooden furniture is not found in COMTRADE’s Harmonized Commodity Description and Coding System (HS) code. In order to facilitate data acquisition and analysis, this study defined WFPs as comprising 14 categories: logs, sawn timber, veneer, special wood, particle board, fiberboard, plywood, wooden products, wooden furniture, wood pulp (including waste paper), paper and its products, charcoal, cork, and other raw materials (including wood chips). The commodity codes and their descriptions are shown in Table 1.

**Table 1.** The commodity codes and specific descriptions of the classified wood forest products (WFPs).

Product Category	Commodity Code	Commodity Descriptions
Log	HS4403	Logs, whether or not peeled, sapwood or rough sawn
Sawn timber	HS4407	Longitudinal saws, slits, sliced or peeled wood
Veneer	HS4408	Decorative veneers, veneer plywood, and other longitudinally sawed, sliced or peeled wood
Special wood	HS4406, HS4409	Any side or face made of continuous wood, railway, and tramway sleepers
Particle board	HS4410	Wood particle board and other similar wood material boards
Fiberboard	HS4411	Wood fiberboard or other wood fiberboard
Plywood	HS4412, HS4413	Plywood, veneer, and similar multilayers, reinforced wood, block, board, strip, or profiled
Wooden product	HS4414–HS4421, 960910	Wooden picture frames, wooden cable reels, wooden pallets, box trays, wooden vats, barrels, pots, wooden figurines and other decorations, pencils, etc.
Wood pulp	HS47	Mechanical wood pulp, chemical wood pulp, sulfite wood pulp, semi-chemical wood pulp, other fibrous cellulose pulp, waste paper, and cardboard products
Paper and its products	HS48, HS49	Rolled or sheeted newsprint, books, pamphlets, loose-leaf prints, and similar prints, whether leaflets, etc.
Charcoal	HS4402	Charcoal, whether or not agglomerated
Wooden furniture	SITC8215	Wooden furniture including kitchen and bedroom wooden furniture
Cork	HS4501–HS4504	Natural cork, cork waste, natural cork products, pressed cork, and its products
Other raw materials	HS4401, HS4404, HS4405	Firewood, chips or pellets, sawdust, wood waste and debris, hoops, rafts, stakes, sticks, chips and similar products, wood wool, wood flour

Table 1 shows that some of the major categories of products contain many small wood products. It is worth pointing out that COMTRADE does not have a clear corresponding HS code for this category of wooden furniture. However, there is a clear commodity code for the SITC8215 in the Standard International Trade Classification (SITC). SITC data is also from COMTRADE. Therefore, the data of wooden furniture in this study uses SITC8215.

## 2.2. Methods

The export scale of China’s WFPs fluctuates dynamically, and the export market distribution, product competitiveness, and product structure are also changing. This requires further analysis of the extent to which various changes affect export volatility. The CMS model can solve these problems.

### 2.2.1. The Basic Analysis Model of Constant Market Share (CMS)

The CMS model applications include two types; one kind is for fluctuation analysis of two markets with a variety of export products, and another kind is for volatility research on a variety of products that are exported to more than one market. China's export of many kinds of WFPs to more than 100 markets is the second type. The common basic equation of CMS analysis model is as follows (Liu et al., 2017) [29]:

$$V^2 - V^1 = rV^1 + \sum_{i=1}^m (r_i - r)V_i^1 + \sum_{j=1}^n \sum_{i=1}^m (r_{ij} - r_i)V_{ij}^1 + \sum_{i=1}^m \sum_{j=1}^n (V_{ij}^2 - V_{ij}^1 - r_{ij}V_{ij}^1) \quad (1)$$

Equation (1) is explained by the indicators used in the export of China's WFPs, and  $V$  represents the export of China's WFPs. The above marks 1 and 2 respectively represent the starting point and cut-off point of the time span. The notations in Equation (1) and their meanings are as follows:

$V^2 - V^1$	the change in the export of China's WFPs in a time span.
$I$	category $I$ export of China's WFPs.
$m$	the number of product categories.
$V_i$	the export of category $i$ of China's WFPs.
$j$	the number $j$ target market for China's WFP exports.
$n$	the number of markets.
$V_{ij}$	the export of category $i$ of China's WFPs to market $j$ .
$r$	the growth rate of world WFP imports in a time span.
$r_i$	the import growth rate of WFP $I$ in the world in a time span.
$r_{ij}$	the import growth rate of WFP $i$ imported by country $j$ in a time span.

The right-hand side of Equation (1) is composed of four parts. The  $rV^1$  represents the impact of world demand on China's WFP exports, i.e., the market size effects. The larger the  $rV^1$ , the greater the impact of world demand.  $\sum_{i=1}^m (r_i - r)V_i^1$  represents the impact of the relative changes in the WFP demand structure of the world on China's WFP exports, i.e., the product structure effect.  $\sum_{j=1}^n \sum_{i=1}^m (r_{ij} - r_i)V_{ij}^1$  represents the impact of the relative changes in the import demand of each target market on China's WFP exports, i.e., the market distribution effect.  $\sum_{i=1}^m \sum_{j=1}^n (V_{ij}^2 - V_{ij}^1 - r_{ij}V_{ij}^1)$  represents the impact of the changes in China's WFP competitiveness on its exports, i.e., competitiveness effect.

### 2.2.2. Revision of CMS Basic Analysis Model

The CMS basic analysis model has two drawbacks. First, the practical significance of  $\sum_{j=1}^n \sum_{i=1}^m (r_{ij} - r_i)V_{ij}^1$  is the impact on China's WFP exports by the gross value of the relative changes in demand for various WFP imports from all kinds of target markets. The market distribution effect needs to be reflected in the impact on China's WFP exports by the relative changes in the demand for all WFPs in each target market (Li et al., 2007; Zhang et al., 2010) [30,31]. Therefore, it is necessary to further decompose the impact of changes in the import growth rates of various WFPs in each target market. Second, the competitiveness effect of item 4 on the right-hand side of Equation (1) also needs to be subdivided. Because competitiveness is relative, the export competitiveness of the same kind of WFP is different in different markets. The revised CMS model can better solve the above problems.

Considering all export markets of China's WFPs as a whole, Equation (1) can be simplified as:

$$V^2 - V^1 = rV^1 + \sum_{i=1}^m (r_i - r)V_i^1 + \sum_{i=1}^m (V_i^2 - V_i^1 - r_iV_i^1) \quad (2)$$

Because all markets are considered as a whole, Equation (2) does not have the form of a market distribution effect. In fact, the market distribution effect is included in the product structure effect.



All WFPs are identified as one product, and  $r_j$  and  $V_j$  are introduced, where  $r_j$  represents the import growth rate of all WFPs in the market  $j$  in a certain span, and  $V_j$  represents the gross value of China's WFP exports to market  $j$  in the same span. Equation (1) can be simplified as:

$$V^2 - V^1 = rV^1 + \sum_{j=1}^n (r_j - r) + \sum_{j=1}^n (V_j^2 - V_j^1 - r_j V_j^1) \quad (3)$$

Due to all WFPs being a kind of product, Equation (3) does not have the form of a product structure effect. In fact, the product structure effect is involved in the market distribution effect. The sum of Equations (2) and (3) becomes Equation (4):

$$V^2 - V^1 = rV^1 + \frac{1}{2}\sum_{i=1}^m (r_i - r)V_i^1 + \frac{1}{2}\sum_{j=1}^n (r_j - r)V_j^1 + \frac{1}{2}\sum_{i=1}^m (V_i^2 - V_i^1 - r_i V_i^1) + \frac{1}{2}\sum_{j=1}^n (V_j^2 - V_j^1 - r_j V_j^1) \quad (4)$$

The five items on the right-hand side of Equation (4) respectively represent the market size effect, the product structure effect, the market distribution effect, the product competitiveness effect, and the market competitiveness effect. These five effects constitute the main drivers of China's WFP export growth.

### 2.3. Data Source, Market Selection, and Time Division

First, to ensure the consistency of the study data, all data in this study were sourced from the COMTRADE database. COMTRADE's trade values for WFPs were in the current US dollar values, and the exchange rate that was used, was the annual average exchange rate [32].

Second, considering the large number of markets in the world, in order to facilitate the analysis, this study selected major export markets for the analysis sample. This study selected the USA, Canada, United Kingdom, Germany, France, Netherlands, Australia, Japan, China Hong Kong, Korea, Singapore, Saudi Arabia, Malaysia, Vietnam, and India as analysis markets. COMTRADE Statistics show that China's export share of WFPs to these markets totaled 70.37% in 2015–2016, so the samples had a strong representation [32]. The time span of the research data was 2002–2016.

Third, the CMS model has higher requirements for time segmentation. The time division must correspond to the rhythm of export fluctuations. Major economic events affecting exports may also be considered as time division points in order to improve the pertinence and effectiveness of the model analysis. Because of the global financial crisis, the export trend in 2009 fell slightly. Since 2010, China's WFP exports have resumed growth. However, in 2016, China's WFP exports fell by \$3 billion. Therefore, this study divided the time span into four periods, 2002–2008, 2008–2009, 2009–2015, and 2015–2016.

## 3. Results

The gross value of WFPs imported from the world and China at each time point in the 15 markets was calculated, respectively expressed as  $R_j$  and  $V_j$ .  $R_j$  is used to measure  $r_j$ . The import value of WFPs in the sample markets at each time point is shown in Table A3. The value of each classified WFPs imported from the world and China at each time point was calculated, respectively expressed as  $R_i$  and  $V_i$ , and  $R_i$  was used to calculate the index  $r_i$ . The calculation of the classified WFP imports at each time point is shown in Table A4. The data (Tables A3 and A4) were substituted into Equation (4), and the calculation results of the causes of China's WFP export growth are shown in Table 2.

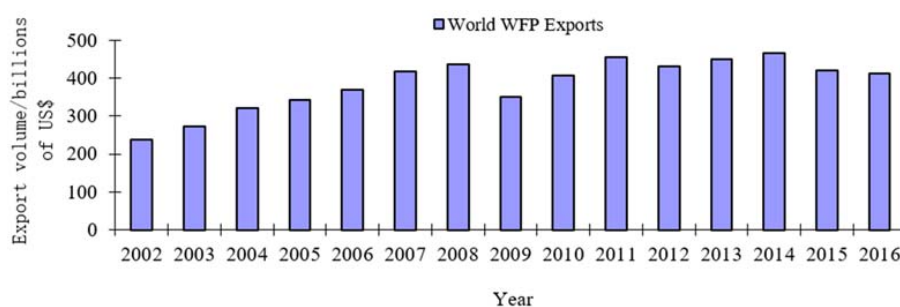
**Table 2.** Decomposition of China's WFP export growth from 2002 to 2016.

Export Growth Drivers	2002–2008		2008–2009		2009–2015		2005–2016	
	C 1/\$Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%
Actual change in exports	19.45	100.00	−1.24	100.00	28.15	100.00	−2.94	100.00
Market size effect	6.24	32.07	−5.35	429.98	5.22	18.54	−0.95	32.3
Product structure effect	0.04	0.22	−0.16	12.54	0.01	0.05	0.03	−1.09
Market distribution effect	−1.56	−8.03	−0.04	3.22	0.69	2.46	−0.12	3.94
Product competitiveness effect	6.56	33.75	2.21	−177.57	11.45	40.68	−1.03	34.95
Market competitiveness effect	8.17	41.99	2.09	−168.17	10.77	38.27	−0.88	29.90

Note: <sup>1</sup> C is an abbreviation for “contribution”; <sup>2</sup> CR is an abbreviation for “contribution ratio”.

### 3.1. Market Size Effect

Table 2 shows that the effect of market size had a greater impact on China's WFP export growth, with the lowest contribution rate in the four periods reaching 18.54%. In particular, the most significant impact was from 2008 to 2009, which led to a decline in China's WFP exports. This shows that the financial crisis has not only led to a decline in import demand for WFPs in the world, but also seriously affected China's WFP exports. The calculation results show that the market size effects in 2008–2009 and 2015–2016 were negative, indicating that international market demand has declined, and that China's WFP export has also declined correspondingly. The trend of WFP imports in the world from 2002 to 2016 is shown in Figure 1.



**Figure 1.** Trends of WFP global import fluctuations from 2002 to 2016.

Comparing Figure A1 with Figure 1, the fluctuations of the two figures were similar. In 2009 and 2016, the world's WFP imports and China's WFP exports fell in tandem, and the years other than 2015 also maintained simultaneous growth. The convergence of the two charts coincided with the conclusion of the CMS model analysis, which further verified the conclusion that China's WFP exports are easily affected by fluctuations in world demand. This impact will offset the promotion of China's WFP competitiveness and export structure optimization.

### 3.2. Structure Distribution Effect

The structure distribution effect is the collective name for the product structure and the market structure effects. Judging from the model decomposition, the average surplus of the product structure effect in the four periods did not exceed \$0.1 billion, and the pull of China's WFP exports was not obvious. It showed that the structure of China's exports of WFPs did not adapt well to the world's rapidly changing WFP import demand structure. To a certain extent, it reflected the lack of innovation and the added value of China's export of WFPs. As a result, the overall export growth rate of classified WFPs did not surpass the global average. The product structure of China's export of WFPs is in urgent need of optimization and upgrading.

On the other hand, the market distribution effect of China's export WFP was also small. From the data analysis, the surplus of the market distribution effect were \$−1.56 billion, \$−0.04 billion,

\$0.69 billion, and \$−0.12 billion from the first phase to the fourth phase, and there was still a gap compared with the scale effect. This indicates that the market distribution effect contributed poorly to the export of China's WFPs. The above research shows that China's exports to emerging markets such as Australia, Saudi Arabia, Singapore, and other emerging markets have seen a large increase, and that the low market distribution effect indicates that the growth of emerging markets has been completely offset by the decline in exports from traditional key markets such as the USA, China Hong Kong, and Japan. The decline in the share of major traditional export markets and the limited contribution of growth in emerging markets have affected the export performance of China's export WFPs. Overall, the performance of these traditional markets is still the biggest impact on the market distribution effect of China's WFPs.

### 3.3. Competitive Effect

The absolute values of the contribution of competitiveness in the four periods were \$14.73 billion, \$4.30 billion, \$22.22 billion, and \$9.94 billion, respectively. Compared with the market size and structural distribution effects, the competitiveness effect had the greatest impact on China's WFP export growth.

#### 3.3.1. Product Competitiveness Effect

The detailed decomposition of product competitiveness effect affecting the export growth of China's WFP in 2002–2016 is shown in Table 3. The order of products in Table 3 was based on the cumulative value of the product competitiveness effect surplus (Table A5) of each product from 2002 to 2016.

**Table 3.** Decomposition of product competitiveness effect drives China's WFP export growth.

Product	2002–2008		2008–2009		2009–2015		2015–2016	
	C <sup>1</sup> Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%	C 1/\$Billion	CR <sup>2</sup> /%
Paper and its products	3.02	45.93	0.60	27.33	6.88	60.07	−0.42	41.23
Wooden furniture	1.45	22.1	1.10	49.79	2.76	24.07	−0.29	28.63
Plywood	1.30	19.78	0.17	7.51	0.71	6.18	−0.04	3.60
Wooden products	0.02	0.32	0.26	11.92	1.09	9.49	−0.14	13.69
Fiberboard	0.53	8.00	0.03	1.14	0.15	1.30	−0.009	9.40
Special wood	0.28	4.22	0.02	0.80	−0.08	−0.66	−0.022	2.12
Veneer	0.06	0.85	0.003	0.13	0.04	0.33	−0.006	0.58
Particle board	0.003	0.05	−0.001	−0.04	0.04	0.32	−0.001	0.12
Wood pulp	0.03	0.46	0.01	0.44	−0.011	−0.10	0.001	−0.09
Log	−0.002	−0.04	0.002	0.10	−0.002	−0.01	0.013	−1.27
Cork	0.003	0.04	0.001	0.04	0.002	0.02	−0.001	0.08
Charcoal	−0.06	−0.90	0.001	0.04	0.03	0.29	−0.003	0.34
Sawn timber	0.07	1.05	0.02	1.00	−0.16	−1.35	−0.008	0.80
Other raw materials	−0.12	−1.87	−0.004	−0.20	0.007	0.06	−0.008	0.79
All products	6.56	100.00	2.21	100.00	11.45	100.00	−1.03	100.00

Note: <sup>1</sup> C is an abbreviation for "contribution"; <sup>2</sup> CR is an abbreviation for "contribution ratio".

Table 3 shows that China's WFP competitiveness effect surpluses were positive in 2002–2008, 2008–2009, and 2009–2015, indicating that the product competitiveness effect had a significant export promotion role for the entire WFP. However, the surplus of product competitiveness in 2015–2016 was negative, indicating that the competitiveness of China's WFP exports declined during this period. Overall, China's WFP product competitiveness came mainly from paper and its products, wooden furniture, wooden products, and plywood products. During the financial crisis of 2008–2009, the sharp reduction in international import scale led to a market-size surplus of China's WFP exports of \$−5.35 billion, while the surplus of product competitiveness in the same period reached \$2.21 billion. The largest contributors to the product's competitiveness during this period were wooden furniture, paper and its products, wooden products, and plywood (Figure 2).



Figure 2 shows that the competitive effect surplus of wood furniture, paper and its products, wooden products, and plywood in 2008–2009 accounted for 49.79%, 27.33%, 11.92%, and 7.51% respectively, with a cumulative proportion of 96.55%. From the evolutionary trend, the product competitiveness effect surplus of paper and its products, wood furniture, and plywood had a large positive value over the periods of 2002–2008 and 2009–2015 but declined in the periods of 2008–2009 and 2015–2016. However, the product competitiveness effect of wooden products showed a large increase in 2008–2009, and its contribution rate to China’s WFP exports also showed an overall growth trend from 2002 to 2016 (Table 3). Additionally, except for 2008–2009, the contribution rate of paper and its products in the other period was higher than that of wooden furniture (Table 3).

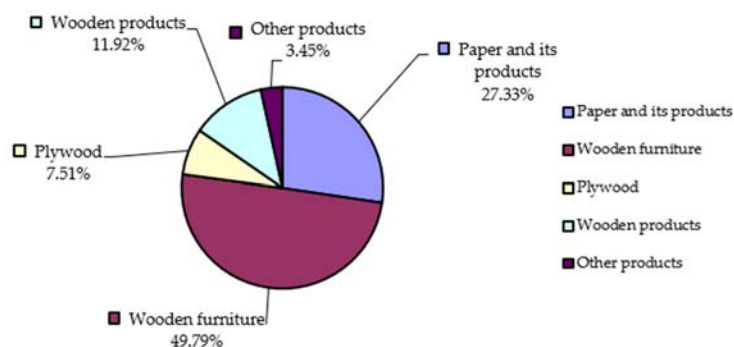


Figure 2. The main structure of the product competitiveness effect surplus of China’s WFPs in 2008–2009.

### 3.3.2. Market Competitiveness Effect

The detailed decomposition of the market competitiveness effect, affecting the export growth of China’s WFPs in 2002–2016, is shown in Table 4. The order of the markets in Table 4 was based on the cumulative value of the market competitiveness effect surplus (Table A6) of each market from 2002 to 2016.

Table 4. Decomposition of market competitiveness effect drives China’s WFP export growth.

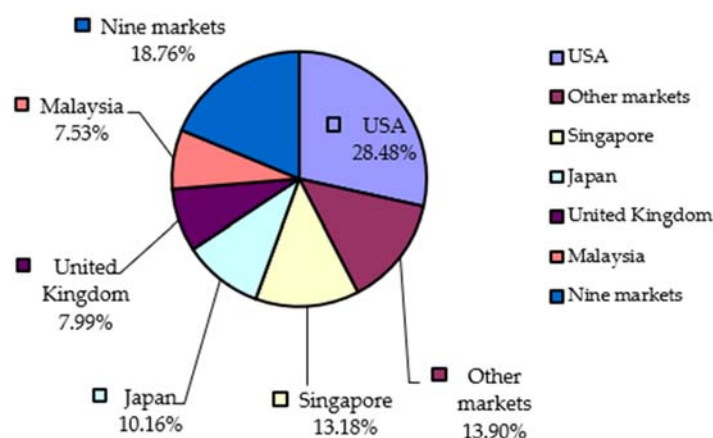
Market	2002–2008		2008–2009		2009–2015		2015–2016	
	C 1/\$Billion	CR <sup>2</sup> %	C 1/\$Billion	CR <sup>2</sup> %	C 1/\$Billion	CR <sup>2</sup> %	C 1/\$Billion	CR <sup>2</sup> %
Other markets	2.68	32.79	0.29	13.9	4.63	42.95	−0.74	83.76
USA	2.39	29.23	0.6	28.48	1.9	17.61	−0.43	48.67
China Hong Kong	0.4	4.94	0.07	3.21	0.76	7.02	0.22	−24.34
United Kingdom	0.42	5.17	0.17	7.99	0.56	5.16	−0.01	0.57
Japan	0.42	5.17	0.21	10.16	0.21	1.96	−0.01	1.13
Australia	0.29	3.5	0.05	2.35	0.51	4.75	−0.07	7.92
Malaysia	0.13	1.63	0.16	7.53	0.25	2.32	0.08	−9.05
Singapore	0.06	0.71	0.28	13.18	0.37	3.45	−0.01	1.13
Canada	0.29	3.49	0.03	1.29	0.22	2.02	0.00	−0.17
Saudi Arabia	0.15	1.82	0.03	1.63	0.19	1.76	0.07	−7.36
Korea	0.19	2.29	0.013	0.62	0.24	2.26	0.03	−2.83
Vietnam	0.05	0.63	0.005	0.23	0.28	2.58	0.07	−7.36
Germany	0.23	2.86	0.08	3.77	0.22	2.07	−0.05	5.09
India	0.18	2.15	0.03	1.18	0.14	1.29	0.03	−3.4
France	0.16	1.99	0.05	2.55	0.14	1.32	−0.01	0.57
Netherlands	0.13	1.63	0.04	1.93	0.16	1.48	−0.05	5.66
World	8.17	100.00	2.09	100.00	10.77	100.00	−0.88	100.00

Note: <sup>1</sup> C is an abbreviation for “contribution”; <sup>2</sup> CR is an abbreviation for “contribution ratio”.

Table 4 shows that the product competitiveness effect surplus was similar to the market competitiveness effect surpluses in 2002–2008, 2008–2009, and 2009–2015, which were positive, indicating that the market competitiveness effect effectively promoted China’s WFP exports. However, the market competition effect surplus in 2015–2016 was negative, indicating that the market competitiveness of China’s WFP exports declined during this period. Overall, China’s WFP market

competitiveness mainly came from the USA, China Hong Kong, United Kingdom, and Japan (Table 4). For example, during the financial crisis of 2008–2009, the competitiveness of China’s WFP export market remained at \$2.09 billion. The markets that contributed the most were USA, other markets, Singapore, and Japan (Figure 3).

Figure 3 shows that the market competitiveness contribution ratios of USA, Singapore, Japan, United Kingdom, and Malaysia in 2008–2009 were 28.46%, 13.18%, 10.16%, 7.99%, and 7.53%, respectively, for a total of 67.32%. From an evolutionary trend, the market competitiveness effect surpluses of key markets such as the USA, China Hong Kong, and United Kingdom were relatively large in 2002–2008 and 2009–2015, but these decreased significantly in 2008–2009 and 2015–2016. However, the market competitiveness effect surpluses of Singapore and Malaysia during the 2008–2009 financial crisis continued to grow (Table 4). It should be said that China’s WFPs had strong adaptability and competitiveness in these key markets. These markets are critical to China’s WFP exports. If any time period is not competitive in a key market, it will directly affect the overall market competitiveness of China’s WFPs. For example, the market competitiveness of China’s WFPs in America from 2015 to 2016 was a surplus of \$−0.43 billion (Table 4), which had the greatest negative impact on the market competitiveness of China’s WFPs in the same period.



**Figure 3.** The main structure of the market competitiveness effect surplus of China’s WFPs in 2008–2009. The nine markets refer to the nine sample markets that did not appear on the chart.

#### 4. Discussion

This study improves the product scope of WFPs. The category of WFPs has been expanded to 14 categories and 30 sub-categories, which is more detailed and more developed than in previous literature. Additionally, this paper uses the revised CMS model to measure and analyze empirically the factors affecting the export growth of China’s WFPs from the perspective of market, structure, and competitiveness. The summary points are worth discussing.

- (1) The application of the CMS model. The CMS model can analyze the causes of export growth of products or industries from the perspectives of the market, its structure, and its competitiveness. The model is convenient for obtaining official trade data, and has a high applicability and promotion value. The modified CMS model of this study has made some conversions based on the basic analysis model, and it has three main advantages. First, it measures the market distribution effect index better. Second, it further subdivides the competitiveness effect. Third, data collection and statistics are reduced. Because the data collection work of  $r_{ij}$  and  $V_{ij}$  in the basic analysis mode is quite heavy, there is no such cross-term in the correction model.
- (2) The experience and confusion generated in the study. First, there are many missing COMTRADE data, especially the lack of export data for Malaysia, Vietnam, and India from 2007 to 2011. At this time, it is necessary to inquire about the data imported by the countries of the world from

the three countries, and then to summarize the data. Second, COMTRADE data and China's statistical data often have many inconsistencies, which may be due to different statistical calibers, omissions, and so on. Therefore, the study requires a unified data source for the same study. Finally, the number of study samples will also have an impact on the conclusions. The more the research samples, the higher the accuracy, and the higher the overall accuracy of the study. However, due to there being so many countries in the world and too many products to analyze, it is too difficult to apply all the data to the CMS model. Therefore, the sample must select the top countries (regions) with the highest export volumes.

- (3) Implications for the development of China's WFP exports. First, the product structure effect is relatively low, reflecting the fact that China's export WFP market is not well adapted to changes in world market demand, and this needs to be improved. Second, the market distribution effect needs to be further improved. This will not only require further exploration of the trade potential of traditional markets, but also a focus on emerging markets. Finally, the product competitiveness effect mainly comes from resource- and labor-intensive products such as paper and its products, and wooden furniture. However, Vietnam's comparative advantage in terms of resources and costs is more prominent. Therefore, accelerating the pace of upgrading WFPs and industrial structure has become China's only choice. In general, China's WFP manufacturers must not blindly pursue the expansion of export volume, while ignoring technological upgrades, environmental standards, and sustainable development.

## 5. Conclusions

The conclusions of the CMS empirical analysis are summarized as follows:

- (1) The size effect of market demand has a great impact on the export growth of China's WFPs. The minimum contribution rate of the four periods has also reached 18.54%, especially in the period of the 2008–2009 financial crisis. It shows that China's WFP exports are easily affected by fluctuations in world demand. Therefore, a stable international market environment is very important for the export of China's WFPs.
- (2) Product structure effect has less impact on China's WFP exports. It shows that the structure of China's export of WFPs does not adapt well to the world's rapidly changing WFP import demand structure. It also reflects the lack of product innovation and the structural upgrading capabilities of China's export WFPs. The product structure of China's export of WFPs is in urgent need of optimization and upgrade. The market distribution effect of China's export WFPs is also small. It indicates that the growth of emerging markets has been completely offset by the decline in exports from traditional key markets such as the USA, China Hong Kong, and Japan. The decline in the share of major traditional export markets and the limited contribution of growth in emerging markets have affected the export performance of China's export WFPs. Overall, the performance of these traditional markets is still the biggest impact on the market distribution effect of China's WFPs.
- (3) Compared with the market size effect and structural distribution effect, the competitiveness effect contributes the most to the growth of China's WFP exports. The competitiveness effects of the four periods from 2002 to 2016 were positive, with a cumulative surplus of \$39.34 billion. Among them, the product competitiveness effect mainly comes from paper and its products, wooden furniture, wooden products, and plywood. The market competitiveness effect mainly comes from traditional export markets such as other markets, the USA, China Hong Kong, United Kingdom, Japan, Australia, Malaysia, and Singapore. It can be said that the competitiveness sources of China's export WFPs are mainly concentrated in labor- and resource-intensive products, while the contribution rate of technology-intensive products is low. With this kind of source structure of the product competitiveness effect of China's WFPs, it is very difficult to ensure a long-term stable share in developed markets.

**Author Contributions:** Data curation, X.C. and S.Y.; Formal analysis, X.C. and S.Y.; Methodology, X.C.; Project administration, X.C.; Resources, X.C.; Supervision, S.Y., X.H. and J.T.; Validation, S.Y.; Writing—original draft, X.C.; Writing—review and editing, X.C., S.Y. and X.H.

**Funding:** This work was supported by Jiangsu Agricultural Development Committee Agricultural Soft Science Research Foundation in China (Grant No. 18ASS036).

**Acknowledgments:** We are grateful for the comments and criticisms of an early version of this manuscript by the journal's editors and reviewers.

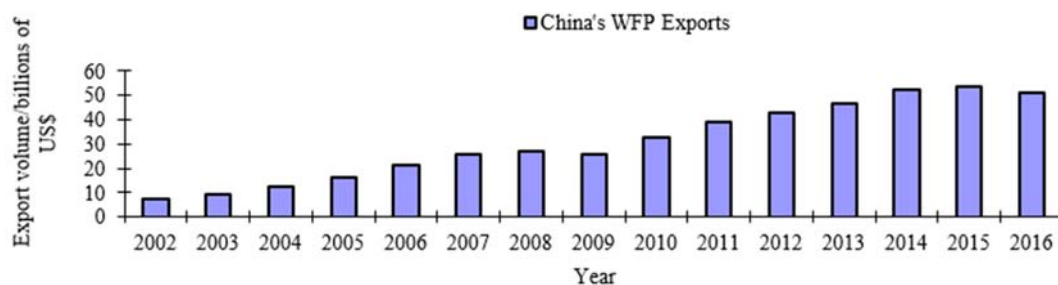
**Conflicts of Interest:** The authors declare no conflict of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

WFPs	Wood forest products
WFP	Wood forest product
COMTRADE	United Nations Comtrade Database
SITC	The Standard International Trade Classification
CMS	Constant market share
OECD	The Organisation for Economic Co-operation and Development
APEC	Asia-Pacific Economic Cooperation
GTAP	Global trade analysis project
WTO	World Trade Organization
ASEAN	Association of Southeast Asian Nations
EU	European Union
FAO	The United Nations Food and Agriculture Organization
HS	Harmonized Commodity Description and Coding System

## Appendix A



**Figure A1.** Trend in the growth of the export volume of China's WFPs from 2002 to 2016.

**Table A1.** Export product structure of China's WFPs from 2002 to 2016 (Unit/%).

Year	Log	Sawn Timber	Veneer	Special Wood	Particle Board	Fibreboard	Plywood	Wooden Product	Wood Pulp	Paper and Its Products	Charcoal	Wooden Furniture	Cork	Other Raw Materials
2002	0.04	2.59	1.22	0.30	0.28	1.70	5.98	25.38	0.76	28.36	0.21	31.62	0.12	1.44
2003	0.03	2.48	1.17	0.21	0.22	2.02	5.42	24.35	0.67	30.06	0.22	31.86	0.11	1.17
2004	0.02	1.72	0.96	0.17	0.99	2.22	10.15	23.24	0.31	29.15	0.13	29.94	0.11	0.90
2005	0.01	1.71	0.79	0.11	2.43	3.43	11.62	19.22	0.14	28.51	0.22	31.09	0.10	0.62
2006	0.01	1.65	0.80	0.12	2.97	3.43	13.67	17.71	0.12	26.87	0.27	31.94	0.11	0.33
2007	0.00	1.51	0.77	0.13	4.20	3.06	13.89	14.81	0.08	25.68	0.36	35.30	0.07	0.13
2008	0.00	1.50	0.91	0.17	4.09	2.94	12.75	13.15	0.09	25.47	0.37	38.41	0.07	0.08
2009	0.02	1.35	0.68	0.13	3.46	2.34	9.92	13.01	0.10	29.69	0.36	38.85	0.06	0.04
2010	0.03	1.03	0.64	0.13	3.38	1.99	10.35	12.50	0.11	32.07	0.43	37.26	0.05	0.03
2011	0.02	0.91	0.70	0.14	3.66	1.61	11.07	11.55	0.10	28.82	0.59	40.77	0.05	0.03
2012	0.00	0.77	0.55	0.16	3.76	1.62	11.19	11.31	0.10	27.76	0.30	42.42	0.04	0.02
2013	0.01	0.70	0.51	0.21	3.28	1.40	10.84	11.10	0.14	26.63	0.23	44.89	0.04	0.03
2014	0.02	0.56	0.53	0.27	3.12	1.25	11.13	11.35	0.17	26.87	0.22	44.35	0.04	0.11
2015	0.01	0.38	0.53	0.22	2.65	1.04	10.23	12.02	0.20	27.27	0.21	45.14	0.04	0.06
2016	0.06	0.38	0.55	0.24	2.42	0.97	10.41	12.43	0.20	27.22	0.22	44.83	0.04	0.03

**Table A2.** Major export markets of China's WFP from 2002 to 2016 (Unit/%).

Year	USA	Canada	United Kingdom	Germany	France	Netherlands	Australia	Japan	China Hong Kong	Korea	Singapore	Malaysia	Saudi Arabia	Vietnam	India
2002	31.22	1.19	3.95	1.52	1.02	1.34	1.59	18.30	19.80	3.96	1.06	0.72	0.83	0.26	0.16
2003	32.55	1.42	3.42	1.58	0.95	1.32	1.75	17.97	18.56	3.39	0.89	0.74	0.93	0.27	0.20
2004	34.02	2.12	3.94	1.88	1.06	1.26	2.00	15.71	16.12	2.87	0.84	0.64	1.09	0.39	0.33
2005	33.26	2.38	4.06	2.06	1.26	1.31	2.18	13.71	13.89	3.01	0.79	0.68	1.28	0.55	0.49
2006	32.63	2.56	4.58	2.00	1.24	1.40	2.32	11.46	11.52	3.59	0.79	0.98	1.40	0.54	1.00
2007	29.72	2.50	4.78	2.41	1.64	1.53	2.56	9.52	9.43	3.52	0.98	1.20	1.52	0.77	1.38
2008	27.84	2.62	4.73	2.43	1.74	1.69	2.97	9.52	8.24	3.18	0.97	1.30	1.71	0.81	1.46
2009	26.47	2.56	4.95	2.72	1.92	1.69	2.96	10.25	7.77	2.65	3.02	2.39	1.82	0.82	1.48
2010	25.38	2.77	4.98	2.75	1.98	1.65	2.88	8.79	6.66	2.54	2.32	1.90	1.87	1.06	1.92
2011	22.96	2.52	4.52	2.87	1.90	1.67	3.13	9.09	6.12	2.77	2.51	1.99	2.20	1.21	1.81
2012	23.66	2.55	4.76	2.75	1.85	1.49	3.40	8.78	6.08	2.66	1.74	2.55	2.27	1.17	1.56
2013	23.25	2.46	4.54	2.54	1.58	1.40	3.39	8.03	6.69	2.79	2.02	3.01	2.10	1.33	1.59
2014	22.33	2.22	4.54	2.46	1.46	1.45	3.38	7.03	6.61	2.76	2.51	2.59	2.05	1.57	1.70
2015	24.41	2.11	4.92	2.26	1.31	1.47	3.53	6.12	7.07	2.71	3.40	2.31	2.35	1.82	1.75
2016	24.53	2.15	4.77	2.18	1.37	1.41	3.35	6.42	7.77	2.90	3.24	2.86	2.16	2.12	1.93



**Table A3.** Import of WFPs from sample markets at each time span point (Unit/\$ Billion).

Market	2002		2008		2009		2015		2016	
	$R_j$	$V_j$	$R_j$	$V_j$	$R_j$	$V_j$	$R_j$	$V_j$	$R_j$	$V_j$
USA	47.11	2.29	55.15	7.46	41.19	6.77	56.72	13.11	57.61	12.45
Canada	9.42	0.09	14.34	0.70	12.23	0.65	13.15	1.14	12.58	1.09
United Kingdom	17.05	0.29	24.92	1.27	18.27	1.27	22.09	2.64	20.34	2.42
Germany	20.14	0.11	33.09	0.65	27.31	0.70	30.14	1.22	29.74	1.11
France	13.50	0.08	25.31	0.47	20.92	0.49	17.96	0.71	18.00	0.70
Netherlands	7.24	0.10	13.63	0.45	10.54	0.43	11.52	0.79	11.82	0.71
Australia	3.17	0.12	6.12	0.80	5.05	0.76	5.83	1.90	5.66	1.70
Japan	14.15	1.35	17.96	2.55	15.45	2.62	16.90	3.29	16.85	3.26
China Hong Kong	4.87	1.46	4.69	2.21	3.93	1.99	4.52	3.80	4.18	3.95
Korea	4.23	0.29	6.98	0.85	5.32	0.68	7.60	1.45	7.44	1.47
Singapore	1.42	0.08	2.59	0.26	2.21	0.77	3.11	1.83	2.83	1.65
Malaysia	1.77	0.05	2.77	0.35	2.35	0.61	2.84	1.24	2.97	1.45
Saudi Arabia	1.12	0.06	2.94	0.46	2.55	0.47	4.84	1.26	3.70	1.10
Vietnam	0.41	0.02	2.44	0.22	2.26	0.21	4.54	0.98	4.39	1.08
India	1.44	0.01	4.92	0.39	4.14	0.38	7.23	0.94	7.07	0.98
Other markets	89.43	0.96	219.37	7.71	176.22	6.78	212.41	17.42	208.74	15.64
World	236.46	7.35	437.20	26.80	349.92	25.56	421.39	53.70	413.92	50.76

**Table A4.** Import of classified WFPs at each time point (Unit/\$ Billion).

Product	2002		2008		2009		2015		2016	
	$R_i$	$V_i$	$R_i$	$V_i$	$R_i$	$V_i$	$R_i$	$V_i$	$R_i$	$V_i$
Log	8.73	0.003	16.53	0.001	11.39	0.005	16.71	0.004	16.23	0.03
Sawn timber	22.93	0.19	31.81	0.40	23.88	0.35	35.65	0.21	36.41	0.19
Veneer	2.50	0.09	3.72	0.24	2.55	0.17	3.08	0.28	3.17	0.28
Special wood	3.13	0.13	5.87	0.79	4.18	0.60	4.96	0.56	4.75	0.49
Particle board	3.84	0.02	6.88	0.05	5.02	0.03	6.85	0.12	7.41	0.12
Fiberboard	4.09	0.02	8.74	1.10	6.65	0.88	8.47	1.42	8.47	1.23
Plywood	7.22	0.44	13.50	3.42	8.71	2.54	14.02	5.50	13.66	5.28
Wooden product	14.55	1.87	27.17	3.53	21.57	3.33	27.79	6.46	28.37	6.31
Wood pulp	19.46	0.02	45.20	0.10	33.01	0.09	49.08	0.11	46.56	0.11
Paper and its products	123.07	2.32	225.85	10.29	191.37	9.93	202.10	24.24	196.76	22.75
Charcoal	0.29	0.06	0.74	0.02	0.75	0.03	1.19	0.11	1.19	0.10
Wooden furniture	22.68	2.08	42.70	6.83	33.71	7.59	40.57	14.64	39.91	13.82
Cork	1.37	0.009	1.93	0.02	1.51	0.02	1.65	0.02	1.69	0.02
Other raw materials	2.59	0.11	6.55	0.02	5.64	0.010	9.29	0.03	9.35	0.02
All products	236.46	7.35	437.20	26.80	349.92	25.56	421.39	53.70	413.92	50.76

**Table A5.** The total value of the product competitiveness effect surplus of each product in 2002–2016.

Product	Product Competitiveness Effect Surplus/\$ Billion
Paper and its products	10.08
Wooden furniture	5.02
Plywood	2.14
Wooden product	1.23
Fiberboard	0.70
Special wood	0.20
Veneer	0.10
Particle board	0.04
Wood pulp	0.03
Log	0.01
Cork	0.005
Charcoal	−0.03
Sawn timber	−0.08
Other raw materials	−0.13

**Table A6.** The total value of the market competitiveness effect surplus of each market in 2002–2016.

Market	Market Competitiveness Effect Surplus/\$Billion
Other markets	6.12
USA	4.03
China Hong Kong	1.66
United Kingdom	1.14
Japan	0.82
Australia	0.71
Malaysia	0.70
Singapore	0.69
Canada	0.54
Saudi Arabia	0.50
Korea	0.49
Vietnam	0.46
Germany	0.44
India	0.41
France	0.34
Netherlands	0.23

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