

## Review

# Impact of Global Supply Chain Crisis on Chinese Forest Product Enterprises: Trade Trends and Literature Review

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**Abstract:** The global supply chain crisis caused by COVID-19 and the trend of “anti-globalization” continuously impact international trade. As one of the central processing centers of global primary products, China’s forest product enterprises import raw materials and export manufactured products, which are vulnerable to the worldwide supply chain crisis. This article reviews research on the influence of the pandemic and the Sino-US trade war on the international trade of wooden products and China’s forestry enterprises that import raw timber materials and export wooden products. Furthermore, with the analysis of trade data, we found that China’s forest product enterprises are facing a shortage of wood materials and rising import prices. Regarding export, they face the problems of increased trade costs and fluctuating product demand. Moreover, the influence of the global supply chain crisis causes China’s trade diversion effect. This article comprehensively analyzes how the global supply chain crisis affects wood-based product enterprises and offers suggestions for further developing China’s forestry enterprises.

**Keywords:** supply chain; forest product industry; COVID-19; trade conflicts; international trade of forest products



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## 1. Introduction

China is the most significant player in the trade of forest products. However, in December 2019, COVID-19 broke out; since then, it has spread rapidly worldwide and caused a public health problem. The WHO claimed the pandemic was a public health emergency and an economic crisis involving every sector and triggered a series of lockdowns, quarantine measures, and restrictive policies, which had a tremendous impact on the global economy with the deep integration and globalization of the world economy. Consequently, demand and supply are disrupted in international trade, and global supply chains face significant challenges [1,2]. Specifically, wood-based product enterprises are also in the global supply chains and face uncertainty. In addition, some scholars believe that trade protectionism began to shock global supply chains before the pandemic, such as the Sino-US trade war and Brexit [3–5].

China is a primary producer of forest products. China’s enterprises of forest products have two characteristics in international trade: first, it imports raw materials such as logs, sawn timber, and chemical wood pulp; second, it exports manufactured products such as wooden furniture and wood-based panels [6]—China has become the largest exporter of wooden products and one of the largest timber buyers in the world [7,8]. Russia, New Zealand, Canada, and the United States are China’s leading exporters, while the United States is the largest importer of manufactured products. As of the first quarter of 2021, the number of forest industry enterprises in China reached 9876. Compared with developed countries, more than 80 percent of these enterprises are small- or medium-sized with low-profit margins. In the meantime, they also have a limited ability for resource

acquisition and technological innovation, more severe impacts from the shifts in demand and supply for wood products, and lower resistance to market risks. Thus, those enterprises are affected by market uncertainties, such as the Sino–US trade war and the COVID-19 pandemic [9,10]. Therefore, when the global supply chains suffered a crisis, China’s wood-based product enterprises faced more challenges.

The COVID-19 pandemic and trade protectionism have seriously affected China’s forestry industry in different ways [11]. The pandemic mainly influenced the service and operation of enterprises by affecting production, transportation, and consumption patterns. While trade protectionism, such as the Sino–US trade war, primarily affected enterprises’ trade by adopting tariffs. Thus far, some scholars have focused on the enterprises’ production, trade, or transportation during the COVID-19 pandemic [12–14]; some others focus on the impact of the Sino–US trade war on bilateral trade [15,16]. However, no studies have comprehensively reviewed the literature from the wood-based product enterprises’ production, transportation, and trade perspective. Therefore, synthesizing the literature and wood products trade data, this review explores the impact of the COVID-19 pandemic and the Sino–US trade war on China’s wood-based product enterprises. We hope this study will contribute to developing further research on how the global supply chain crisis affects wood-based product enterprises and offer them suggestions for future development. Furthermore, it could be a theoretical basis for studying enterprises’ economic effects.

## 2. Materials and Methods

The reviewed literature, including journal articles, reports, government documents, and theses on the imports and exports of wood-based products during the COVID-19 pandemic or the Sino–US trade war, were selected from China National Knowledge Infrastructure (CNKI), Web of Science, and Google Scholar. Specifically, we conducted the first search with the term “Sino-US trade war” AND “wood products trade”. The second search was “COVID-19 pandemic” AND “wood products”. The third search was with the term “Sino-US trade war” AND “transportation cost”, and the fourth search was with the term “COVID-19 pandemic” AND “transportation cost”. After this, we screened the literature. First, we filtered out the articles inconsistent with our research objective according to the title, keywords, and abstracts. Second, we read the full text and removed articles that were not relevant to our study.

Data for the trade trends were collected from International Trade Centre (ITC) [17], including China’s trade quantity and value of wood-based products from 2017 to 2022. First, we selected the data from January 2017 to June 2022 because two major events affected global trade seriously during this period: the Sino–US trade war and the COVID-19 pandemic. Second, China mainly imports logs, sawn timber, and wood pulp and exports wooden furniture and paper products. Therefore, the selected wood-based products include logs (Harmonized System code: 4403), sawn timber (H.S. code: 4407), chemical wood pulp (H.S. code: 4703), wooden office furniture (H.S. code: 940330), commercial copy paper (H.S. code: 4802), food wrapping paper (H.S. code: 481940), and DIY wood products (H.S. code: 442010). Third, the countries we selected are China’s major trade partners with the greatest trade volumes, including Canada, the United States, New Zealand, Germany, Russia, Thailand, Indonesia, and Vietnam. Moreover, we computed the prices by dividing the trade value by the trade quantity. Afterward, STATA 15 was used to show wood-based products’ trade quantity, value, and price changes from 2017 to 2022.

## 3. Results

### 3.1. Raw Materials Import Dilemmas of Wood-Based Product Enterprises

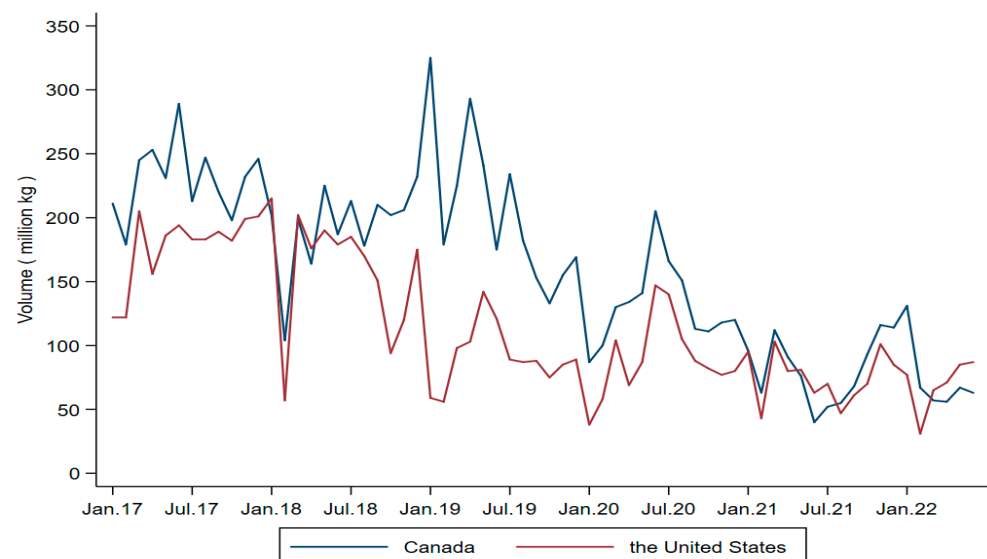
#### 3.1.1. Shortage of Raw Materials

China has low forest coverage and strict law on harvesting, so its timber supply is limited, and its forestry enterprises heavily rely on importing raw materials [18]. However, during the outbreak of COVID-19, most sawmills in the countries that supply timber to China were closed because workers could not work remotely. As a result, many producers in these countries’ forestry sectors are undersupplied for China. In addition, China mainly

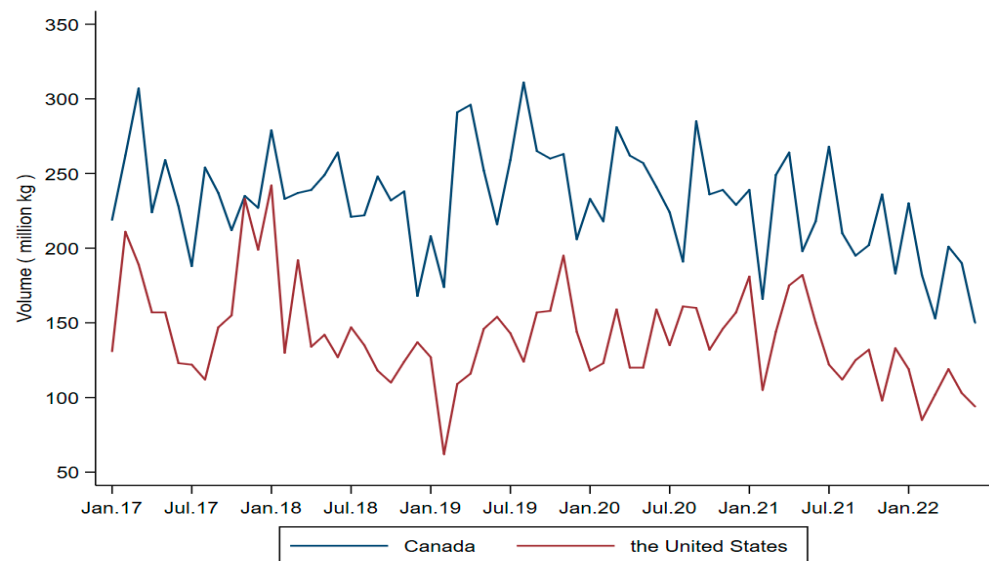
imports sawn timber and paper pulp from Canada and the United States because they carried out log export bans before the outbreak of COVID-19 [19]. Thus, the undersupply of sawn timber and paper pulp in the two countries during the pandemic affected China's imports of raw materials for its wood products.

Many scholars have noticed the shock in the supply. Buongiorno (2021) [20] used the GFPMX model to simulate and predict the impact of the recession caused by COVID-19 on the global forestry sectors and found that as of 2021, global production of roundwood and sawn timber fell by 74 million cubic meters. As a result, the volume of the two products supply for China decreased by 4.6 million cubic meters. Zhang and Stottlemeyer (2021) [21] found that some sawmills in the United States reduced production from March 2020, and some forestry enterprises were forced to close due to the COVID-19 pandemic, which they believed would cause a short timber supply in the United States. As predicted, Muhammad et al., (2022) [12] found that the exports of sawn timber and logs in Tennessee declined by \$38 million compared with 2019, and it was the lowest export volume in the past ten years. In addition, Stanturf and Mansuy (2021) [13] also found that three sawmills and five paper mills in western Canada had reduced production or even closed, while two paper mills and six sawmills in the east reduced production by August 2020; Canada's sawn timber and paper pulp were undersupplied in this case.

The following two figures show the significant decrease in China's import volume of sawn timber and chemical wood pulp during the COVID-19 pandemic. Figure 1 shows that China sharply reduced its import of sawn timber from Canada and the United States in the first quarter of 2020. In the first half of 2021, the spread of COVID-19 led to a further reduction in China's import volume of sawn timber, which has been at the lowest level during the pandemic. At the end of 2021, some countries gradually reduced the pandemic prevention and control measures, and sawn timber imports began to show an upward trend. However, the overall level is still lower than before the pandemic. In Figure 2, China's import volume of chemical wood pulp shows significant volatility but is slightly downward overall. In the early days of the pandemic, China's imports from Canada and the United States declined markedly. However, this downward trend lasted for a short time and rebounded rapidly. Furthermore, the overall level did not significantly differ from before the pandemic.



**Figure 1.** China's import volume of sawn timber from January 2017 to June 2022 (unit: million kg; Harmonized System (H.S.) code: 4407).



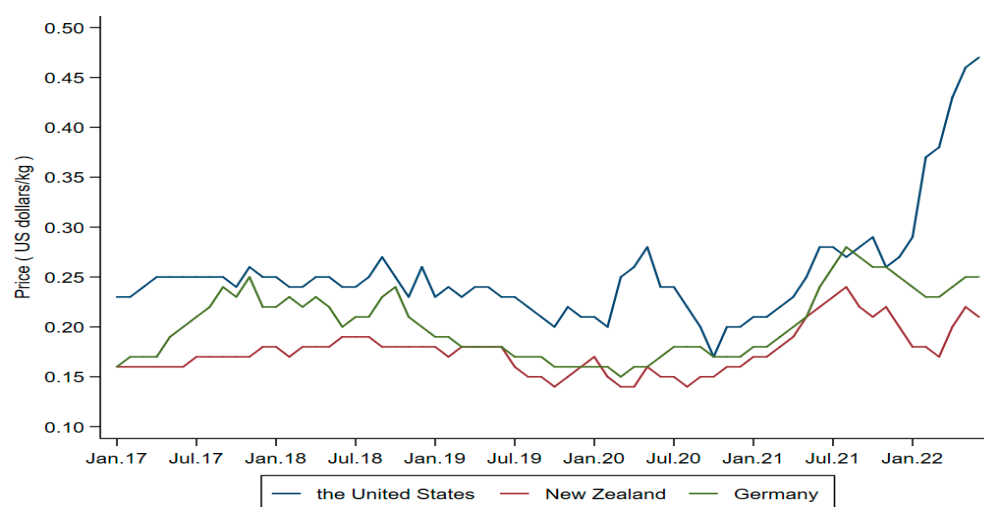
**Figure 2.** Import volume of chemical wood pulp in China from January 2017 to June 2022 (unit: million kg; H.S. code: 4703).

### 3.1.2. Rising Prices of Raw Materials

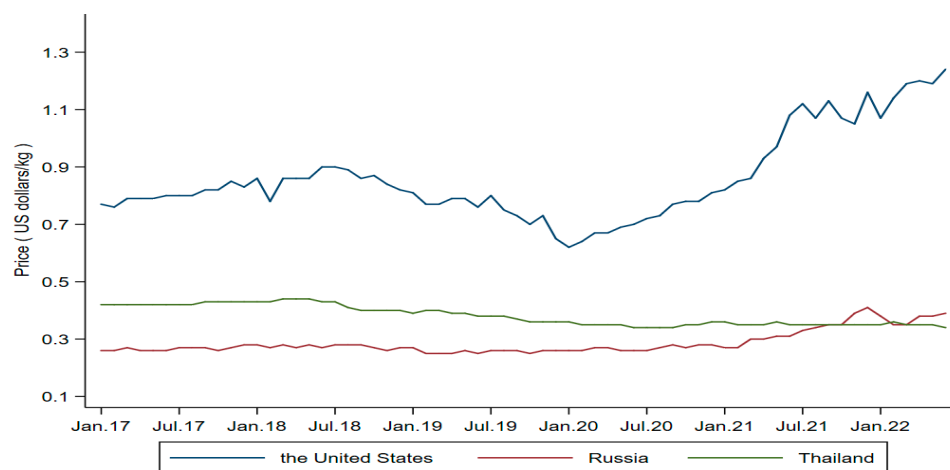
Importers in China are sensitive to timber prices [22]. Many factors have increased timber prices in recent years: first, higher tariffs during the Sino–US trade war increased import prices directly. Second, imbalanced supply and demand caused by the COVID-19 pandemic have pushed up prices more. During the pandemic, global timber production declined [21], while demand for home improvements under telecommuting increased.

The Trump administration’s 301 investigations initially triggered the Sino–US trade war. Its main form is the multi-round tariff increase between China and the United States [23]. During the trade war, four rounds of import tariff adjustments were conducted between China and the United States, which involved 7,853 items of American products and 7,636 items from China [24]. Thus, the United States imposed 10% and 25% tariffs on China’s wood-based products in July 2018 and June 2019, respectively. In response, China imposed 5%–25% tariffs on American logs and sawn timber. As a result, tariffs imposed by China and the United States on wood products led to fluctuations in import prices.

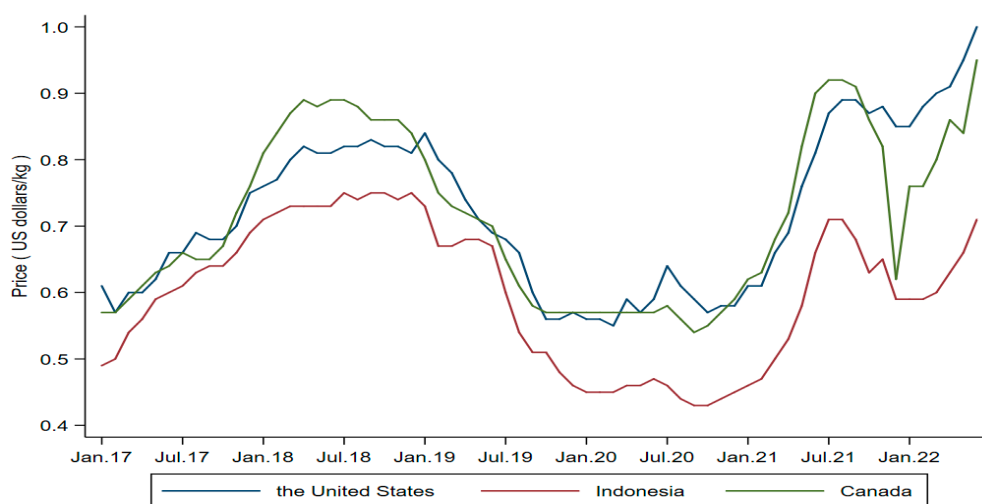
Figures 3–5 show the price fluctuation of imported sawlogs, sawn timber, and wood pulp during the trade war. In 2018, the United States announced that the tax rate for Chinese products would rise from 10% to 25%. Subsequently, China responded quickly by imposing tariffs on goods imported from the United States, including logs, sawn timber, and wood pulp. Under these conditions, their prices from the United States have risen. However, in 2019, the prices began to show a downward trend. It could be because the increased prices of sawlogs, sawn timber, and wood pulp have led to a decrease in China’s imports, and the backlog in the United States caused a price decline. In addition, we find that American timber prices remained higher than other countries from Figures 3 and 4, mainly due to the timber’s better quality [25,26]. Moreover, due to the higher prices of logs and sawn timber during the trade war, China’s imports from the United States declined after 2018.



**Figure 3.** Importing log prices of China's major importers from January 2017 to June 2022 (unit: U.S. dollars/kg; H.S. code: 4403).



**Figure 4.** Sawn timber prices of China's major importers from January 2017 to June 2022 (unit: U.S. dollars/kg; H.S. code: 4407).



**Figure 5.** Chemical wood pulp prices of China's major importers from January 2017 to June 2022 (unit: U.S. dollars/kg; H.S. code: 4703).

Some scholars have studied the impact of the Sino–US trade war on timber prices. For example, Zhang et al., (2020) [16] used a two-stage partial equilibrium displacement model (EDM) to find that as the United States increased tariffs, the imported log, sawn timber, and veneer prices in China rose by 19.86%, 18.45%, and 22.10%, respectively. As a result, China's import demand was reduced by 14.70%, 9.04%, and 57.67%, respectively. Wang et al., (2021) [26] used the robust Regression Discontinuity in Time (RDiT) model to analyze the impact of the Sino–US trade war on China's hardwood import trade and found import price of American hardwood increased by 52.04 \$/m<sup>3</sup>.

The impact of the COVID-19 pandemic on the forestry industry is imbalanced between supply and demand. On the supply side, major international timber manufacturers have closed their factories due to labor shortages or mandated closures, leading to a production decline and timber undersupply in international trade. On the demand side, the pandemic prevention measures made people home quarantined and telecommuted. Therefore, the demand for new furniture increased, especially office furniture and DIY wooden products (H.S. code is 442010; wooden handicraft products such as small wooden sculptures). The imbalance between supply and demand caused more fluctuations in timber prices.

In addition, timber prices gradually increased with the real estate industry's recovery. American housing starts have increased since the passing of the financial crisis of 2008, especially during the COVID-19 pandemic, and homebuilding, remodeling, and the manufacturing of home furnishings demand timber [21]. As shown in Figures 3 and 4, American timber prices were also the most affected during the pandemic compared to other countries. Figure 3 shows that the price of American logs has been more volatile. In May 2020, the price grew and reached the highest level from 2017 to 2020 due to the pandemic. Afterward, American log prices started to fall as the pandemic was under initial control, but the comeback of the pandemic still put the price upward.

Moreover, in 2022, the sawn timber price surged to its highest since 2017. By contrast, the prices of New Zealand and Germany's logs only rose in 2021. China's sawn timber is mainly imported from Russia (48.3%), Thailand (13.5%), and the United States (7.8%) [27]. However, Figure 4 shows that American sawn timber prices demonstrated a more significant and lasting upward trend than Russia and Thailand during the pandemic due to the American housing market's development under the pandemic.

China imports chemical wood pulp mainly from Indonesia, Canada, and the United States [28], whose prices are shown in Figure 5. The prices were high in 2018 but decreased in 2019. It could be due to the improvement in the pulping process and the development of non-wood pulp: the improvement can lower the cost during pulping, and non-wood pulp can substitute for wood pulp [29,30]. However, by mid-2020, the wide pandemic led to a reduction in pulp production and an increase in demand for paper products [31]. Consequently, the undersupply of wood pulp caused the prices to show an upward trend.

Some scholars have been concerned about the changes in timber prices during the COVID-19 pandemic. Franco (2021) [32] found that the surge in timber prices was the most significant increase since World War II. Fernandez (2020) [33] found that as of September 2020, the price of timber affected by the pandemic rose by more than 278%. Van Kooten and Schmitz (2022) [34] found that timber prices have increased by more than 300% by May 2021. They believed two main reasons were the timber supply interruption caused by the labor shortage during the pandemic and the increasing demand for wooden products caused by people starting to make home improvements during the quarantine. Gan et al., (2022) [35] believed timber prices increased mainly due to the undersupply and increased demand during the pandemic. Furthermore, they found that the lumber price reacted more substantially than the sawn timber price using wavelet analysis and event study.

### 3.2. Export Challenges for Harvested Wood Products Manufacturers

#### 3.2.1. Increase in Trade Costs

China has taken advantage of lower labor costs to produce labor-intensive forest products largely for export. However, WTO identified the COVID-19 pandemic as a significant



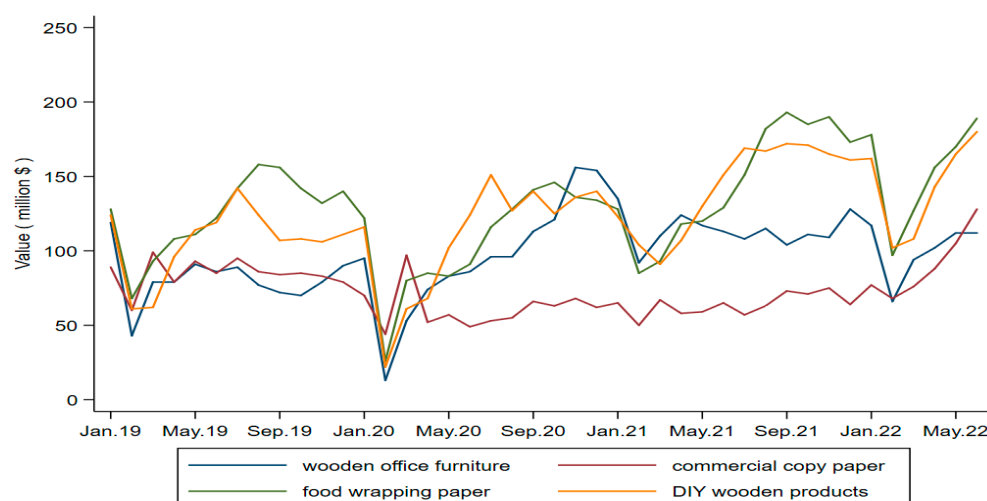
factor pushing up trade costs, with transportation costs most affected [36]. In China, the transportation of forest products can be divided into by railroad and by the sea. For example, Russian timber is imported by railroad, while tropical and North American timber imports and China's manufactured products are transported by sea. During the COVID-19 pandemic, vaccination policies, and transportation uncertainties increased the costs.

Some scholars have studied the impact on transportation costs during the COVID-19 pandemic. For example, Vo and Tran (2021) [37] argued that the policies of different countries to restrict travel led to a sharp increase in the transportation cost of trade during the pandemic. Wagner (2021) [14] found that the lack of ships caused by the pandemic increased the container price from \$2000 to \$15,000 within a year. Moreover, the 750% growth rate eventually raises sea freight prices. Panwar et al., (2022) [38] also found that 60% of containers had poor turnovers during the pandemic. In addition, the price of a 40-foot container commonly used between Asia and Northern Europe has risen from about \$2000 to about \$9000. Therefore, the shortage and cost of containers resulted in increased shipping costs.

Erenow, many researchers have studied the changes in trade costs under the Sino-US trade war. For example, Chen and Zhou (2020) [39] concluded that the trade war increased China's export-oriented firms' costs and lowered their competitive advantages. Furthermore, the trade war increased tariff rates, exchange rate volatility, costs of cross-border warehousing logistics, and patent licensing or authorization fees. Dai and Liu (2021) [40] also argued that China's furniture enterprises faced raised tariffs, WTO investigations, and lawsuits against China during the trade war, which increased the trade costs of China's furniture enterprises. In addition, Jiang et al., (2021) [41] used the Rotterdam demand model to study the trade impact of tariffs imposed by the United States on China's wooden seats. They also found that higher tariffs increased wooden seat prices, which led to higher trade costs.

### 3.2.2. Uncertainties in Demand and Domestic Supply

A series of lockdowns and quarantines during the COVID-19 pandemic led to shut-downs of enterprises, online education of students, and employees' telecommuting, which impacted people's demand for wood products. As a result, in December 2019 and January 2020, export values of wood products (e.g., wooden office furniture and DIY wood products) and paper products (e.g., commercial copy paper and food wrapping paper) showed a sharp decline. As shown in Figure 6, the export value of China's wood and paper products plummeted. Chen and Yang (2021) [42] attributed this phenomenon to the gradual shrinking of consumer markets and a significant decline in consumer expectations in developed countries. In addition, Stanturf (2022) [43] found that lockdowns and quarantines caused a decline in the demand for newsprint and commercial copy paper, attributed to telecommuting and online education. On the other hand, Zhang et al., (2020) [44] found that China's export values, which included export values of wood and paper products, decreased by 15.9% in January and February 2020, and the reason was that workers were trapped in their hometown during the Spring Festival, and the labor shortage in manufacturing sectors disrupted supply. Nevertheless, the decrease in export rebounded after the initial adjustment, as shown in Figure 6. Most export values of the listed products returned to their general levels in May 2020 and showed noticeable increases in 2021.



**Figure 6.** Trends of China's forest products export value from January 2017 to June 2022 (Unit: million U.S. dollars; H.S. code: wooden office furniture 940330, commercial copy paper 4802, food wrapping paper 481940 and DIY wood products 442010).

However, as the time of lockout and quarantine at home increased, people's lifestyles changed. For example, many telecommuters made home improvements, so the demand for household furniture, especially office furniture and DIY wooden products, increased. Moreover, people preferred food that was easy to store, so the demand for paper products increased. Stephens et al., (2020) [45] found that people began to spend more time on home DIY projects during the quarantine, which increased demand for DIY wooden products. Prestemon and Guo (2022) [46] found that homeowners' renovation rates were higher during the COVID-19 pandemic and attributed this to the increase in extra savings caused by reduced spending on holidays and dining out. Liu et al., (2020) [47] also argued that the pandemic triggered an independent lifestyle and convenient food and beverage, which has caused new demand for paper boxes, straws, bags, and food wrapping paper. Likewise, Gurtu et al., (2022) [31] found that the closure and lockdown of public spaces and factories during the pandemic triggered panicked demand for paper packaging, including food wrapping paper. For example, they increased demand for paper packaging due to increased take-home food demand, which is reflected in Figure 6. As a major exporter of paper products and wooden furniture, China's exports of wooden office furniture, food wrapping paper, and DIY wooden products rebounded and showed a further upward trend from March 2021. Specifically, the upward trends of wooden office furniture and DIY wooden products are more pronounced.

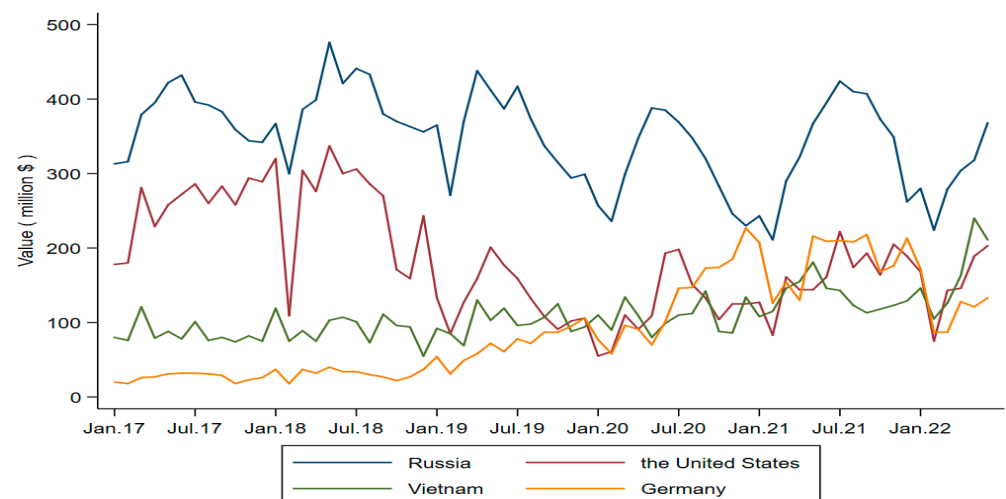
### 3.3. Transfer of Chinese Enterprises' Import Trade Objects

Under the COVID-19 pandemic, small and medium-sized forestry enterprises in China's importers began paying attention to their domestic markets rather than foreign ones [48]. Thus, the supply of their raw materials for wood-based products is also moving inwards. Before the outbreak of COVID-19, some scholars found that tariffs raised by trade protectionism had already affected raw materials import partners for China's wood-based product enterprises. Xia and Chen (2018) [49] used the Global Trade Analysis Project (GTAP) to simulate the economic effects of tariffs imposed by China and the United States and found that the trade war has led to a significant decline in bilateral trade volume. As a result, China has a considerable trade diversion, which means that the United States and China are departing each other as suppliers and demanders. Muhammad and Taylor (2020) [50] argued that the increased tariffs caused by the trade war had reduced China's imports of hardwood lumber from Tennessee. For example, from 2017 to 2019, China's imports of Tennessee oak lumber fell by 70%, from \$69 million to \$20.7 million, while other hardwood lumber imports fell by 75%. In this case, China's imports of hardwood lumber have transferred to other countries. In addition, Tian et al., (2022) [51] used the local equilibrium



analysis tool SMART model to calculate the economic effects of an increased tariff on wood products in the Sino–US trade war and found that \$950 million in China’s wood products imports and \$4.36 billion in exports faced trade diversion.

Figure 7 confirms that China’s leading timber importers have gradually shifted from the United States to Vietnam and Germany. However, the different shares of forest products in the trade between China and the United States made the impact of trade restrictions different. For example, Pan et al., (2021) [15] used the Global Forest Products Model to study the effect of increased tariff rates on forest products by China and the United States, which found that China’s fuel wood and fiber pulp imports will transfer to Vietnam, while waste paper mainly to the U.K.



**Figure 7.** Trade values of China’s major timber importing countries from January 2017 to June 2022 (Unit: million dollars; H.S. code: 44).

#### 4. Discussion and Conclusions

This study analyzes the influence of the global supply chain crisis on China’s wood-based product enterprises, including imports of raw materials, transportation costs, and manufactured product exports. Trade protectionism and the COVID-19 pandemic have disrupted the global supply chain, impacting trade patterns, industrial development, and social life worldwide. The Sino–US trade war increased tariffs while the COVID-19 pandemic triggered lockdowns. Timber was undersupplied during the worldwide supply chain crisis and when transportation costs increased. Therefore, China’s forestry enterprises face problems of raw material shortage and higher trade costs.

On the other hand, the supply chain crisis creates uncertainties for enterprises. First, lockdowns and quarantine measures during the COVID-19 pandemic changed people’s lifestyles, increasing demand for wood-based products (e.g., wooden furniture). Second, because timber from the major exporters is undersupplied and expensive, China is seeking new timber suppliers. Under the situation after the trade war and pandemic, China’s forest product suppliers have both challenges and opportunities: if the supply chain crisis can be better dealt with, the enterprises will gain more profit margin; otherwise, suppliers in other developing countries, such as Vietnam and Malaysia, would take China’s market shares and become new leaders. For forestry enterprises other than China’s, the supply chain crisis is also an opportunity, and the countries with stabler material suppliers and product buyers will benefit from the market volatility.

Based on the status of China’s wood-based product enterprises, some advice is given to China’s forestry sector. First, China should improve domestic timber production’s supply capacity, reducing China’s dependence on imported timber. For example, the government can cease the logging ban and harvest mature and over-mature natural forests to increase the domestic timber supply. Second, the dependence on several suppliers brings more

uncertainty, so enterprises can explore new markets and seek multiple trading partners. Third, forestry enterprises can improve the productivity and quality of their products to meet the new demand for wooden products and gain market advantages.

Currently, restrictions between China and the United States are gradually easing, and lockdowns and quarantine measures caused by the pandemic have also disappeared. However, the influence on the forestry industry and people's lives remains, such as inflation and exchange rate volatility triggered by supply chain disruptions. Thus, many researchers have continued to work on improving global supply chain management. In the future, we can study trends in demand and supply for wooden products and analyze the impact on the welfare of China's forest goods producers and consumers; trade volume and prices can also be modeled and analyzed in detail with partial or general equilibrium models, which could be another future research direction.

**Author Contributions:** Conceptualization, Z.N.; methodology, Z.N.; data curation, Q.L.; writing—original draft preparation, Q.L.; writing—review and editing, Z.N. and Q.L.; visualization, Q.L. All authors have read and agreed to the published version of the manuscript.

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**Data Availability Statement:** The data presented in this study are available at Trade Map | ITC ([intracen.org](https://intracen.org), accessed on 13 March 2022).

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

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