# Market Power of China's Chemical Wood Pulp Imports Based on the Pricing-to-Market Model

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**Abstract**

China is the world's largest importer of chemical wood pulp, which exerts influence in the international market. This paper assesses China's market power in chemical wood pulp imports by using a fixed-effects variable coefficient pricing-to-market model based on panel data from January 2001 to December 2023. Regression results indicate that China's chemical wood pulp import sources can be categorized into three groups. China holds superlative market power in imports from Thailand, Japan, and Russia; holds strong market power in imports from Indonesia and New Zealand; and holds no significant market power in imports from Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil. This fact is associated with multiple factors, including the market share of exporting countries, the development level of the wood-processing industry, production costs, product quality, transportation convenience, presence of Chinese production bases in exporting countries, frequency of natural disasters, and the degree of price manipulation. From these analyses, this paper suggests that China should improve its chemical wood pulp import trade conditions and alleviate domestic resource shortages.

Coupled with the rapid expansion of the domestic paper industry's demand for high-quality raw materials and the implementation of environmental policies such as the Plastic Restriction Order and Waste Ban Order, China's constrained supply of forest resources have led to a growing reliance on imported chemical wood pulp (Sun 2015, Tang et al. 2015). Consequently, China has become the world's largest importer of chemical wood pulp, rendering it highly vulnerable to fluctuations in global chemical wood pulp prices (Rossato et al. 2018). Recent data from the United Nations Comtrade database indicate that China's chemical wood pulp imports have surged from 4.17 million tons in 2001 to 26.79 million tons in 2023, with an average annual growth rate of 8.82 percent. This growth has pushed China's share of global chemical wood pulp imports from 12.74 percent in 2001 to 54.65 percent in 2023, thereby enhancing its potential to wield international market power.

In 2023, the top five countries in global chemical wood pulp imports are China (54.65%)[1], the United States (10.78%), Germany (6.39%), the Netherlands (3.24%), and Turkey (3.21%), underscoring China's substantial dominance compared with other major players (Cheng et al. 2023). The turmoil in the global wood pulp supply chain has intensified the price fluctuation risks for China's imported chemical wood pulp. This gives rise to critical questions regarding China's market power and its import sources, its bargaining power relative to the scale of its imports, and its capacity to use such

[1] The trade volume of Hong Kong, Macao, and Taiwan is calculated separately in China; in this article, China refers only to Chinese Mainland.

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market power to mitigate international price volatility and the the major-country effect. Gaining an understanding of these dynamics is essential for evaluating China's economic interests in the global chemical wood pulp trade and its strategic standing within the global supply chain.

Research on China's market power in the international arena has primarily focused on the following markets: agricultural products, mineral resources, electricity, medical products, airline industry, food and tobacco, carbon emissions trading, and forage (Meng et al. 2009; Song et al. 2009; Zhang et al. 2014; Dai et al. 2018; Zhu et al. 2019a, 2019b; Massot 2020; Dai et al. 2021; Chen and Yu 2022; Wang and Zhang 2022; Wu et al. 2022; Zheng and Pan 2022; Cheng et al. 2023; Ji et al. 2023; Lin et al. 2023; Lv et al. 2023; Marz and Pfeiffer 2023; Yan et al. 2023; Wang et al. 2023). However, research focusing on the chemical wood pulp trade remains limited. Some scholars have examined various aspects of China's chemical wood pulp imports, including demand characteristics, influencing factors, price fluctuation trends, systemic risk assessment, trade structure evolution, and export competitiveness, in-depth research on China's market power in chemical wood pulp imports remains scarce (Ajani 2011, Wang and Mao 2013, Sun 2015, Tang et al. 2015, Rossato et al. 2018, Shang et al. 2022, Shen and Lovric 2022, Cheng et al. 2023).

Scholars both domestically and internationally have performed extensive research on measuring market power in international markets, with mainstream methodologies generally falling into two categories. The first category comprises index-based methods, predominantly used by the structuralist school, that center on quantifying market concentration through the construction of various indices. Key approaches include market structure–based measures, such as the international market concentration ratio and the Herfindahl-Hirschman Index, which are used to assess the degree of market monopoly and competition; performance-based indices, including profit margins, the Bain Index, and Lerner Index, which are used to evaluate market performance and potential market control; and behavior-based indices, such as core technology ownership rates that are designed to reveal market position and influence (Bain 1951, Demsetz 1973, Utton and Morgan 1983, Berger and Hannan 1998). However, given the absence of a theoretical framework that connects market share to market power, a high market share does not necessarily translate to market power. In addition, the challenge of accurately quantifying marginal costs in practical applications may result in misleading conclusions when these indices are used in isolation. Although such methods hold certain reference value, their actual application frequency remains low.

The second category encompasses model-based approaches, primarily used by the new empirical industrial organization theory. These methods assess market power through the derivation of economic models. Prominent examples include the price-cost margin model, which draws on Solow residual theory and relies on statistical parameters for measurement, yielding relatively precise results (Loecker 2011). However, the application of this model is constrained by stringent prerequisites (e.g., assumption of constant returns to scale and Hicks-neutral technological progress) and high demands for data quality, rendering empirical implementation challenging (Kim and Moon 2017). The residual demand elasticity model is also key (Goldberg and Knetter 1999, Engel 2006, Hellerstein 2008, Nakajima 2012). Because of its robust theoretical foundation and relatively straightforward empirical application, it has been widely adopted in academic research (Corsetti et al. 2022). Furthermore, building on the residual demand elasticity model, Song et al. (2009) introduced innovative concepts such as the inverse residual demand function, inverse residual supply function, and supply-demand equilibrium conditions, successfully developing a bilateral partial equilibrium model referred to as the Song-Marchant-Reed (SMR) model.

This model enables the simultaneous measurement of market power from the buyer's and seller's perspectives and is regarded as one of the most scientifically rigorous models for assessing international market power (Yamaura 2011, Zhu et al. 2019a, Lv et al. 2023, Wang et al. 2023). The research scope of the SMR model tends to be confined to a limited number of major trading countries, leading to a relatively narrow coverage. The pricing-to-market (PTM) model is also relevant; it is rooted in the theory of exchange rate pass-through (Krugman 1986; Dizgah et al. 2019). This model not only boasts a robust theoretical foundation and ease of empirical implementation but also incorporates factors such as market structure and consumer utility. It can assess the market power of importers across all source countries (Fitzgerald and Haller 2014, Chen et al. 2024). Given its comprehensive framework, the PTM model is highly compatible with the needs of this study because it enables a more holistic evaluation of China's market power in chemical wood pulp imports.

This paper uses the PTM model to measure China's market power in chemical wood pulp imports. By analyzing the results, it classifies the market power of source countries, analyzes the underlying reasons for the presence or absence of such power, and draws on the development experiences of countries with established market power to propose policy recommendations for China's chemical wood pulp import trade. The core objective is to explore the characteristics and formation mechanisms of China's market power in importing chemical wood pulp from its trading partners.

Compared with existing literature, this study offers potential innovations: It conducts a comprehensive assessment and classification of market power across all chemical wood pulp import source countries. This not only addresses the deficiency of insufficient research on market power in the chemical wood pulp sector but also provides empirical evidence for evaluating import market power and implementing diversification strategies in chemical wood pulp import trade.

## Materials and Methods

### Theoretical analytical framework

Industrial organization theory conceptualizes international market power as the capacity of a country or industry to exercise comprehensive control in the global marketplace. This concept essentially reflects the ultimate pattern of competitive interactions among global industries in terms of productivity and technological innovation within an open economy system. Historically, discourse in this field has often conflated market power with monopoly power. Although both phenomena involve firms setting prices above marginal costs,

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they differ fundamentally. Unlike monopoly power, enterprises with market power typically do not achieve profit levels exceeding the average competitive standard, and such market power tends to be short-term, with limited sustainability over the long run. Consequently, firms possessing market power should not be regarded as a primary focus of antimonopoly efforts. Further research has explicitly noted that monopoly power and market power are not inherently symbiotic, and their nonequivalent relationship reaffirms the essential distinctions between them (Bannock 2005).

From a microeconomic perspective, the mechanism underlying international market power is illustrated in Figure 1, which depicts the interaction between the market demand curve (*D*, downward sloping), the marginal cost curve (*MC*), the marginal revenue curve (*MR*), and the average revenue curve (*AR*, coinciding with *D*). Within an imperfectly competitive market framework, firms operate according to the profit maximization principle ($MR = MC$), where the production equilibrium point lies at the intersection of *MR* and *MC*, denoted as point *E*. The corresponding output and price at this equilibrium are $Q^m$ and $MC^m$, respectively.

Notably, the *D* curve lies above the *MR* curve, so firms can set their product's transaction price at $P^m$ based on the *D* curve. When the difference ($P^m - MC^m$) is positive, it indicates that the firm has price control (i.e., market power occurs). The larger the value of ($P^m - MC^m$), the stronger the firm's market power, which is visually reflected by the vertical distance between $P^m$ and $MC^m$ in the figure (Young 2000). This relationship is closely linked to demand elasticity (ε) and can be quantitatively analyzed using the formula $(P^m - MC^m)/P^m = -1/\varepsilon$. The left-hand side of the equation represents the price-cost markup, thereby revealing the intrinsic connection between market power and market demand elasticity.

## Data collection

The research sample includes countries with chemical wood pulp import volumes accounting for more than 1 percent of China's total chemical wood pulp imports between January 2001 and December 2023. These countries include Brazil, Canada, Chile, Finland, Germany, Indonesia, Japan, New Zealand, the Russian Federation, Sweden, Thailand, and the United States.

The specific data sources and calculation methods are as follows. The chemical wood pulp prices from each source country are calculated based on trade value per trade volume. Data on trade value and volume of chemical wood pulp imported from these countries are sourced from the National Research Network Statistical (2024) database. Nominal exchange rate data for these countries are obtained from the Economy Prediction System (2024) database. The real exchange rate is calculated as the nominal exchange rate multiplied by China's monthly consumer price index (CPI) divided by the source country's monthly CPI. This method is adopted because there is no specific chemical wood pulp price index and previous studies have indicated that results derived from CPI calculations are less accurate than those from nominal exchange rates (Yumkella et al. 1994, Wang et al. 2017). As a robustness check, the calculation results of the real exchange rate are also presented, with CPI data for the countries sourced from the Bureau Van Dijk EIU Countrydata (2024) database.

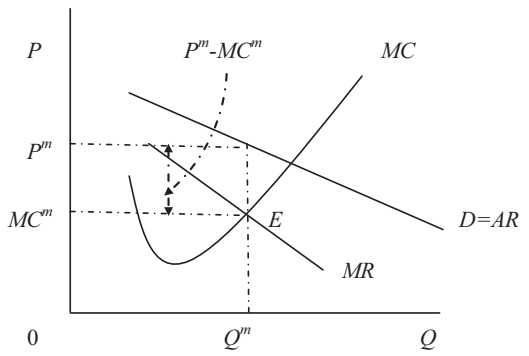


*Figure 1.—Mechanism of international market power.*

## PTM model

Krugman (1986) suggested the PTM model theory, which states that fluctuations in bilateral exchange rates between an exporter and multiple importers lead to changes in the price ratios paid by the importers. Building on this theoretical basis, Goldberg and Knetter (1999) developed a representative model for export pricing strategies, which is constructed based on the principle of profit maximization. In this model, the scenario states that in an exporting country supplying goods to *N* destination countries, the demand in each country is defined as follows:

$$q_{it} = f(p_{it}e_{it})z_{it} \quad \forall i = 1 \ldots N, \forall t = 1 \ldots T \tag{1}$$

In Equation 1, $q_{it}$ denotes the demand from destination country *i* in period *t*; $p_{it}$ represents the export price set by the exporter for *i*, expressed in the exporter's domestic currency in period *t*; $e_{it}$ signifies the bilateral exchange rate between the exporter and destination country *i* in period *t*, expressed as the number of units of the destination country's currency exchanged for one unit of the exporter's currency; and $z_{it}$ is a random variable capturing shifts in the demand curve. Furthermore, the production costs incurred by exporting country are given by the following:

$$C_t = C\left(\sum_{i=1}^{N} q_{it}\right)\delta_t \ \forall i = 1 \ldots N, \forall t = 1 \ldots T \tag{2}$$

where $C_t$ represents the total costs associated with all destination countries *i*, expressed in the exporter's domestic currency; and $\delta_t$ is a random variable that introduces changes in the cost function, such as fluctuations in input prices during period *t*. Therefore, the profit maximization problem for the exporting country can be expressed as follows:

$$\max\pi = \sum_{i=1}^{N}[p_{it}f(p_{it}e_{it})z_{it}] - C\left\{\sum_{i=1}^{N}[f(p_{it}e_{it})z_{it}]\right\}\delta_t \tag{3}$$

In Equation 3, by taking the derivative with respect to $p_{it}$ and expressing it in terms of elasticity, the first-order condition is derived as follows:

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$$p_{it} = c_t \left( \frac{\varepsilon_t^i}{\varepsilon_t^i - 1} \right) \forall i = 1 \ldots N, \forall t = 1 \ldots T \quad (4)$$

where $c_t$ represents the common marginal cost faced by the exporting country in period $t$, and $\varepsilon^i{}_t$ denotes the absolute value of the price elasticity of demand faced by the exporter in destination country $i$ during period $t$. Therefore, the price in the exporter's currency should reflect the price-cost markup, with the markup depending on the demand elasticity in destination market $i$ (Varma and Issar 2016). If the demand elasticity in destination country $i$ is not constant, fluctuation in the exchange rate between the exporting and destination countries will influence the transaction price by affecting either the marginal cost or the demand elasticity. Specifically, changes in marginal cost will affect all destination countries, while variations in demand elasticity will only affect the destination country where the exchange rate change occurs (Dawson et al. 2017). Taking the natural logarithm of Equation 4 and performing a total differential yields the final form of the export PTM model as follows:

$$\ln P_{it} = \alpha + \beta_i \ln e_{it} + \lambda_i + \theta_t + \mu_{it} \quad \forall i = 1 \ldots N, \forall t = 1 \ldots T \quad (5)$$

where $p_{it}$ represents the price in the exporter's currency for exports from the exporting country to country $i$ in period $t$; $\beta_i$ is the parameter to be estimated, reflecting the elasticity of export prices to exchange rate fluctuations and serving as a measure of the exchange rate pass-through effect in destination country $i$; $\lambda_i$ captures country-specific effects; $\theta_t$ represents the time effect as a monthly dummy variable to control for seasonal influences, thereby eliminating the need for seasonal adjustments to the price and exchange rate series; and $\mu_{it}$ is the error term.

Building on the export pricing strategy model developed by Goldberg and Knetter (1999), Manitra and Shapouri (2001) introduced the import PTM model. The specific formulation of the PTM model is as follows:

$$\ln r_{jt} = \phi + \varphi_j \ln e_{jt} + \lambda_j + \theta_t + \mu_{jt} \quad \forall j = 1 \ldots N, \forall t = 1 \ldots T \quad (6)$$

In Equation 6, $r_{jt}$ represents the price of chemical wood pulp imported from country $j$ to China in period $t$, denominated in Renminbi (RMB) with the unit of measurement being yuan per ton; $e_{jt}$ represents the bilateral exchange rate between China and source country $j$, expressed as the amount of RMB (China's lawful currency) per unit of $j$'s currency; $\varphi_j$ is the parameter to be estimated, reflecting the elasticity of chemical wood pulp import prices with respect to exchange rate fluctuations and measures the exchange rate pass-through effect for country $j$; $\lambda_j$ represents country-specific effects; $\theta_t$ accounts for time effects as a monthly dummy variable to control for seasonal variations, thus eliminating the need for seasonal adjustment of the price and exchange rate series; and $\mu_{jt}$ is the error term.

Some scholars have attempted to extend the PTM model by incorporating additional control variables such as gross domestic product. However, results indicate that the original PTM model by Goldberg and Knetter (1999) provides more reliable outcomes. This occurs primarily because from a multilateral trade perspective, the inclusion of individual and time effects in the PTM model already accounts for unobservable heterogeneity. Adding additional control variables may reduce degrees of freedom and affect the accuracy of the model's results (Griffith and Mullen 2001, Pall et al. 2013, Wang et al. 2017).

Building on the analytical framework, the exchange rate pass-through effect (ERPT*) reflects the effect of exchange rate fluctuations on the price of chemical wood pulp denominated in foreign currency, embodying the market power of chemical wood pulp exporting country. Conversely, the PTM ability (PTM*) captures the effect of exchange rate fluctuations on the price of chemical wood pulp denominated in RMB($\varphi_j$), which signifies China's market power in chemical wood pulp imports. Note that PTM* = ERPT* + 1. Assuming constant costs, when foreign currencies appreciate, the research findings can be categorized into the following seven scenarios based on the values of ERPT* and PTM* (Table 1; specific explanations provided in the Appendix).

# Results

## Analysis of key characteristics

With the rapid development of China's paper industry, domestic demand for high-quality raw materials, such as wood pulp, has surged. Because of China's relatively limited forest resources and the delayed integration of the forestry and paper industries, domestic wood pulp production remains severely constrained, resulting in a significant structural supply shortage that can be alleviated only through imports (Cheng et al. 2023).

From 2001 to 2023, China's chemical wood pulp imports grew steadily. Table 2 details the breakdown of China's chemical wood pulp import sources in 2001 and 2023, revealing a high degree of supplier concentration. This concentration not only weakens China's bargaining power in import trade but also elevates international trade risks, leaving China's chemical wood pulp supply highly vulnerable to policy shifts in source countries and potential trade frictions. In 2001, China primarily imported chemical wood pulp from 10 countries, including Indonesia, Russia, and Canada, which collectively accounted for 97.9 percent of total imports. By 2023, Brazil, Indonesia, and Chile had become the main sources, contributing 94.25 percent of the total. Notably, Brazil has emerged as the largest supplier of China's chemical wood pulp imports, while the positions of Indonesia, Canada, Chile, and the United States have remained stable contributors. In contrast, shares from Russia and New Zealand have declined significantly.

## Diagnostic tests for the PTM model

To ensure the scientific validity of the regression results, a series of diagnostic tests were conducted on the PTM model, including stationarity tests, cointegration tests, Hausman tests, two-way fixed effects tests, varying coefficient model tests, Wald heteroskedasticity tests, Wooldridge autocorrelation tests, and multicollinearity tests. Ultimately, it was determined that a varying coefficient PTM model incorporating both individual and time-fixed effects should be adopted. The model was then estimated using feasible generalized least squares regression to address heteroscedasticity issues

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Table 1.—Relationship between China's chemical wood pulp import demand elasticity, ERPT*, PTM*, and market power.[a]

| $\varepsilon^j_t$ | ERPT* | Import price in foreign currency | PTM* ($\varphi_j$) | Import price in local currency | ERPT and market power (China's imports) |
|---|---|---|---|---|---|
| Perfectly inelastic ($\varepsilon^j_t = 0$) | >0 | Increase | >1 | Increase > exchange rate fluctuation | Reverse pass-through of exchange rates, no market power |
| Perfectly inelastic ($\varepsilon^j_t = 0$) | 0 | Remain unchanged | 1 | Increase = exchange rate fluctuation | Complete nonpass-through of exchange rates, no market power |
| Lack of elasticity ($0 < \varepsilon^j_t < 1$) | ($-\frac{1}{2}$, 0) | 0 < decrease < ½ of the exchange rate fluctuation | ($\frac{1}{2}$, 1) | ½ < increase < exchange rate fluctuation | Incomplete pass-through of exchange rates, relatively weak market power |
| Unit elasticity ($\varepsilon^j_t = 1$) | $-\frac{1}{2}$ | Decrease = ½ of the exchange rate fluctuation | ½ | Increase = ½ of exchange rate fluctuation | Incomplete pass-through of exchange rates, equal market power |
| Highly elastic ($\varepsilon^j_t > 1$) | ($-1$, $-\frac{1}{2}$) | ½ < decrease < exchange rate fluctuation | (0, ½) | 0 < increase < ½ of exchange rate fluctuation | Incomplete pass-through of exchange rates, relatively strong market power |
| Infinite elasticity ($\varepsilon^j_t \to \infty$) | −1 | Decrease = exchange rate fluctuation | 0 | Remain unchanged | Complete pass-through of exchange rates, strong market power |
| Infinite elasticity ($\varepsilon^j_t \to \infty$) | <−1 | Decrease > exchange rate fluctuation | <0 | Decrease | Excessive pass-through of exchange rates, dominant market power |

Note: Based on PTM theory, $\varepsilon^j_t$ represents the absolute value of the price elasticity of demand faced by country *j* in China; domestic currency refers to Renminbi; foreign currency refers to the currency of country *j*; exchange rate fluctuations are exemplified by the appreciation of the foreign currency; analysis of exchange rate pass-through is based on the interpretation of ERPT* values; market power refers to China's import market power in the source country; and market power is relative—strong import market power for China in the source country indicates weaker market power for the source country's exports.

[a] ERPT* = exchange rate pass-through effect; PTM* = pricing to market ability.

and ensure the reliability of the estimation results. The specific diagnostic process is as follows.

*Stationarity tests.*—To avoid the issue of spurious regression, Fisher-type and Levin-Lin-Chu tests were used to assess the stationarity of the panel data. The Fisher-type test is applicable to data with heterogeneous unit roots, whereas the Levin-Lin-Chu test is suitable for homogeneous unit roots. Panel data can be determined stationary only if both tests confirm stationarity. In the data, *rwp* represents the price of chemical wood pulp imported by China, and *ewp* denotes the bilateral exchange rate between China and the source countries of chemical wood pulp imports. Test results show that all series are stationary, confirming that the data constitute a long panel (Table 3).

*Cointegration tests.*—The Pedroni Residual and Kao Residual tests were used to examine the cointegration relationship among variables. The Pedroni test is applicable to heterogeneous panels, whereas the Kao test is suited for homogeneous panels. Cointegration is confirmed only when both tests simultaneously reject the null hypothesis. Results indicate a long-term cointegration relationship between ln*rwp* and ln*ewp* (Table 4).

*Other tests.*—For the PTM model of China's chemical wood pulp imports, the Hausman test yields a $\chi^2$ statistic of 26.56, which significantly rejects the null hypothesis at the 1 percent level. The *F* tests for individual and time-fixed effects produce values of 24.15 and 19.85, respectively, both of which also significantly reject the null hypothesis at the 1 percent level. Additionally, the $\chi^2$ statistic for testing parameter stability is 4.5 by $10^4$, which again significantly rejects the null hypothesis at the 1 percent level. Consequently, a varying coefficient PTM model with individual and time-fixed effects should be constructed (Tables 5 to 7).

Table 2.—Regional structure of China's chemical wood pulp imports.

| 2001 | | | 2023 | | |
|---|---|---|---|---|---|
| Country of origin | Import volume/million tons | Proportion/% | Country of origin | Import volume/million tons | Proportion/% |
| Indonesia | 1.02 | 24.40 | Brazil | 8.86 | 33.07 |
| Russia | 0.84 | 20.03 | Indonesia | 3.87 | 14.46 |
| Canada | 0.69 | 16.43 | Chile | 2.80 | 10.44 |
| Chile | 0.62 | 14.83 | Canada | 2.38 | 8.88 |
| Brazil | 0.36 | 8.64 | Finland | 2.08 | 7.75 |
| United States | 0.24 | 5.83 | Russia | 1.88 | 7.01 |
| New Zealand | 0.12 | 2.81 | United States | 1.69 | 6.30 |
| Thailand | 0.11 | 2.74 | Uruguay | 1.28 | 4.78 |
| Portugal | 0.02 | 1.13 | Sweden | 0.73 | 2.75 |
| Finland | 0.04 | 1.06 | Germany | 0.28 | 1.04 |
| Total | 4.08 | 97.90 | Total | 25.85 | 96.48 |

Note: According to the calculation of the National Research Network (2024) database, the table lists only countries that account for more than 1% (i.e., sample countries).



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Table 3.—Stationarity tests for each series.

| | Fisher-type | | | | Levin-Lin-Chu | |
|---|---|---|---|---|---|---|
| Variable name | *P* value | *Z* value | *L** value | $P_m$ value | *t* value | Consequence |
| ln*rwp* | 154.90***[a] | −7.39*** | −12.14*** | 18.89*** | −1.93*** | Stable |
| ln*ewp* | 93.81*** | −6.52*** | −7.32*** | 10.08*** | −3.25*** | Stable |

Note: Calculated through Stata 15 software. $L^*$ represents a specific statistic derived from the inverse logit t(64).
[a] *** represents significance levels of 1%.

The $\chi^2$ statistic for Wald heteroscedasticity test is 256.46, which significantly rejects the null hypothesis at the 1 percent level, indicating the presence of heteroscedasticity. The Wooldridge autocorrelation test yields an *F* statistic of 7.25, also significantly rejecting the null hypothesis at the 1 percent level, suggesting the presence of autocorrelation. The variance inflation factor is 1, indicating the absence of multicollinearity (Table 8). Therefore, to ensure the reliability of the results, the feasible generalized least squares method should be used for estimation.

## Analysis of empirical results for the PTM model

R results of the PTM model are displayed in Table 9. Here, the estimates derived from the nominal exchange rate are treated as the baseline, whereas those from the real exchange rate are used for robustness checks. Through analysis, it is determined that although the specific values of $\varphi_j$ differ, the overall assessment of market power remains highly consistent. This indicates that inflation exerts a negligible effect on market power in China's chemical wood pulp import trade and does not lead to any significant changes. This consistency further validates both the reliability of the constructed PTM model and the robustness of its results. Table 9 shows that notable disparities occur in market power among different source countries in China's chemical wood pulp import trade. Based on the degree of market power, the source countries of China's chemical wood pulp imports can be classified into the following three categories.

*Category 1: China holds superlative market power.*—Category 1 includes Thailand, Japan, and Russia. When the currencies of these three countries appreciate by 1 percent, the prices of chemical wood pulp quoted in their currencies drop by 1.78, 1.12, and 1.03 percent, respectively, exceeding the magnitude of the currency appreciation. In contrast, the RMB-denominated prices of chemical wood pulp decrease only by 0.78, 0.12, and 0.03 percent, respectively, indicating that China holds remarkably strong bargaining power in these markets. The costs arising from currency appreciation are fully borne by the source countries, allowing China to capitalize on its market position to negotiate lower import prices.

In this category, Thailand is an upper-middle-income country in Southeast Asia, Japan is a high-income country in Asia, and Russia is an upper-middle-income country in Europe. The limited market power of these countries in China's chemical wood pulp import trade can be attributed to several factors. As of 2023, Thailand, Japan, and Russia account for 0.06, 0.62, and 4.02 percent of global chemical wood pulp exports, respectively, whereas their shares in China's total chemical wood pulp imports stand at 0.11, 0.61, and 7.08 percent, respectively. This indicates that these three countries hold relatively marginal positions both in the global chemical wood pulp market and in China's import market. Conversely, China accounts for 48.15, 55.91, and 69.21 percent of Thailand's, Japan's, and Russia's total chemical wood pulp exports, respectively, making it the largest importer of chemical wood pulp from each of countries. This underscores the critical significance of the Chinese market to these exporters.

For example, Thailand's domestically produced chemical wood pulp, compared with that from Europe and the United States, features higher moisture content and lower quality. This directly gives rise to greater challenges in storage and transportation, thereby undermining its market competitiveness. Moreover, major Chinese multinational paper companies (e.g., Lee & Man Paper Manufacturing, Ltd.; Rongcheng Paper Co., Ltd.; Sun Paper Industry Co., Ltd.; Nine Dragons Paper [Holdings] Limited) have actively implemented the "going out" strategy. They have invested in Thailand to develop advanced integrated forest-pulp-paper bases, a move that not only optimizes the use of local resources but also integrates the supply chain (Lin et al. 2020). This has effectively reduced production costs, notably improved overall profitability, and further strengthened their bargaining power when importing chemical wood pulp from Thailand.

Although Japan has successfully mitigated the shortage of local wood resources and met domestic demand for chemical wood pulp-achieved through advanced production technologies, higher paper-recycling rates, and expanded use of broadleaf wood-it still confronts distinct challenges when compared with Europe and the United States. These challenges encompass difficulties in securing raw materials security and the escalating costs of imported wood chips,

Table 4.—Cointegration tests for variables.

| | Pedroni residual | | | Kao residual | |
|---|---|---|---|---|---|
| Variable name | rho value | *P* value | ADF value[a] | *t* value | Consequence |
| ln*rwp* and ln*ewp* | −20.96***[b] | −10.09*** | −7.60*** | −5.62*** | Cointegration relationship occurs |

Note: Calculated through Stata 15 software.
[a] ADF = Augmented Dickey Fuller.
[b] *** represents significance levels of 1%.



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*Table 5.—Hausman test for the model.*

| Product | Fixed (*b*) | Random (*B*) | Different (*b*-*B*) | SE[a] | $\chi^2$ |
|---|---|---|---|---|---|
| Chemical wood pulp | −0.10 | −0.02 | −0.08 | 0.02 | 26.56***[b] |

Note: Calculated through Stata 15 software.
[a] SE = standard error.
[b] *** represents significance levels of 1%.

both of which directly push up production costs (Hayafune and Tachibana 2024). Additionally, Japan's chemical wood pulp production facilities are predominantly concentrated in the earthquake-prone northeastern coastal regions, areas highly susceptible to earthquakes and tsunamis. Such natural disasters can damage production equipment, disrupt operational processes, trigger supply chain disruptions, and even cause market panic. Consequently, pulp export prices may decline, thereby undermining Japan's international competitiveness.

Although geographically part of Europe, Russia has not been integrated into the unified exporter system for chemical wood pulp in Europe and the United States. Because of its relatively outdated production equipment and technologies, Russia lags significantly behind exporters from the United States, Germany, Sweden, and Finland in terms of product quality and price stability; this fact has severely constrained its pricing power in the global chemical wood pulp market (Gordeev 2020). As a result, when conducting transactions with China, Russia tends to adopt a more flexible approach and is more willing to accommodate Chinese buyers' price proposals.

*Category 2: China holds strong market power.*—Category 2 includes Indonesia and New Zealand. When the currencies of these two countries appreciate by 1 percent, the prices of their chemical wood pulp dominated in their respective currencies decrease by 0.92 and 0.78 percent, respectively, exceeding one-half of the currency appreciation rate. In contrast, when measured in RMB, the prices of their chemical wood pulp rise by a mere 0.08 and 0.22 percent, respectively, accounting for less than one-half of the currency appreciation rate. This indicates that China holds significant market power in these markets. Although the appreciation of these foreign currencies raises the costs associated with chemical wood pulp, the majority of such cost increases are absorbed by the exporting countries, with only a small portion being passed on to China.

In Category 2, Indonesia is a middle-income country in Southeast Asia, and New Zealand is a high-income country in Oceania. Both countries hold relatively weak market power in China's chemical wood pulp import trade for the following reasons. In 2023, Indonesia's and New Zealand's chemical wood pulp export values accounted for 7.58 and 0.93 percent of the global total, respectively; in China's total chemical wood pulp imports, their shares stood at 13.31 and 0.49 percent, respectively. Conversely, China, the largest importer of chemical wood pulp for both countries, holds 68.18 percent of Indonesia's exports and 30.01 percent of New Zealand's exports in this category, which underscores the pivotal role of the Chinese market for these exporting countries.

Indonesia's situation bears similarities to Thailand's. Constrained by outdated production technologies and equipment in its local chemical wood pulp sector, Indonesia experiences subpar pulp quality and low production efficiency. However, capitalizing on the opportunities brought by the Belt and Road initiative, Chinese private capital has established Chinese-invested business entities in Indonesia. These entities focus on developing a high-end, efficient, and integrated industrial chain for timber production and processing, directly accessing local commercial forest resources. This development is conducive to strengthening China's bargaining power in chemical wood pulp imports.

Moreover, Indonesia's severe deforestation problem has promoted the government to impose high value-added tax rates on all stages of wood processing and production. This has significantly increased the production costs of chemical wood pulp, pushing many local companies into financial straits and undermining the competitiveness of their exports (Obidzinski and Dermawan 2012, Fischer et al. 2021, Gunawan et al. 2024).

Beyond market share considerations, New Zealand primarily exports raw timber products—radiata pine, for instance. This focus results in a shortage of raw materials for chemical wood pulp production (Liao and Ning 2023, Kumar and Luo 2024). Coupled with the overall underdevelopment of New Zealand's wood industry, production and transportation costs for chemical wood pulp remain relatively high, which further undermines the competitiveness of New Zealand's chemical wood pulp exports.

*Category 3: China holds no market power.*—This category comprises Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil. The estimated coefficients for these seven countries are not statistically significant, indicating that China does not hold market power in these markets. Chile and Brazil are categorized as high-income and upper middle–income countries in South America, respectively; the United States and Canada are high-income countries in North America; and Germany, Sweden, and Finland are considered high-income countries in Europe.

*Table 6.—Individual and time-fixed effect tests for the model.*

| Product | Individual fixed-effect test (*F*) | Time fixed-effect test (*F*) | Consequence |
|---|---|---|---|
| Chemical wood pulp | 24.15***[a] | 19.85*** | Both fixed |

Note: Calculated through Stata 15 software.
[a] *** represents significance levels of 1%.



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Table 7.—Varying coefficient test for the model.

| Product | $\chi^2$ | Consequence |
|---|---|---|
| Chemical wood pulp | 4.5e + 04***[a] | Varying coefficient |

Note: Calculated through Stata 15 software.
[a] *** represents significance levels of 1%.

Table 8.—Other three tests for the model.

| Tests | Test value | Consequence |
|---|---|---|
| Wald heteroskedasticity test | $\chi^2$ = 256.46***[a] | Presence of heteroscedasticity |
| Wooldridge autocorrelation test | $F$ = 7.25*** | Presence of autocorrelation |
| VIF[b] test | VIF = 1*** | Absence of multicollinearity |

Note: Calculated through Stata 15 software.
[a] *** represents significance levels of 1%.
[b] VIF = variance inflation factor test.

China lacks market power in importing chemical wood pulp from certain countries, primarily attributing to these following factors. China's heavy reliance on imported chemical wood pulp significantly undermines its weak market power. Specifically, in 2023, the dependence rate of China on imported softwood pulp exceeded 90 percent, whereas that on imported hardwood pulp surpassed 50 percent. Moreover, the global production and supply of chemical wood pulp are highly concentrated in these seven countries. Collectively, they account for 84.22 percent of the global chemical wood pulp export market and 71.93 percent of the total value of China's chemical wood pulp imports.

Furthermore, the seven countries are located in Europe and North America, regions that wield substantial control over the international chemical wood pulp market. Notably, these countries demonstrate a high level of coordination in their pricing strategies. During market upturns, they may jointly raise prices; during downturns, they can control supply quantities to stabilize prices. This coordinated behavior effectively influences market prices, thereby further weakening China's bargaining power in the import of chemical wood pulp (Carvalho et al. 2009, Silva and Maciel 2022, Jiang and Dai 2023).

In chemical wood pulp trade with these seven countries, China primarily adopts two procurement models: signing long-term agreements directly with suppliers where prices are determined by the suppliers in line with market fluctuations and making purchases through domestic traders. Due to the low concentration of China's chemical wood pulp industry, importing enterprises face difficulties in forming a unified negotiating stance. This leads to a situation where purchasing prices are often controlled by the suppliers, and consequently, China generally lacks market power in the import of chemical wood pulp.

## Discussion

### International market level

Research shows that China holds superlative market power in its chemical wood pulp imports from Thailand, Japan, and Russia and strong market power in imports from Indonesia and New Zealand. However, China lacks market power in chemical wood pulp imports from Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil. Analysis further reveals that the likelihood of China having weaker market power in chemical wood pulp imports rises when the source countries exhibit the following conditions. (1) The country holds a small share in both the global and Chinese chemical wood pulp markets, whereas China accounts for the majority of its pulp exports; (2) its wood-processing industry is underdeveloped, resulting in lower-quality chemical wood pulp products (Gordeev 2020); (3) China has established integrated forestry-pulp-paper production bases in the country, allowing for the direct use of local timber resources; (4) the country faces raw material shortages, which raise production costs (Liao and Ning 2023, Hayafune and Tachibana 2024, Kumar and Luo 2024); (5) the country is frequently hit by natural disasters (e.g., earthquakes, tsunamis), leading to poor market stability; and (6) the country lacks coordinated price control efforts with other nations.

In contrast, the likelihood of China wielding stronger market power in chemical wood pulp imports increases when the source countries demonstrate the following traits. (1) The country commands a significant share in both the global and Chinese chemical wood pulp markets, and China is highly dependent on it (Li et al. 2008, Karthikeyan et al. 2013); (2) it boasts advanced wood-processing technologies and equipment, which enables the production of high-quality chemical wood pulp products (Silva et al. 2019); (3) it has an ample supply of raw materials, ensuring convenient production; (4) it exercises strong price control in the international chemical wood pulp market (Silva and Maciel 2022, Cheng et al. 2023 Jiang and Dai 2023, Zou and Xu 2024); and (5) its industry features a high level of concentration, which facilitates coordinated negotiation efforts.

A large market share is one of the conditions for attaining market power, but it does not automatically ensure it; therefore, "market power" should not be conflated with "monopoly power"—a point that reinforces the argument that using market concentration as a measure of market power lacks a robust theoretical foundation. This perspective provides a more nuanced understanding of the true nature of market power. To improve China's chemical wood pulp import trade conditions, efforts should be focus on the previously outlined factors, and adjustments to the import market structure could be made to increase market share in countries with significant market power.

China imports large quantities of chemical wood pulp and has a high degree of dependence on foreign trade, yet it holds a relatively weak bargaining position in the international market. This study is valuable for improving the stability of China's chemical wood pulp import trade and ensuring the security of domestic chemical wood pulp supply. Gaining market power commensurate with the scale of its import trade will effectively mitigate the adverse effects of the large country effect, reduce trade losses, and further promote the sustainable development of the domestic paper industry.

Therefore, China should adopt measures concerning its chemical wood pulp imports. China should adjust the import market structure by increasing the import share from source countries with market power, such as Thailand, Japan, Russia, Indonesia, and New Zealand. Meanwhile, China should actively explore new import sources to reduce

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*Table 9.—Estimation results of market power in China's chemical wood pulp import market.*

| | Nominal exchange rate | | | Real exchange rate | | |
|---|---|---|---|---|---|---|
| Import source | ERPT*[a] | PTM* ($\varphi_j$) | Market power | ERPT* | PTM* ($\varphi_j$) | Market power |
| Thailand | −1.78 | −0.78***[b] | Superlative | −1.37 | −0.37*** | Superlative |
| Japan | −1.12 | −0.12** | Superlative | −1.13 | −0.13*** | Superlative |
| Russia | −1.03 | −0.03** | Superlative | −1.03 | −0.03*** | Superlative |
| Indonesia | −0.92 | 0.08** | Strong | −0.82 | 0.18*** | Strong |
| New Zealand | −0.78 | 0.22* | Strong | −0.82 | 0.18** | Strong |
| Chile | −0.98 | 0.02 | No | −0.96 | 0.04 | No |
| United States | −0.98 | 0.02 | No | −0.92 | 0.08 | No |
| Germany | −0.96 | 0.04 | No | −0.95 | 0.05 | No |
| Sweden | −0.96 | 0.04 | No | −0.96 | 0.04 | No |
| Finland | −0.95 | 0.05 | No | −0.97 | 0.03 | No |
| Canada | −0.94 | 0.06 | No | −0.98 | 0.02 | No |
| Brazil | −0.93 | 0.07 | No | −0.98 | 0.02 | No |
| Cross-section fixed (dummy variables) | | | | | | |
| Period fixed (dummy variables) | | | | | | |
| | $R^2 = 0.75$ | | | $R^2 = 0.74$ | | |
| | Log likelihood = 2641.55 | | | Log likelihood = 2622.85 | | |
| | $F$ statistic = 29.06 | | | $F$ statistic = 28.55 | | |
| | Prob ($F$ statistic) = 0.00 | | | Prob ($F$ statistic) = 0.00 | | |

Note: Calculated through Stata 15 software.
[a] ERPT* = exchange rate pass-through effect; PTM* = pricing to market ability.
[b] ***, **, * represents significance levels of 1%, 5%, and 10%, respectively.

reliance on countries where it lacks market power, including Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil. This task is feasible because China has been pursuing a diversified import strategy for chemical wood pulp in recent years to mitigate import trade risks. For instance, amid the United States–China trade frictions, China has met domestic demand for chemical wood pulp by increasing imports from trading partners other than the United States. Currently, the focus of chemical wood pulp imports has shifted from North America to the Asia-Pacific region, where countries such as Indonesia have grown in prominence as China's trading partners.

China should extend the successful experience gained in Thailand by proactively establishing factories and developing forest exploitation bases in regions abundant in forest resource. This approach will help alleviate raw material shortages, enhance the depth and intensity of participation in the global value chain, and effectively guard against the risk of price manipulation in international trade. China could establish long-term cooperative partnerships with countries such as Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil. By signing bilateral or multilateral chemical wood pulp trade agreements, it will be possible to stabilize both supply and transaction prices. Drawing on the chemical wood pulp export practices of countries such as Chile, China could standardize the order of its domestic chemical wood pulp import market, strengthen the role of industry associations, reduce information exchange costs, forge a unified external synergy, and enhance discourse power in negotiations.

## Domestic market level

According to Food and Agriculture Organization of the United Nations database, in 2023, China's chemical wood pulp output reached 24.57 million tons, with imports totaling 32.84 million tons and exports at 0.27 million tons. From these figures, China's domestic consumption stood at 57.14 million tons. The data on output, imports, and exports clearly indicates that China's imports of chemical wood pulp are used to meet domestic market demand. To address raw material shortages, in addition to actively implementing measures to stabilize international supply and transaction prices, the following strategies can be considered for the domestic market in China.

Accelerate the establishment of fast-growing timber reserves dedicated to pulping. This entails integrating seedling cultivation, forest management, and timber harvesting while advancing the informatization of forestland to build a comprehensive forest mapping database. The aim is to extend the forestry industry chain, upgrade the technological level of forestry development, meet diverse needs such as afforestation and logging, and enhance the economic value of the forestry sector.

Intensify research and development on new papermaking materials and technologies to reduce reliance on chemical wood pulp and effectively overcome the constraints imposed by scarce forest resources. For instance, actively explore the development and use of nonwood fiber raw materials (e.g., crop straw, bamboo, reed) to diversify papermaking material sources (Guan and Zhang 2023).

Raise the level of domestic integrated forest-pulp-paper cyclical development. While ensuring clean production and energy conservation, China should continuously explore innovative models for comprehensive resource use and industrial cyclical development. This includes building a circular economy ecological chain of resources–products–renewable resources and developing a complete industrial system characterized by supporting forests through paper, promoting paper through forests, and integrating forest and paper industries. The goal is to maximize resource use and facilitate the development of resource-saving, environmentally friendly, and green circular development models (Dai et al. 2023).



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## Conclusions

As the world's largest importer of chemical wood pulp, China boasts substantial potential to gain international market power through its trade volume. Drawing on panel data spanning from January 2001 to December 2023, this study assesses the market power of China's chemical wood pulp import trade by constructing a fixed-effect varying coefficient PTM model. Key findings are as follows.

Regression results indicate that China's chemical wood pulp import sources can be divided into three categories. China holds superlative market power in imports from Thailand, Japan, and Russia; holds strong market power from Indonesia and New Zealand; but holds no significant market power in imports from Chile, the United States, Germany, Sweden, Finland, Canada, and Brazil.

This phenomenon is closely associated with multiple factors, such as the market share of import source countries, the development level of the wood-processing industry, production costs, product quality, transportation accessibility, the establishment of production bases in the source countries, the frequency of natural disasters, and the existence of coordinated price manipulation. Based on the identified causes of China's current status of market power in chemical wood pulp imports, this study recommends improving China's chemical wood pulp import trade conditions and alleviating domestic resource shortages.

This study addresses China's market power in chemical wood pulp imports, which not only influences China's economic interests in international chemical wood pulp trade but also directly affects the development and security of the domestic paper industry. Because data accessibility constraints, this paper presents an analysis of China's market power only in chemical wood pulp imports and does not provide a detailed examination of all of pulp-type imports into China. Considering that chemical wood pulp accounts for two-thirds of global pulp trade and 74.96 percent of China's pulp imports, this study remains highly representative and carries significant reference value. This paper repeatedly incorporated variables such as gross domestic product, government interventions, certification schemes, chemical wood pulp inventory levels, and market indicators for chemical wood pulp end products into the PTM model, but the inability to obtain monthly data on these variables across countries leaves the final selected variables confined to existing research frameworks.

According to studies by Griffith and Mullen (2001), Pall et al. (2013), and Wang et al. (2017), the original PTM model developed by Goldberg and Knetter (1999) delivers more reliable results—thus lending credibility to the findings of this paper. Future research will expand the set of research variables and build on the empirical insights of this study and explore China's market power in chemical pulp imports from its trading partners through scenario analysis.

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## Appendix

$ERPT^* > 0$, $PTM^* > 1$: Reverse pass-through effect. In this scenario, the demand for the source country's products in the Chinese market is perfectly inelastic. The full cost increase arising from foreign currency appreciation is borne by China's imports, enabling the source country to raise its cost mark-up and amplify the effect of exchange rate fluctuations. This indicates that the source country holds exceptionally strong market power in the Chinese market, whereas China's import market power is negligible.

$ERPT^* = 0$, $PTM^* = 1$: Complete nonpass-through effect. Similar to the reverse pass-through effect scenario, the demand for the source country's products in the Chinese market is perfectly inelastic. When the foreign currency appreciates by 1%, the foreign currency–denominated price remains unchanged, whereas the Renminbi-denominated price rises by an equivalent 1%. This situation indicates that China's import market power is negligible.

$-\frac{1}{2} < ERPT^* < 0$, $\frac{1}{2} < PTM^* < 1$: Incomplete pass-through effect. In this scenario, the demand for the source country's products in the Chinese market is relatively inelastic and insensitive to price changes. When the foreign currency appreciates, the source country absorbs a small portion of the cost arising from exchange rate fluctuations and slightly reduces its prices, while passing most of the cost increase on to China, resulting in a significant rise in the Renminbi-denominated price. This indicates that the source country holds substantial market power in the Chinese market, whereas China's market power is relatively weak.

$ERPT^* = -\frac{1}{2}$, $PTM^* = \frac{1}{2}$: Incomplete pass-through effect. In this scenario, the demand elasticity for the source country's products in the Chinese market equals 1, meaning the source country and China bear the effect of exchange rate fluctuations equally. This situation reflects a balance of market power between the two parties, with both possessing equivalent market influence.

$-1 < ERPT^* < -\frac{1}{2}$, $0 < PTM^* < \frac{1}{2}$: Incomplete pass-through effect. In this scenario, the demand for the source country's products in the Chinese market is elastic, with an elasticity greater than 1. The source country bears a significant portion of the cost from exchange rate fluctuations and can only pass a small fraction of the cost increase on to the Chinese market to maintain its market share. This indicates that China holds considerable market power in its trade with this source country.

$ERPT^* = -1$, $PTM^* = 0$: Complete pass-through effect. In this scenario, the full burden of exchange rate fluctuations is borne by the source country, with no change in the Renminbi-denominated price. This indicates that China holds significant market power in its trade with this source country.

$ERPT^* < -1$, $PTM^* < 0$: Excessive pass-through effect. In this scenario, the demand for the source country's products in the Chinese market is infinitely elastic, meaning it is highly sensitive even to minor price changes. When the foreign currency appreciates, the foreign-currency-denominated price decreases by more than the appreciation rate, while the Renminbi-denominated price also declines. This indicates that China holds exceptionally strong market power in its trade with this source country.

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