The study on the effect of restrictive rosewood trade policies on China's rosewood import prices

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Abstract

Purpose – Rosewood, as the most internationally traded endangered species, is subject to a series of restrictive trade policies globally. China has historically been the largest importer of rosewood in the world. The fluctuation of China's rosewood import prices will have a profound impact on the global rosewood trade pattern. This study, therefore, assessed the impact of restrictive trade policies on China's rosewood import prices to explore the fluctuation rule of rosewood trade prices under restrictive policies.

Design/methodology/approach – The study built a partial equilibrium framework about the formation mechanism of rosewood import price bubbles under supply constraints. On this basis, with China's daily import prices of major rosewood species, the generalized supremum augmented Dickey–Fuller (GSADF) and backward supremum augmented Dickey–Fuller (BSADF) tests were applied to explore the effect of restrictive trade policies on China's rosewood import prices.

Findings – The empirical analysis revealed that there were multiple price bubbles for five of the seven rosewood species. The largest bubbles were always created before and after the deployment of supply constraints. The empirical results for the counterfactual examples implied that price bubbles would not have occurred if restrictive rosewood trade policies had not been implemented. The above findings indicated that these measures tended to trigger significant price bubbles in China's rosewood imports.

Originality/value – The effect of restrictive rosewood trade policies on rosewood trade prices had not yet been explored in previous research studies. This study empirically analyzed the effect of restrictive trade policies on China's rosewood import prices using econometric models.

Keywords Rosewood, Restrictive trade policies, China, Import prices, Price bubbles

Paper type Research paper

1. Introduction

The rosewood defined in China National Standards is divided into two families (*Leguminosae* and *Ebenaceae*) and five genera (*Dalbergia*, *Pterocarpus*, *Cassia*, *Millettia* and *Diospyros*), covering 29 species (Standardization Administration of China, 2017). Rosewood is a precious tropical hardwood timber that originates principally in Southeast Asia and Africa; it is primarily used to manufacture expensive furniture (Huang *et al.*, 2018; Siriwat and Nijman, 2018a). Due to rapidly escalating prices, rosewood is the most sought-after timber in the

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international market; however, global rosewood reserves are extremely limited, because rosewood species have an extremely long growth cycle (Chen, 2021). Rosewood has become the most heavily traded species product worldwide (Sundström, 2016). According to data from the United Nations Office on Drugs and Crime (2016), rosewood accounted for 35% of all species interceptions between 2005 and 2015.

International trade is a major threat to the survival of wild rosewood populations (Siriwat and Nijman, 2018b). The overexploitation of rosewood resources has received much attention from the international community. The Convention on International Trade in Endangered Species (CITES) is the most authoritative international agreement between governments on species conservation. The convention aims to ensure that international trade does not threaten the survival of endangered species (CITES, 2014). CITES grants different degrees of protection to wild species by applying the provisions contained within its three CITES appendices. CITES lists 17 rosewood species in these CITES appendices. *Dalbergia nigra* has been added to CITES Appendix I, and the other species are included in CITES Appendix II (CITES, 2023). Under the legal framework of CITES, member states with rosewood resources have established their own domestic laws to restrain the felling or trade of rosewood. As presented in Table 1, most rosewood species imported into China are subject to CITES regulations and trade policies in their countries of origin. The CITES regulations and national legislation of member states form the comprehensive policy framework of rosewood trade. These policies aimed at regulating the international trade order of rosewood, preventing the over exploitation of rosewood resources and safeguarding the reproduction and survival of the rosewood populations. Thus, it's referred to in the term of restrictive rosewood trade policies.

The rosewood resources in China have long been exhausted. China, therefore, relies on rosewood imports to meet domestic demand. The rosewood imports into China are mainly logs and sawn timber (Bian *et al.*, 2020). China imported 5.50 million m^3 of rosewood logs and 0.83 million m^3 of rosewood sawn timber from 2014 to 2019 (Yin *et al.*, 2021). China has emerged as the ultimate destination for the vast majority of international rosewood trade and has become the largest importer of rosewood in the world (John, 2019; Treanor, 2015). So China's rosewood import prices play a leading role in the international market. Its fluctuation could not only change the rosewood trade structure between China and related rosewood source countries, but also have a profound impact on the trend of global rosewood trade pattern. These will be key factors in the effectiveness of rosewood resource conservation. Rosewood is scarce high-grade wood. Its trade price is sensitive to the change of supply in the international market. Restrictive trade policies, including CITES regulations and national legislations, will thus have a significant effect on China's rosewood import prices. It is, therefore, of great importance to explore the influence of restrictive trade policies on China's rosewood import prices.

The economic impact of restrictive rosewood trade policies is an important topic. Some scholars focused on the effect of restrictive policies on rosewood trade. Shi *et al.* (2015) found that international organizations and relevant countries were imposing the stringent restrictions on rosewood resources. Bian *et al.* (2020) demonstrated that the import of rosewood was notably impacted by export restrictions implemented by source countries and international conventions, such as CITES. Siriwat and Nijman (2018a) found that CITES appeared to be ineffective in restricting the illegal trade of rosewood from Thailand (*Dalbergia cochinchinensis*, *Dalbergia bariensis* and *Pterocarpus macrocarpus*). Vardeman and Runk (2020) revealed that the harvesting of *Dalbergia retusa* in Panama grew dramatically, following the implementation of local bans. Waeber *et al.* (2019) uncovered that after genera *Dalbergia* was listed in CITES Appendix II in 2016, local hoarding of genera *Dalbergia* expanded in Madagascar. Cargill (2022) further pointed out that the CITES restrictions triggered an average annual increase in Malagasy rosewood logging of 127.6%. The research

Region	Species	CITES listing	Country of origin	National policies
Southeast Asia	*Pterocarpus macrocarpus*		Laos	Laos prohibited timber exporters from purchasing rare timber in the local market in 2014 Laos banned the export of logs in June 2016
			Myanmar	Myanmar banned the export of logs in 2014 Myanmar halted the export of timber and wood products in June 2017
			Cambodia	Cambodia completely stopped the export of timber and closed all rosewood smuggling channels in 2017
	Dalbergia latifolia	CITES Appendix II (2016)	Indonesia	Indonesia has restricted the export of logs since 2010
	Dalbergia oliveri	CITES Appendix II (2016)	Laos	Laos banned the export of logs in June 2016
			Myanmar	Myanmar halted the export of timber and wood products in June 2017
	Dalbergia cochinchinensis	CITES Appendix II (2013)	Vietnam	Vietnam banned the export of *D. cochinchinensis* in October 2014
			Thailand	Thailand implemented a logging and trading ban on *D. cochinchinensis* in 2012
			Cambodia	Cambodia imposed a total ban on the trade of *D. cochinchinensis* in 2013
			Laos	Laos banned the export of *D. cochinchinensis* in October 2014
Africa	*Pterocarpus erinaceus*	CITES Appendix II (2016)	Nigeria	Nigeria banned the export of semi-processed wood in December 2016 Nigeria further banned the export of *P. erinaceus* at the request of the CITES committee in 2018
			Ghana	Ghana imposed a total ban on the logging and export of *P. erinaceus* in January 2014
			Gambia	Gambia implemented a ban on the export of logs in November 2012
	Millettia laurentii		Congo Cameroon	
Latin America	*Dalbergia retusa*	CITES Appendix II (2013)	Panama	Panama has prohibited the logging of *D. retusa* since 2010
			Nicaragua	Nicaragua has restricted the export of *D. retusa* since 2014

Source(s): Table created by authors

Table 1. Restrictive policies on major rosewood imports into China

of Dumenu (2019) further exhibited a 129% increase in Ghanaian rosewood (*P. erinaceus*) exploitation when felling/export bans and CITES designation came into effect. Kansanga *et al.* (2021) reached a similar conclusion. His evidence hinted that the export volume of *P. erinaceus* jumped by 66% in 2012, which was the first year of the local ban on rosewood logging in Ghana.

Some studies focused on the effect of restrictive policies on rosewood industry. Zhai *et al.* (2014) highlighted that conservation-oriented trade policies became a crucial restraining factor for the development of rosewood industry. Yin *et al.* (2021) pointed out that restrictive policies introduced by international organizations regarding rosewood trade had a significant influence on China's rosewood industry. Huang *et al.* (2018) emphasized that restrictive policies towards rosewood resources would increasingly impede international trade related to rosewood, emerging as a significant hindrance to the growth of rosewood industry.

In summary, previous studies primarily revolved around the influence of restrictive trade policies on rosewood trade and rosewood industry. These studies contributed to understanding the escalating impact of CITES rules or national statutes on the harvesting, exports and processing of rosewood. However, the impact of these policies on rosewood trade prices remains an underexplored topic. Furthermore, the impact of rosewood trade policies was primarily evaluated using statistical data in previous research and econometric methods have not yet been adopted to conduct more in-depth analysis of this issue. This study attempted to overcome these deficiencies. On the basis of previous studies, we explore the theoretical mechanism of restrictive trade policies on rosewood trade prices and establish an econometric model for verification.

The mutual complementation of CITES regulations and national legislation is central to the whole policy system of rosewood trade. These policies will inevitably have a significant impact on global rosewood trade prices. Due to the leading position of China in global rosewood imports, we empirically analyzed the effect of restrictive trade policies on China's rosewood import prices using econometric models. The value of this study lies in providing reference for exploring the fluctuation rule of international trade prices of rosewood under restrictive trade policies. The conclusions of this paper have implications for the theoretical research on international trade prices of wildlife species under supply constraints. Moreover, this research tries to unveil the formation mechanism of price bubbles in China's rosewood imports under restrictive trade policies. This provides theoretical guidance for preventing the risk of price bubbles in rosewood imports and mitigating the impact of speculative activities on rosewood trade to foster the rational and orderly development of international rosewood trade.

2. Theoretical basis

We construct a partial equilibrium framework with a competitive market structure to illustrate the formation mechanism of rosewood import price bubbles under supply constraints (Figure 1). In the initial stage of the rosewood import market, the supply curve S_1 intersects the demand curve D_1 at the equilibrium point E_1. Assuming no entry of speculative capital, P_1 and Q_1 represent the market-clearing price and the quantity, respectively. The statements about a forthcoming ban on rosewood trade send a signal of a decline in future supply. It induces rosewood importers to form the strong expectations of higher future prices. With the enhancement of investment demand for rosewood, the massive influx of speculative capital into the rosewood import market would shift the entire demand curve outward from D_1 to D_2. The equilibrium point slides from E_1 to E_2 along the supply curve S_1. Importers stockpile rosewood in a legal manner. This would lead to an increase in both equilibrium price (P_1 to P_2) and equilibrium quantity (Q_1 to Q_2). After the implementation of the ban, the supply of rosewood in the international market is restricted. It implies an inward shift in supply from S_1 to S_2. This results in the third equilibrium point E_3 with the higher price (P_2 to P_3) but the lower quantity (Q_2 to Q_3). The successive rise in the import price further stimulates the growth of investment demand for rosewood. The demand curve would continue to shift outward from D_2 to D_3. The equilibrium point moves from E_3 to E_4 at the low level of supply

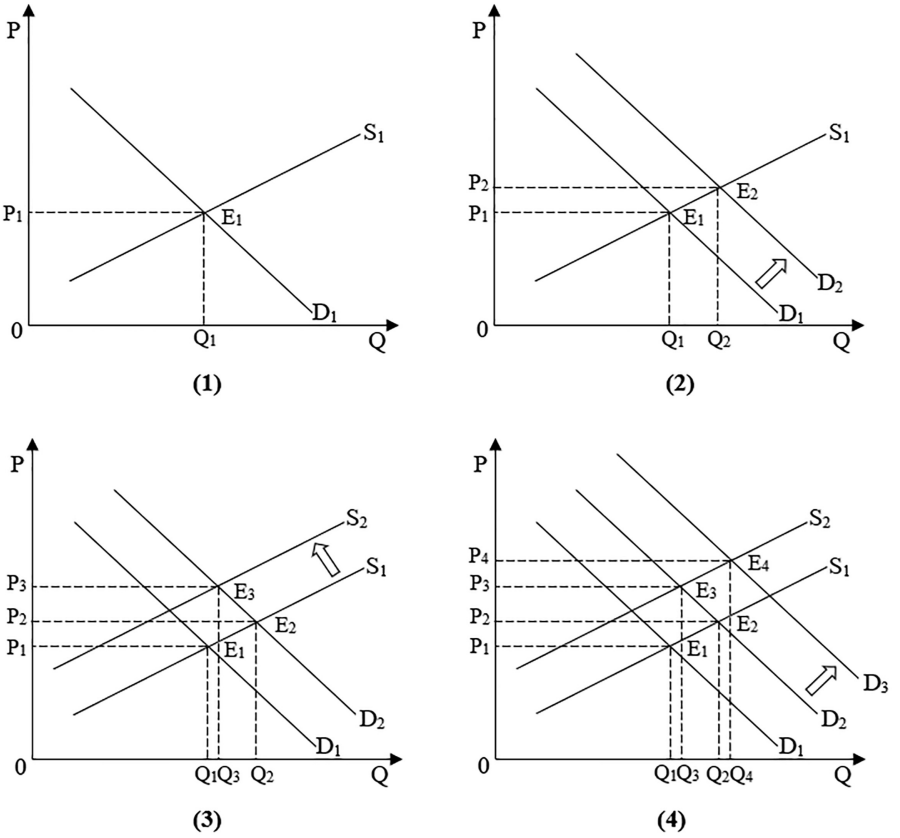

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Figure 1.
The supply and demand dynamics of rosewood imports before and after the implementation of restrictive trade policies

S_2. Importers try to expand the storage of rosewood in an illegal way. This incurs a further rise in the equilibrium price (P_3 to P_4) and a rebound in the equilibrium quantity (Q_3 to Q_4). As the equilibrium price deviates more and more from the actual value (P_1), the price bubbles of rosewood imports are eventually created.

In summary, restrictive rosewood trade policies may well bring about rosewood import price bubbles. We try to take China as an example to verify this argument with time series analysis.

3. Methodology

3.1 Model specification

The supremum augmented Dickey–Fuller (SADF) test was proposed to detect a price bubble by Phillips *et al.* (2011). The SADF test is based on continuous forward recursive regression of the right-tailed augmented Dickey–Fuller (ADF) test to determine the existence of the bubble. Its basic principle is as follows: take the subsample sequence, starting point r_1, ending point r_2. $r_2 = r_1 + r_w$. r_w denotes the optimal subsample capacity ratio and expands from r_0 to 1. Then the SADF statistic is expressed as:

$$SADF(r_0) = \sup_{r_2 \in [r_0,1]} \{ADF_0^{r_2}\} \quad (1)$$

where r_0 and 1 represent the minimum and maximum values of the regression window length, respectively. The SADF test fixes r_1 at 0. So $r_2 = r_w$ and r_2 moves between r_0 and 1. The ADF statistic for a subsample that runs from 0 to r_2 is set as $ADF_0^{r_2}$.

The SADF test is suited to identify the existence of single bubble, but cannot detect multiple bubbles. The generalized supremum augmented Dickey–Fuller (GSADF) test was developed to identify the presence of multiple bubbles with a flexible recursive window (Phillips *et al.*, 2015). It recurses the start and end points simultaneously and thus has high power for estimating multiple consecutive bubbles. The GSADF statistic can be defined as:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0,1] \\ r_1 \in [0, r_2 - r_0]}} \left\{ADF_{r_1}^{r_2}\right\} \quad (2)$$

where the start point r_1 moves between 0 and r_2-r_0. The end point r_2 changes within the range of [r_0, 1]. The estimated ADF statistic is represented as $ADF_{r_1}^{r_2}$. If the GSADF statistic is greater than its corresponding right-tail critical value, the alternative hypothesis that at least one bubble exists is not rejected.

Next, the backward supremum augmented Dickey–Fuller (BSADF) test was applied to determine the occurrence and bursting times of each bubble. The BSADF test is conducted within the GSADF framework using a bubble date-stamping method, but performs a sup ADF test based on the backward recursive technique. The BSADF statistic is calculated as follows:

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \left\{ADF_{r_1}^{r_2}\right\} \quad (3)$$

where the end point r_2 is fixed first, and the start point r_1 varies from r_2-r_0 to 0. The corresponding ADF statistic sequence is defined as $\{ADF_{r_1}^{r_2}\}_{r_1 \in [0, r_2 - r_0]}$. When the BSADF statistic is higher or lower than the critical value for the first time, it can be inferred that the first bubble occurs or ends. If numerous bubbles exist, the recursive calculation continues from the end of the first bubble, and the emergence and bursting of every bubble is thereby identified.

Combining the GSADF and BSADF tests has the advantage over traditional bubble tests (e.g. the variance bounds test and West two-step test) of being able to test multiple price bubbles. Conventional tests fail to identify periodic explosive bubbles. In contrast, the GSADF test has high testing power for multiple bubbles (Su *et al.*, 2020) and the BSADF test can determine the duration of multiple bubbles concurrently (Umar *et al.*, 2021). Therefore, both tests were used to explore whether seven rosewood import price series for China displayed episodes of explosive behavior. Subsequently, the degree of temporal coincidence between the appearance of bubbles and implementation of rosewood trade supply constraints was examined to evaluate their influence on rosewood import prices. If large bubbles were created before and after the deployment of supply constraints, the measures were considered to strengthen the investment properties of rosewood, and China's rosewood importers were driven to engage in speculative trade behavior.

3.2 Data collection

We collected China's daily import prices of the major rosewood species from Yuzhu International Timber Market [1]. The market is located in Guangzhou City, Guangdong

Province and has become one of the largest rosewood trading centers in China (Huang and Sun, 2013). The rosewood import prices released by Yuzhu International Timber Market are important factors in decision-making for domestic and foreign rosewood traders. The period studied was from August 1, 2010 to December 31, 2019. The dataset included seven rosewood species: *P. erinaceus*, *D. cochinchinensis*, *D. retusa*, *P. macrocarpus*, *Millettia laurentii*, *Dalbergia latifolia* and *Dalbergia oliveri*. *Dalbergia cochinchinensis, P. macrocarpus*, *D. latifolia* and *D. oliveri* originate from Southeast Asia; *P. erinaceus* and *M. laurentii* originate from Africa and *D. retusa* originates from Latin America. These species account for >90% of the rosewood market in China (Yin *et al.*, 2021). Table 2 provides a list of the rosewood species along with their specifications, characteristics and units of measurement.

4. Empirical results

The GSADF test statistics for *D. cochinchinensis*, *D. retusa*, *P. macrocarpus* and *D. oliveri* all exceeded the corresponding 1% critical values, while the significance level of the test statistic for *P. erinaceus* was <5% (Table 3). This indicated that at least one explosive bubble was formed for each of these rosewood species. The significance levels for *M. laurentii* and *D. latifolia* were >10%, indicating that there was no bubble for either species.

The BSADF test results further confirmed that there were multiple bubbles for *P. erinaceus*, *D. cochinchinensis*, *D. retusa*, *P. macrocarpus* and *D. oliveri*, but not for the other two rosewood species. In terms of the date-stamping strategy, the commencement date and deadline of every bubble are given in Figure 2.

Table 4 presents the characteristics of multiple price bubbles in China's rosewood imports. Six *P. erinaceus* bubbles were identified and seven *D. cochinchinensis* bubbles were detected. Ten bubbles were created in the price series of *D. retusa*. Seven bubbles were recognized in the price series of *P. macrocarpus*. Six bubbles were identified in the price series of *D. oliveri*. Most bubbles were positive and they generally had a longer duration and greater fluctuation than negative bubbles. The largest bubble for every rosewood species was always positive, and the markups in these bubbles were much greater than their price reductions; this indicates a heavy demand for rosewood in China.

The price series of *P. erinaceus* experienced the largest bubble, spanning from November 29, 2013 to February 27, 2014, with a growth from the start to the peak of 25.96%. More than 90% of the *P. erinaceus* imports in China originated from Ghana (Dumenu, 2019). Ghana has prohibited the harvesting and export of *P. erinaceus* since 2014. The prohibition was a shock to China's import market for *P. erinaceus*, which was likely the chief cause of the *P. erinaceus* bubble.

The largest *D. cochinchinensis* bubble lasted from September 11, 2013 to June 25, 2014. The price in this positive bubble episode soared by 29.07% from the start to the peak. *Dalbergia cochinchinensis* was added to CITES Appendix II at the 16th CITES Conference in 2013, and

Species	Specification (cm)	Measurement unit
Pterocarpus erinaceus	1.5–3 m × 20–30	Thousand CNY per ton
Dalbergia cochinchinensis	1.8–2.2 m × 15–35	Thousand CNY per ton
Dalbergia retusa	1.5–3 m × 10–30	Thousand CNY per ton
Pterocarpus macrocarpus	1.5–3 m × 20–40	Thousand CNY per ton
Millettia laurentii	2–3.5 m × 40–60	Thousand CNY per m^3
Dalbergia latifolia	1.5–3 m × 5–12	Thousand CNY per ton
Dalbergia oliveri	2–4 m × 20–30	Thousand CNY per ton

Source(s): Table created by authors

Table 2. Rosewood specifications and measurement units

	Pterocarpus erinaceus	*Dalbergia cochinchinensis*	*Dalbergia retusa*	*Pterocarpus macrocarpus*	*Millettia laurentii*	*Dalbergia latifolia*	*Dalbergia oliveri*
	2.986**	6.637***	6.580***	7.734***	−0.233	0.501	6.228***
	(0.013)	(0.000)	(0.000)	(0.000)	(1.000)	(0.999)	(0.000)
Critical value							
90%	2.291	2.288	2.288	2.288	2.311	2.311	2.311
95%	2.536	2.540	2.541	2.549	2.560	2.560	2.560
99%	3.125	3.125	3.125	3.119	3.125	3.125	3.125

Note(s): The critical values for both tests were generated by Monte Carlo simulations with 1,000 replications; the *p*-values are presented in parentheses. The same below. *** denotes significance at the 1% level. ** denotes significance at the 5% level
Source(s): Table created by authors

Table 3.
Results of GSADF test of rosewood prices

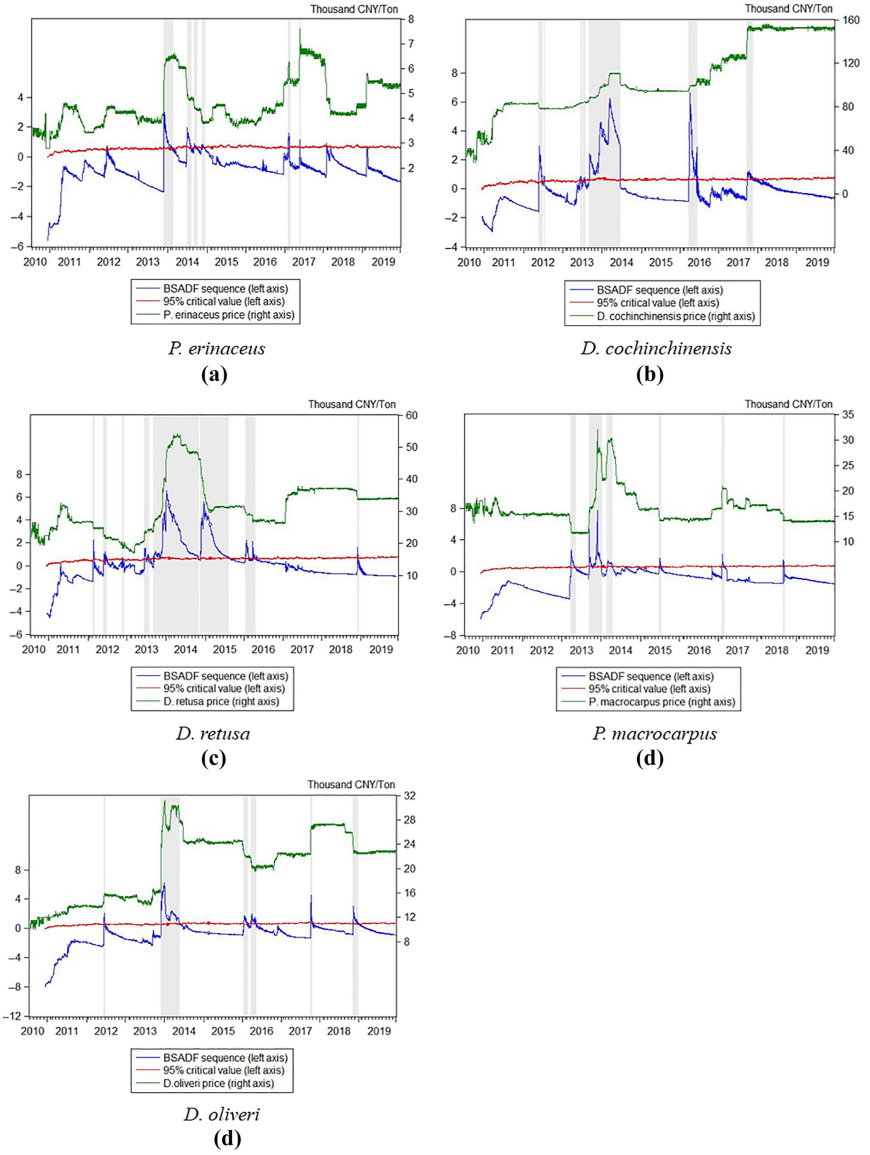
its export ban has been implemented by Cambodia since 2013. It is possible that these restrictions have caused this bubble.

The largest *D. retusa* bubble persisted from September 12, 2013 to October 29, 2014. The price rose sharply (by 108.46%) to reach a peak in this period. *Dalbergia retusa* was listed in CITES Appendix II at the 16th CITES Conference in 2013. Nicaragua was the main country of origin for *D. retusa* and also severely restricted its exports since 2014. It is likely that these policies led to a surge in the trade price and stimulated speculative behavior in terms of China's imports of *D. retusa*.

The period from October 23, 2013 to January 6, 2014 was the largest *P. macrocarpus* bubble. The price surged by 86.05% at the peak of this bubble; this was the result of the joint influence of dual factors. Trade in upmarket rosewood, such as *D. cochinchinensis*, has been supervised by CITES since 2013. Timber traders were desperate for an alternative rosewood to address the market demand. *Pterocarpus macrocarpus*, as a medium-grade rosewood, was priced moderately at that time; it has not yet been added to the CITES appendices and, therefore, became an ideal alternative (Gaisberger *et al.*, 2022), such that its imports into China rapidly expanded (China Wood Industry Information Network, 2013). Nevertheless, Myanmar and Laos, as the chief sources of *P. macrocarpus*, initiated timber control measures in 2014. Myanmar forbade the exports of logs and Laos prohibited the felling of precious tree species. The early release of the bans encouraged China's rosewood importers to hoard *P. macrocarpus* in advance and finally spurred the formation of an explosive bubble. Hence, the substitutability and restrictive practices gave rise to speculative trade in *P. macrocarpus*.

For *D. oliveri*, the largest bubble emerged on November 29, 2013 and burst on May 27, 2014. The price jumped by 38.67% at the highest point of the bubble. The trade of *D. cochinchinensis* has been limited under the CITES restrictions since 2013. *Dalbergia oliveri* belongs to the same genus as *D. cochinchinensis*. The woody texture of both species is similar, but the price of *D. oliveri* is much lower than that of *D. cochinchinensis*. This triggered China's rosewood importers to stock *D. oliveri* as a substitute for *D. cochinchinensis* (Gaisberger *et al.*, 2022) and the duration of the largest bubbles for both species, therefore, overlapped, with similar price rises.

The test results revealed no *M. laurentii* and *D. latifolia* price bubbles, but for the opposite reasons. *Millettia laurentii* is not included in the CITES appendices, and its countries of origin, Congo and Cameroon, do not have restrictive practices targeting its cutting or trade. In contrast, India, as the leading producer of *D. latifolia*, severely restricted its exports as early as 1980 (Winfield *et al.*, 2016). Although *D. latifolia* was added to CITES Appendix II at the 17th



Note(s): The BSADF statistic and 95% critical values were obtained from Monte Carlo simulations with 1,000 replications. The shaded areas reflect bubble intervals where the BSADF statistic exceeded the critical value. The shadows are sub-periods with bubbles lasting at least 3 days. All time series spanned the period August 1, 2010-December 31, 2019
Source(s): Figure created by authors

Figure 2.
Dates of rosewood price bubbles

CITES Conference in 2016, the initial trade control on *D. latifolia* in India resulted in a negligible impact of the CITES designation on its price.

Table 4. Bubble period durations (days) and price changes

Species	Bubble period	Duration (days)	Peak value	Price change of positive bubbles (%)		Price change of negative bubbles (%)		Implementation of restrictive rosewood trade policies
				Start to peak	Peak to end	Start to trough	Trough to end	
Pterocarpus erinaceus	Nov 29, 2013 to Feb 27, 2014	76	2.99	25.96	−1.07			Ghana imposed a total ban on the logging and export of *P. erinaceus* in January 2014
	Jul 5 to Aug 11, 2014	38	1.96			−10.48	1.70	
	Sep 6–27, 2014	22	0.90			−4.84	0.00	
	Nov 18 to Dec 4, 2014	17	0.85			−3.80	0.00	
	Feb 23 to Mar 6, 2017	12	1.58	5.00	−1.59			
	Jun 3–7, 2017	5	1.13	4.11	−1.32			
	Sum	170						
Dalbergia cochinchinensis	Jun 6 to Jul 2, 2012	27	0.56			−2.50	1.03	
	Jul 20–25, 2012	6	0.57			−0.45	0.19	
	Jun 25 to Jul 4, 2013	10	0.59	0.24	−0.24			
	Jul 22 to Aug 5, 2013	15	0.58	0.71	−0.24			
	Sep 11, 2013 to Jun 25, 2014	243	0.79	29.07	−0.63			(1) *D. cochinchinensis* was added to CITES Appendix II at the 16th CITES Conference in 2013. (2) Cambodia imposed a total ban on the trade of *D. cochinchinensis* in 2013
	Apr 12 to Jun 21, 2016	71	0.71	10.07	0.00			
	Oct 2 to Nov 16, 2017	46	0.70	3.33	−2.58			
	Sum	418						

(*continued*)

Table 4.

Species	Bubble period	Duration (days)	Peak value	Price change of positive bubbles (%) Start to peak	Price change of positive bubbles (%) Peak to end	Price change of negative bubbles (%) Start to trough	Price change of negative bubbles (%) Trough to end	Implementation of restrictive rosewood trade policies
Dalbergia retusa	Mar 8–14, 2012	7	2.26			−1.61	0.00	
	Jun 8–16, 2012	9	0.88			−2.22	1.36	
	Jun 21 to Jul 3, 2012	13	1.20			−2.73	0.47	
	Nov 22–27, 2012	6	0.72	0.54	−1.36			
	Jun 21 to Aug 1, 2013	42	1.55	8.89	−0.82			
	Sep 12, 2013 to Oct 29, 2014	398	6.58	108.46	−13.65			(1) *D. retusa* was listed in CITES Appendix II at the 16th CITES Conference in 2013. (2) Nicaragua restricted the export of *D. retusa* since 2014
	Nov 16, 2014 to Aug 15, 2015	249	5.58			−33.33	4.00	
	Jan 14 to Mar 7, 2016	32	2.27			−3.36		
	Apr 6–25, 2016	20	2.14			−1.85	1.85	
	Dec 4–12, 2018	9	1.64			−1.47	0.00	
	Sum	785						
Pterocarpus macrocarpus	Apr 10 to May 19, 2013	40	2.81			−8.00	0.00	
	Sep 17 to Oct 14, 2013	28	5.37	5.63	−0.60			
	Oct 23, 2013 to Jan 6, 2014	76	7.73	86.05	−18.52			(1) Myanmar banned the export of logs in 2014. (2) Laos prohibited timber exporters from purchasing rare timber in the local market in 2014
	Mar 11 to Apr 23, 2014	44	1.39	9.78	−2.71			
	Jul 8–18, 2015	11	1.73			−3.45	0.71	
	Feb 23 to Mar 15, 2017	21	2.21	5.71	−2.38			
	Sep 7–15, 2018	9	1.47			−1.41	0.00	
	Sum	229						

(*continued*)

Table 4.

Species	Bubble period	Duration (days)	Peak value	Price change of positive bubbles (%) Start to peak	Price change of positive bubbles (%) Peak to end	Price change of negative bubbles (%) Start to trough	Price change of negative bubbles (%) Trough to end	Implementation of restrictive rosewood trade policies
Dalbergia oliveri	Jun 24 to Jul 1, 2012	8	2.04	3.23	−1.88			
	Nov 29, 2013 to May 27, 2014	165	6.23	38.67	−9.94			The trade of *D. cochinchinensis*, with the similar woody texture to *D. oliveri*, has been limited under the CITES restrictions since 2013. This caused the hoarding of *D. oliveri* as an alternative to *D. cochinchinensis*
	Jan 14 to Mar 7, 2016	32	1.75			−3.54	0.45	
	Apr 8 to May 23, 2016	46	1.94			−7.14	2.56	
	Oct 14–23, 2017	10	4.58	5.88	−0.74			
	Nov 14 to Dec 28, 2018	45	3.06			−5.88	0.45	
	Sum	306						

Note(s): Bubble length was identified by the BSADF test with 95% critical values obtained from a recursive bootstrap procedure with 1,000 replications. The peak value (largest BSADF statistic during the bubble period) was used to determine the extent of the bubble
Source(s): Table created by authors

We drew on counterfactual research methods to examine whether price bubbles would not have occurred if restrictive rosewood trade policies had not been implemented. We conducted a comparative analysis involving non-CITES species as counterfactual examples to support the argument that price bubbles would be triggered by restrictive rosewood trade policies. We utilized the price series of three non-CITES species, namely *Dryobalanops*, *Aucoumea klaineana* and *Vatairea guianensis*. These species were similar to the rosewood species studied above in terms of precious hardwood. And these species, not included in the CITES appendices, were exempt from the restrictions of trade policies.

We collected the daily import prices of three non-CITES species from Yuzhu International Timber Market in China, spanning from August 1, 2010 to December 31, 2019. The data source and time dimension were consistent with the rosewood species studied above to enhance the comparability of the counterfactual examples. The results of GSADF test for three non-CITES species were shown in Table 5. The significance levels for *Dryobalanops, A. klaineana* and *V. guianensis* were all greater than 10%. This confirms that there was no explosive bubble for these non-CITES species. The results revealed that these non-CITES species did not exhibit significant price bubbles over the same time period as the rosewood species studied above. This further confirms that the formation of price bubbles in China's rosewood imports could attribute to restrictive trade policies.

5. Summary and discussion

We studied the effect of restrictive rosewood trade policies on China's rosewood import prices. Empirical results showed that constraint measures were inclined to spark off enormous price bubbles in China's rosewood imports. The formation of multiple price bubbles revealed the prevalence of speculative behavior in the rosewood trade. Excessive consumption for rosewood as an investment good is constantly created in the pursuit of speculative profits by traders. This could increase rosewood trade through either legal routes or illicit channels.

The chain reaction caused by restrictive rosewood trade policies between rosewood international market and importers is presented (Figure 3). The introduction of restrictive rosewood trade policies sent a strong signal to the international market that rosewood harvesting would fall sharply. This signal strengthened the expectations among rosewood importers that prices were likely to soar. The potential financial returns of rosewood, therefore, also increased. As a result, large amounts of speculative capital flew into the rosewood market. Before the implementation of restrictive rosewood trade policies, rosewood importers hoarded by way of legal trade and initially pushed up the import prices of rosewood. In fact, there is always a long time lag between the issuance and enforcement of restrictive trade policies. For example, the new lists of endangered species in the CITES

	Dryobalanops	*Aucoumea klaineana*	*Vatairea guianensis*
	−3.404	−0.913	−1.551
	(1.000)	(1.000)	(1.000)
Critical value			
90%	2.197	2.216	2.197
95%	2.415	2.461	2.415
99%	2.927	2.949	2.927

Source(s): Table created by authors

Table 5. The results of GSADF test for three non-CITES species

Appendices of the 17th CITES Conference, held in September 2016, did not take effect for 7 months. This delay means that rosewood importers have plenty of time to stockpile rosewood in the available window.

After these policies went into effect, the logging of rosewood was subject to the relevant regulations. The contraction of rosewood production triggered further price escalation. The speculative trade in rosewood was thus stimulated and rosewood importers increased the amount of rosewood inventory through illegal channels (Yin and Qiao, 2020). For example, while Ghana, Nigeria, Gambia and Sierra Leone have long-standing prohibitions on the harvesting or export of rosewood, according to data provided by China Customs, large quantities of rosewood still flow out of these countries every year due to weak enforcement (Treanor, 2015). With the spread of speculative behavior in the rosewood market, the price bubbles of rosewood were spawned.

The frequent price bubbles in the rosewood trade arise from the relationship between demand preference and policy restrictions. The preference for rosewood has a long history in China. As early as the Ming Dynasty (1368–1644), rosewood was a symbol of social standing. Some rare rosewood species became the exclusive resource of the royal family (Zhu, 2017). With the recent return of Chinese traditional culture, the domestic demand for rosewood is increasing and rosewood is now considered synonymous with high-end furniture (United Nations Office on Drugs and Crime, 2016). Against the background of high demand for rosewood, trade limitation measures have led to highly dynamic shifts in supply and demand for rosewood. The investment demand for rosewood has been boosted, which has encouraged speculative rosewood trade (Zhu, 2020). Ultimately, huge, consecutive price bubbles have been generated.

We specifically investigate the formation mechanism of rosewood import price bubbles under supply constraints. In contrast to previous studies that primarily relied on statistical assessments, our utilization of econometric methods allows for a deeper analysis of the impact of restrictive trade policies on China's rosewood import prices. Further exploration on this topic could expand the research objects to all rosewood trading countries in the world so that we could investigate the effect of restrictive rosewood trade policies on global rosewood trade prices. Moreover, the research perspective could cover every link in global rosewood industry chain, including rosewood logging, transportation, processing and sales of finished products. This would assist us in conducting a more thorough study on the influence of restrictive rosewood trade policies.

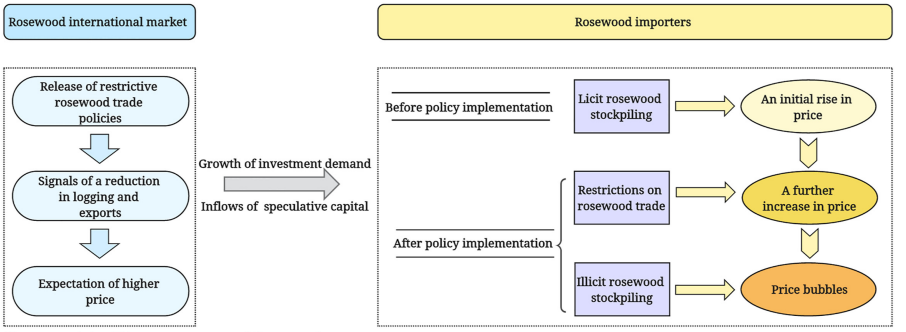


Figure 3.
The chain reaction caused by restrictive rosewood trade policies between rosewood international market and importers

Source(s): Figure created by authors

Note

1. Yuzhu International Timber Market: http://yz.yuzhuprice.com:8003/

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