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Impact of China's National Sword Policy on Waste Import Margins: A Difference-in-Differences Approach

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Abstract: As a major destination of waste products, China implemented the National Sword Policy (NSP) to regulate the high pollution of waste imports. The existing literature primarily focuses on the motivations behind China's waste imports and the policy implications of the NSP on China's waste imports and the global recycling market. This study innovatively focuses on the extensive, intensive, price, and quantity marginal effects of the NSP on China's waste imports using a difference-in-differences (DID) approach with 26 categories of waste products for 150 countries and regions from 2007 to 2021. The findings indicate that: (1) The NSP has led to declines in the intensive and quantity margins of regulated waste imports, while the price margin has increased. (2) In the years following the implementation of the NSP, the impacts continued to intensify. (3) The NSP has reduced the motivation for exporters to export highly polluting waste to China in search of a "Pollution Haven". (4) Orientations implementing policies that place the responsibility for products' environmental impact and encourage waste sorting can effectively alleviate the inhibitory effects of the NSP. These results suggest that the Chinese government needs to strengthen the control of high-polluting and low-value product imports. Waste-exporting countries should encourage enterprises to take responsibility for the entire lifecycle of products and promote waste sorting and treatment facilities. Enterprises should strengthen the environmental impact assessment of the entire product lifecycle and consider materials that are easy to sort and recycle.

Keywords: waste imports; National Sword Policy; difference-in-differences (DID); quantity margin; price margin

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1. Introduction

With sustained economic growth, the rapid generation of solid waste has become an important environmental issue. According to statistics, the world produces 7–10 billion tons of waste annually, of which approximately 10% is traded across borders through international trade, raising profound externalities [1]. The resource-hunting hypothesis suggests that there is a direct correlation between the wealth of a country and its per capita waste production, notably, more affluent developed countries generate more waste [2,3]. The recycling departments of developed countries are unable to fully digest the supply of these solid wastes, so they package and sell these wastes to developing countries [4]. The pollution haven hypothesis further reveals a trend whereby the international movement of solid waste tends to flow from countries with stricter environmental regulations to those with looser environmental regulations [4]. This trend has led to a 500% surge in the volume of transboundary waste trade over the past 30 years and has caused widespread concern on a global scale [1]. The transboundary movement of solid waste is not only a matter of environmental protection and public health but also a broader issue of sustainable resource utilization and global environmental justice [5–7].

Among developing countries, for decades, China has been one of the main destinations for solid waste recycling and disposal around the world, especially for developed countries.

In 2016, China's waste imports accounted for approximately 40% of the global waste markets [8]. Moreover, China's import of wastepaper and waste plastic accounts for a higher proportion globally [9]. Although using waste as a cheap intermediate input to meet the needs of domestic and international markets, China confronts persistent obstacles. These include the inefficiencies in waste management systems and the rampant issue of illegal waste trafficking, which pose significant challenges to the country's environmental and public health objectives [3,10].

Historically, China has been a party to the Basel Convention and has been actively involved in international hazardous waste management. But for non-hazardous wastes, China grappled with import wastes that were often of poor quality and highly polluting due to inadequate regulation and enforcement capabilities. In response, the Chinese government officially implemented the "Measures on the Administration of Import of Solid Waste" in August 2011. This regulation primarily dictates the licensing, supervision, and management of solid waste imports [11]. Between February and December 2013, Chinese customs authorities initiated an enforcement campaign known as Operation Green Fence (OGF) [12]. Its objective was to prevent the entry of illegal hazardous waste using stringent inspections and to limit the import of goods with pollution levels exceeding 1.5% of their permissible weight [13]. However, several studies indicate that the effects of OGF on China's waste imports were transient [9,13,14].

As an extension and intensification of OGF, the National Sword Policy (NSP) was launched by Chinese customs in February 2017, which involved enhanced scrutiny of imported waste [9]. In July of the same year, China officially notified the World Trade Organization (WTO) of its decision to ban the import of 24 types of solid waste [15]. The NSP imposed restrictions on the import of goods with pollution levels exceeding 0.5% of their weight allowance, thereby elevating the environmental standards for waste imports. This policy is widely seen as China's concrete response to the Basel Convention and contributes to the Plastic Waste Amendment adopted by the Accord in 2019. The implementation of the NSP resulted in a substantial reduction in the volume of waste imports by the Chinese government, which concurrently sought to bolster domestic waste recycling and processing capabilities. This shift signifies a pivotal development in China's approach to waste management and environmental protection, exerting a profound influence on the global waste trade landscape and the recycling industries of various nations.

The purpose of this study is to evaluate the impact of the NSP on changes in China's waste imports and to decompose this impact into quantity and price dimensions. By collecting data on waste product transactions between China and 150 exporting countries from 2007 to 2021 and using the difference-in-differences method to construct a quasi-natural model, we draw answers to the following questions: First, compared with unregulated waste imports, how does the NSP impact the margins of regulated waste imports? Second, how does the NSP impact exporters, especially high-income economies' motivation to export highly polluting waste to China in search of a "Pollution Haven"? Finally, how will the implementation of policies for exporters who are responsible for the environment impact the inhibitory effect of the NSP?

This study makes three major contributions. First, we constructed a quasi-natural experiment and empirically analyzed the impact of the NSP on the category, quantity, and price margins of Chinese imports for the first time. Second, we further confirm, based on Li et al. [3], that the NSP mainly suppresses the motivation of developed economies to seek a "Pollution Haven" for exporting highly polluting waste to China but does not affect China's access to intermediate input resources from developing economies. Third, we discussed the heterogeneity in national environmental policies and demonstrated that the waste market of economies that actively implement product environmental impacts and encourage waste classification and recycling policies will not be significantly impacted.

The rest of this paper is arranged as follows. Section 2 provides a brief literature review. Section 3 provides an overview that briefly describes the status of China's waste imports before and after the NSP. Section 4 discusses the methodology and the model specification in this study. In Sections 5 and 6, we discuss the empirical results, conduct robustness checks, and consider heterogeneity by region, national income, and national environmental policy. The final section concludes with some policy implications.

2. Literature Review

2.1. Global and Chinese Waste Import Motivation

This study reviews the literature on the determinants of global waste trade, expanding on traditional international trade theory, which typically emphasizes exporting country production capacity, importing country demand, and bilateral geographical distance. A review by Kellenberg [6] states that environmental regulations, industrial production, resource demand, and trade balance significantly influence waste trade. Early analyses of the flow of waste from developed to developing countries revealed that less stringent environmental policies correlate with higher waste imports in developing countries [16]. Drawing inspiration from the pollution haven hypothesis, Kellenberg [4] further explains this phenomenon using the waste haven hypothesis. From the perspective of the circular economy, Gregson et al. [17] define waste as a recyclable commodity that can be used as an input in industrial production. Some empirical studies have since demonstrated that developing countries' industrialization and economic expansion bolster their waste importation from developed countries [18]. In addition, Kellenberg [19] notes that since the 1990s, the divergence of global production and consumption has skewed international trade, impacting shipping logistics and creating uneven transportation costs. He states that the voluminous nature and low value of waste lead developing countries to fill empty cargo spaces on return voyages from developed countries with waste imports.

Over the recent decades, China has emerged as a leading importer of non-hazardous materials, not covered by the Basel Convention [20], for recycling and reuse in manufacturing [13]. China's dominance is evident in its once over 50% share of global wastepaper and waste plastic imports, underscoring its pivotal role in the international waste recycling and reuse market [9]. Li et al. [3] utilized a gravity model and panel data on 28 waste categories imported by China from 1995 to 2018 to analyze its drivers. Their findings suggest China's strategy to procure cost-effective intermediate goods from the global market, leading to substantial imports of scrap metal from developed nations and diverse waste types from developing countries. The research also indicates a "Pollution Haven" incentive for China's importation of waste plastics and textiles from advanced economies. After the global financial crisis, a suppressed international market curtailed China's industrial capacity and resource demand [3]. Consequently, the Chinese government has heightened scrutiny over the import and illegal trafficking of low-quality waste and its associated environmental hazards from inadequate sorting processes [1]. In response, China enacted the Measures on the Administration of Import of Solid Waste in 2011 and introduced the OGF and NSP policies in 2013 and 2017, respectively, which have constrained its access to international resources with stricter environmental regulations [3].

2.2. Policy Impact of China's Waste Import Ban

The second strand of the literature that relates to our study examines the effect of China's waste import ban. Balkevicius et al. [13] used a gravity model to assess the repercussions of OGF on the international waste trade, particularly analyzing the reduction in low-quality waste exports from developed nations to China. Utilizing the average unit value of waste as an indicator of quality, their findings indicated a 26% decrease in the influx of substandard waste into China post-OGF implementation. Furthermore, Balkevicius et al. [13] investigated the policy's indirect effects but found no evidence of low-quality waste diversion to other developing nations. Conversely, Sun [11] used a difference-in-differences approach, treating OGF as a quasi-experimental setup to probe its impact on China's waste import border enforcement. The study revealed a 9.48% increase in the volume of waste imports relative to other resources, accompanied by a 7.6% decline in their prices post-policy. These findings reflect China's pivotal role in the global secondary resource market and suggest that stringent waste import controls could precipitate an international waste surplus and depress import prices in China [11].

The NSP exerts a more pronounced and potentially enduring effect on the global waste trade compared with OGF, thus attracting significant scholarly attention [9]. Utilizing global trade data, Tran et al. [9] dissected the impact of the NSP on the waste trade, particularly in the plastic and paper sectors, through both intensive (price and share changes) and extensive (entry and exit changes) margins. Their findings indicate a marked reduction in China's waste imports, especially in terms of volume, with a modest uptick in import prices, primarily within the intensive margin. The NSP has also rerouted waste streams to lower- and middle-income nations in East Asia, the Pacific, Europe, and Central Asia. Lin et al. [21] applied a difference-in-differences approach and natural experiments to evaluate the NSP's influence on China's waste import prices. Analyzing trade interactions between China and 119 countries from 2015 to 2019, Lin distinguished between NSP-targeted waste types and other wastes. The results underscored a significant decrease in both the volume and unit price of NSP-regulated waste, attributing the change to trade suppression rather than quality shifts. Furthermore, a body of research has zoomed in on the NSP's sector-specific impacts on trade dynamics and environmental outcomes, with studies focusing on plastic waste [22–24], paper waste [25], and metal waste [26,27].

The NSP has redirected waste export flows from China to various regions, significantly affecting the global recycling industry. Studies have investigated the repercussions of the NSP across countries with varying income levels. Regarding high-income countries, Tran et al. [9] observed that Germany and the Netherlands have effectively adapted to increased waste imports due to their stringent environmental laws, efficient management, and sophisticated processing technologies. Conversely, the United States has seen a decline in plastic recycling and a rise in landfill use post-NSP, highlighting issues within its secondary materials market and recycling sector [14]. As a response, some European Union nations have adopted Extended Producer Responsibility (EPR) policies, which require producers to take more responsibility for their products throughout their life cycle, to increase the rate of return to utilization of product waste [28]. In low- and middle-income countries, particularly in Southeast Asia, some studies noted a dramatic influx of waste imports post-NSP, placing a strain on local recycling capacities [29,30]. These countries have since tightened import controls and introduced licensing frameworks. Further, Yoshida [31] uncovered a shift in China's waste plastics import strategy, moving from direct imports to sourcing recycled pellets from Southeast Asian nations. This shift has spurred growth in Southeast Asia's recycling and resource utilization sectors and led to increased processing costs for waste plastics.

A review of the literature indicates that the initial studies on the global waste trade were grounded in international trade theories, focusing on drivers such as environmental regulations, resource scarcity, and trade imbalances. Recent policy shifts in China have pivoted toward reducing the quantity and enhancing the quality of waste imports. Research findings are mixed regarding the effect of these policies on the unit price of imported waste. Some studies indicate that the NSP may lead to an oversupply in the global recycling market, potentially driving prices down. Conversely, others indicate that the NSP's stringent quality standards for imported waste could increase sorting costs for exporters, resulting in higher unit prices. Overall, the existing research indicates that China's restrictions on waste imports have had profound implications for both domestic and global waste trade dynamics, necessitating significant adjustments within the recycling industries of various economies.

3. Overview of China's Waste Import and Ternary Margins

3.1. China's Waste Import

At the end of 2001, China's accession to the WTO resulted in a significant increase in both the amount and quantity of waste imports [3]. The ensuing years witnessed a steady expansion in waste importation, culminating in an unprecedented zenith in 2011.

Nevertheless, the promulgation of the Solid Waste Import Management Measures in the same year heralded a persistent decline in total waste imports for six years. Intriguingly, this diminution was predominantly attributed to commodities exempt from NSP regulations, as the import value of NSP-regulated products remained relatively stable. The advent of the NSP in 2017 signaled a dramatic contraction in China's waste import volumes, persisting for four consecutive years. The NSP's regulatory grip was so effective that by 2018, the importation of regulated waste products had dwindled to negligible levels, as illustrated in Figure 1.

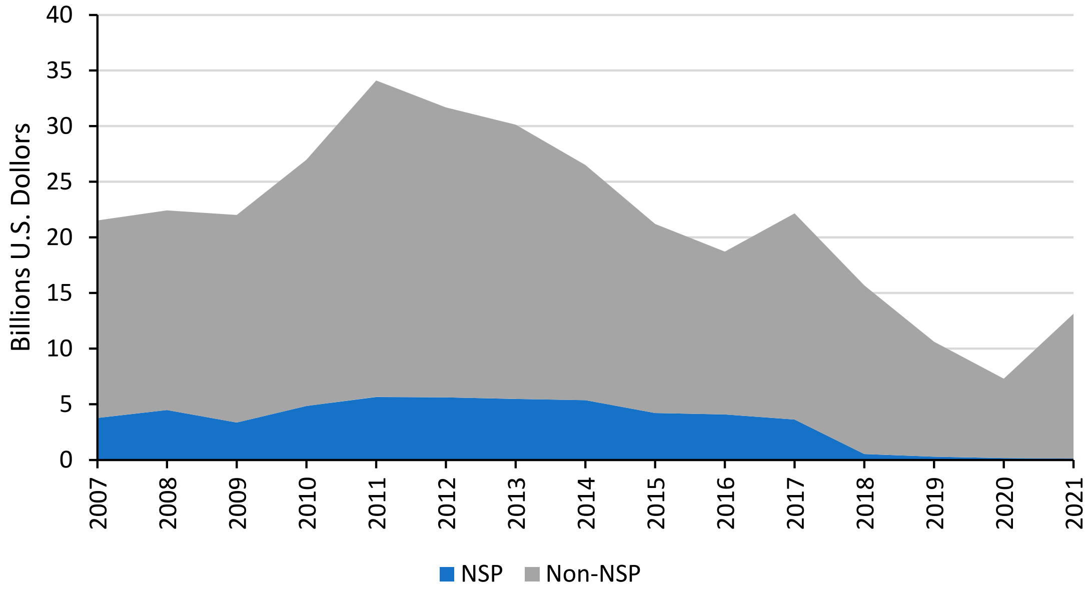

Figure 1. The total value of China's waste imports for 2007–2021 (Source: CEPII-BACI database).

Figure 2 describes the trajectory of China's waste import weights from 2007 to 2021. The general trend mirrors that of the total import volumes, with both metrics exhibiting a consistent pattern in most years. Post-2012, a gradual decline in total weight is observable. However, it was the NSP's enforcement in 2017 that catalyzed a significant downturn in the total weight of waste imports, with the weight of NSP-regulated waste plummeting to near zero in subsequent years.

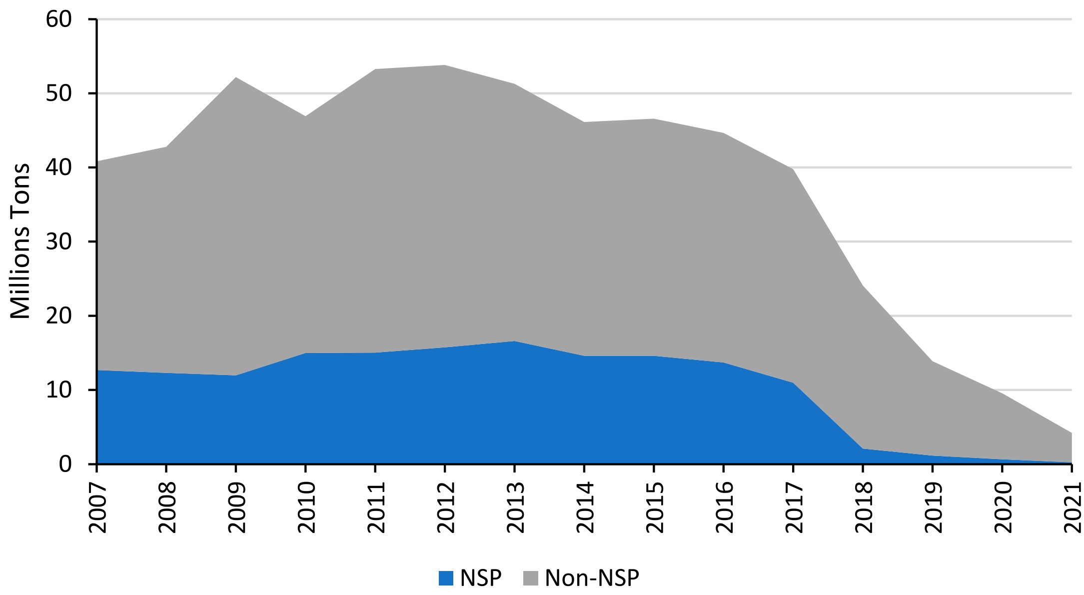

Figure 2. The total quantity of China's waste imports for 2007–2021 (Source: CEPII-BACI database).

3.2. Ternary Margins of China's Waste Import

To dissect the dynamics of China's shifting waste import patterns, we invoked the ternary margin concept from international trade theory. Drawing from the methodologies of Hummels and Klenow [32] and Shi [33], we quantified the intensive margin, extensive margin, quantity margin, and price margin of China's waste imports. As depicted in Figure 3, prior to 2017, the intensive margin, extensive margin, and quantity margin generally fluctuated in unison. The enactment of the NSP, however, precipitated a pronounced decline across these metrics, which only began to recover with the advent of the COVID-19 pandemic in 2020. Conversely, the price margin exhibited volatility up until the NSP's implementation, after which it embarked on a consistent upward trajectory.

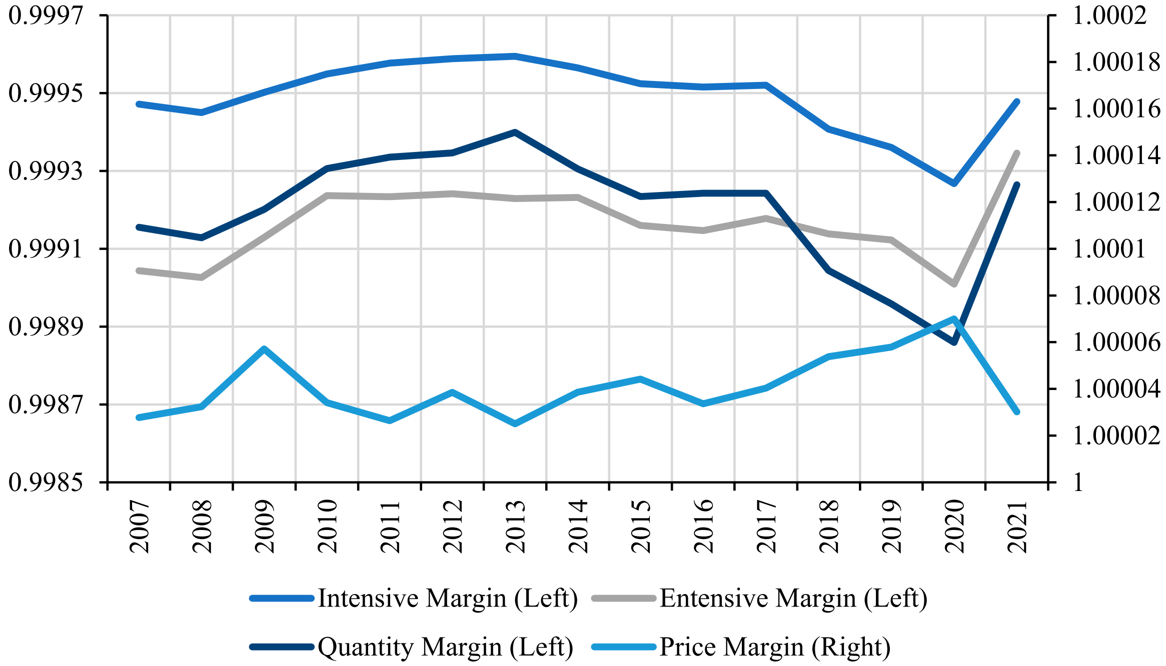

Figure 3. Ternary margins of China's waste imports for 2007–2021. (Source: CEPII-BACI database).

In summary, our analysis indicates a persistent downtrend in both the value and quantity of China's waste imports since 2011. Initially, this decline was primarily driven by a reduction in the import of waste products not subject to the NSP. Post-2017, the enforcement of the NSP has led to a marked diminution in the importation of NSP-regulated products, both in terms of value and quantity. Using the ternary margins concept to examine the impact of the NSP, we found significant contractions in the intensive margin, extensive margin, and quantity margin of waste imports. Concurrently, the price margin, previously characterized by its volatility, has entered a phase of steady increase.

4. Methodology and Data

4.1. Econometric Specification

According to Abudu [34], and Li [35], DID is a useful technique in environmental economics research. As an econometric method, it is used to study policy effects and helps to understand potential causality. This study used the DID method to investigate the impacts of China's National Sword Policy on the margins of China's waste imports. Following Hummels and Klenow [32] and Shi [33], this paper calculates the extensive margin ($lnEM_{jckt}$), intensive margin ($lnIM_{jckt}$), price margin ($lnPM_{jckt}$), and quantity margin ($lnQM_{jckt}$) on the HS2 level using HS6 level data. The waste products are listed in Table A3. The models are specified as follows:

$$lnEM_{jckt} = \alpha_1 + \beta_1 DID_{kt} + \gamma_1 C + I + \varepsilon_{jckt} \tag{1}$$

$$lnIM_{jckt} = \alpha_2 + \beta_2 DID_{kt} + \gamma_2 C + I + \mu_{jckt} \quad (2)$$

$$lnPM_{jckt} = \alpha_3 + \beta_3 DID_{kt} + \gamma_3 C + I + u_{jckt} \quad (3)$$

$$lnQM_{jckt} = \alpha_4 + \beta_4 DID_{kt} + \gamma_4 C + I + v_{jckt} \quad (4)$$

where EM_{jckt} represents the extensive margin of China's waste imports from country j, for the HS2 level category k at time t. IM_{jckt} represents the intensive margin of China's waste imports from country j for category k at time t. PM_{jckt} represents the price margin of China's waste imports from country j for category k at time t. QM_{jckt} represents the quantity margin of China's waste imports from country j for category k at time t. The extensive margin reflects the number of varieties of waste products that country j exports to China. The intensive margin represents the value of waste products of each variety. The intensive margin can be decomposed into the quantity margin and the price margin. The change in the intensive margin of waste imports can be decomposed into the change in the quantity of waste imports and the change in the price. The calculation methodology for the margins is presented in Appendix B. DID_{kt} is the dummy variable and equals one for category k, which includes the waste products regulated by China's NSP after the year the policy was promulgated. There are 6 categories of waste at the HS2 level including the products targeted by the policy.

In Equations (1)–(4), C denotes the vector of control variables. Following Sun [11] and Lin [21], this study includes the GDP, GDP per capita, trade openness, and nature resources of orientation country j. Following Balkevicius et al. [13] and Kellenberg [4], we also controlled whether the exporter has a free trade agreement with China. As pointed out by Li et al. [3] and Tran et al. [9], the trade on waste products is sensitive to the shipment cost, which will be influenced by "reverse haulage" logistics caused by empty containers on the "back-run" routes. China's trade surplus with exporter j is added into regressions. I denotes the fixed effects used in the model. In the baseline regressions, this research uses country, category, and year fixed effects. Country-category fixed effects are also included for a robustness check.

To investigate whether the environmental policies and governance of exporters will impact the waste trade, following Balkevicius et al. [13] and Li et al. [3], the empirical model is specified as follows:

$$lnMargin_{jckt} = \alpha_1 + \beta_1 DID_{kt} * EP_{jt} + \beta_2 DID_{kt} + \beta_3 EP_{jt} + +\gamma_1 C + I + \varepsilon_{jckt} \quad (5)$$

where $Margin_{jckt}$ is the same as that listed in Equations (1)–(4), including the extensive margin, intensive margin, quantity margin and price margin. EP_{jt} represents whether exporter j adopts environmental policies. Following Schroder [36], environmental policies can be classified into four categories. First, extended producer responsibility policies place the responsibility for the environmental impacts of products throughout the product life cycle on producers and are often applied to collection processing and the re-utilization of waste. Second, national circular economy policies involve any national circular economy policies already in place as well as national green growth or sustainable development strategies that integrate circular economy principles. Third, product policies support circular practices relating to the design, manufacture, distribution, or import of specific products and materials. Fourth, waste management recycling policies encourage circular practices relating to the management of waste covering generation, segregation, transfer, sorting, treatment, recovery, and disposal. $DID_{kt} * EP_{jt}$ captures exporters' environmental regulatory impact on the waste's export restricted by China.

China's waste products are imported from various countries. We also classify the orientation countries into high-income countries and middle- and low-income countries following Tran et al. [9] and the World Bank [37].

4.2. Data and Descriptions of Variables

This study utilizes 26 categories of waste products at the HS2 level according to Kellenberg [4], 6 of which are restricted by China's NSP. Due to the availability of data, we excluded some countries and regions with significant data gaps and constructed the panel dataset including 150 countries and regions from 2007 to 2021. Data for the independent variables were updated to 2021 and came from the CEPII-BACI database, which is usually updated with a lag of two years. All numerical variables, except the dummy variables, were logarithmically treated to avoid the problem of heteroscedasticity. Table 1 presents the data sources and descriptions of variables. The summary statistics of variables identified in Table 1 are presented in Table A1.

Table 1. Data sources and descriptions of variables.

Variable Name	Description	Data Source
	Explained variables	
$lnEM_{jckt}$	Log of extensive margin for country j's export to China at time t for category k.	CEPII-BACI Database
$lnIM_{jckt}$	Log of intensive margin for country j's export to China at time t for category k.	CEPII-BACI Database
$lnPM_{jckt}$	Log of price margin for country j's export to China at time t for category k.	CEPII-BACI Database
$lnQM_{jckt}$	Log of quantity margin for country j's export to China at time t for category k.	CEPII-BACI Database
	Key variable	
DID_{kt}	$DID_{kt} = NSP_k * Time_t$, where NSP_k represents category k involving the 24 types of waste products regulated by China's National Sword Policy. $Time_t$ equals to one for the year 2018 and thereafter, which is the year the policies were enforced.	Ministry of Ecology and Environmental of the PRC
	Control variables	
$lnGDP_{jt}$	Log of country j's GDP at time t.	World Bank WDI
$lnGDPcap_{jt}$	Log of country j's GDP per capital time t.	World Bank WDI
$tradesurplus_{jt}$	China's trade surplus with country j at time t.	CEPII-BACI Database
$lntradeopen_{jt}$	Log of county j's trade openness at time t.	World Bank WDI
FTA_{jt}	Dummy variable that equals one if country j has a free trade agreement with China.	WTO Database
$lnresource_{jt}$	Log of country j's total natural resource rents divided by GDP at time t.	World Bank WDI
	Environmental policies	
EPR_{jt}	Dummy variable that equals one if country j adopts policies that place the responsibility for the environmental impacts of products throughout the product life cycle on producers and is often applied to the collection, processing, and re-utilization of waste at time t.	Chatham House
$Circular_{jt}$	Dummy variable that equals one if country j adopts national circular economy policies as well as national green growth or sustainable development strategies that integrate circular economy principles at time t.	Chatham House

Table 1. *Cont.*

Variable Name	Description	Data Source
$Product_{jt}$	Dummy variable that equals one if country *j* adopts policies that support circular practices relating to the design, manufacture, distribution, or import of specific products and materials at time *t*.	Chatham House
$Waste_{jt}$	Dummy variable that equals one if country *j* adopts policies that encourage circular practices relating to the management of waste covering generation, segregation, transfer, sorting, treatment, recovery, and disposal.	Chatham House

5. Results

To satisfy the parallel trend assumption of the difference-in-differences methodology, following Sun [11], we performed a parallel trend test. The results are plotted in Figure 4. For the estimations in pre-periods, zero is located within a 95% confidence interval, indicating that the variance between the control group and treatment group are insignificant before the NSP and the trends for these two groups are parallel before the regulation. The results fail to reject the parallel trends in the pre-period, suggesting that the DID methodology's assumption is satisfied.

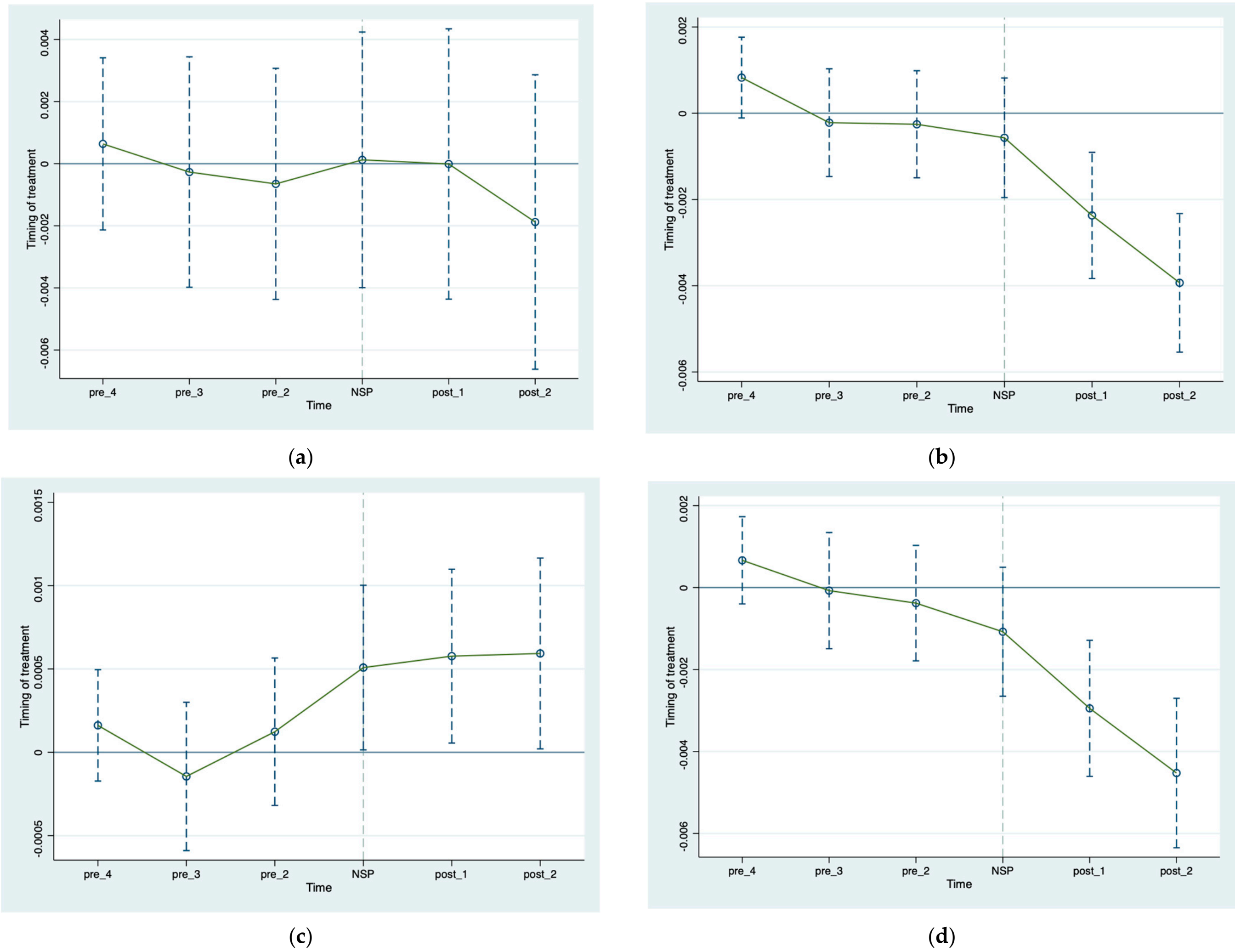

Figure 4. Parallel test for the extensive margin, intensive margin, price margin, and quantity margin. (**a**) EM, (**b**) IM, (**c**) PM, and (**d**) QM.

Table 2 presents the baseline results of Equations (1)–(4). Columns (1)–(4) show the country, category, and year fixed effects controlled. The coefficients show that the intensive margin and quantity margin declined. The price margin increased after China's NSP was implemented. However, there was no significant impact on the extensive margin. These results suggest that the import value of the waste categories regulated by China's environmental policies declined. The decline in import value can be decomposed into a relatively large drop in the quantity of waste product imports and a relatively small increase in price. The decline in quantity is caused by restrictions on China's waste product imports. After China's NSP, exporters must pay extra costs for waste sorting; hence, the prices for the categories regulated by the NSP increased. Overall, the drop in quantity outweighs the rise in price. For more restricted control of the fixed effects, we used country–category fixed effects, which capture characteristics of the countries' waste product supply as a robustness check. The results are presented in Columns (5)–(8) of Table 2. Compared with Columns (1)–(4), the results are consistent.

Table 2. Baseline results.

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM	(5) lnEM	(6) lnIM	(7) lnPM	(8) lnQM
DID_{kt}	−0.0008	−0.0020 ***	0.0003 **	−0.0022 ***	0.0007	−0.0026 ***	0.0004 ***	−0.0030 ***
	(−0.7454)	(−2.9526)	(2.0207)	(−3.1244)	(1.6036)	(−6.6832)	(3.2128)	(−6.9015)
$lnGDP_{jt}$	−0.0018	−0.0024	−0.0010	−0.0014	−0.0035 *	−0.0028	−0.0011 *	−0.0016
	(−0.3575)	(−0.8174)	(−1.5955)	(−0.4431)	(−1.7143)	(−1.6103)	(−1.8665)	(−0.8365)
$lnGDPcap_{jt}$	0.0006	0.0015	0.0012 *	0.0004	0.0024	0.0021	0.0013 **	0.0008
	(0.1179)	(0.4887)	(1.7548)	(0.1081)	(1.0935)	(1.1636)	(1.9967)	(0.4016)
$tradesurplus_{jt}$	−0.0006	0.0004	−0.0000	0.0005	0.0009	0.0009	−0.0000	0.0009
	(−0.1714)	(0.2294)	(−0.0731)	(0.2263)	(0.6555)	(0.7901)	(−0.0377)	(0.7089)
$lntradeopen_{jt}$	−0.0005	0.0001	−0.0001	0.0002	−0.0006	0.0002	−0.0001	0.0003
	(−0.2912)	(0.1092)	(−0.3228)	(0.1641)	(−0.7812)	(0.2841)	(−0.3632)	(0.3643)
FTA_{jt}	0.0003	0.0000	−0.0002	0.0002	−0.0002	−0.0001	−0.0002	0.0001
	(0.2326)	(0.0473)	(−0.8465)	(0.2095)	(−0.3391)	(−0.2037)	(−0.8593)	(0.0892)
$lnresource_{jt}$	0.0015	−0.0001	−0.0001	−0.0001	0.0010 **	−0.0003	−0.0001	−0.0002
	(1.4219)	(−0.2133)	(−0.4455)	(−0.1099)	(2.4775)	(−0.7707)	(−0.5935)	(−0.4942)
Constant	0.0306	0.0412	0.0171	0.0241	0.0601 *	0.0463	0.0194 *	0.0269
	(0.3521)	(0.7986)	(1.5617)	(0.4324)	(1.6931)	(1.5498)	(1.8334)	(0.7934)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	No	No	No	No
Category FE	Yes	Yes	Yes	Yes	No	No	No	No
Country–category FE	No	No	No	No	Yes	Yes	Yes	Yes
Obs.	3038	3038	3038	3038	2983	2983	2983	2983
R-square	0.3944	0.3724	0.0687	0.3670	0.9086	0.8100	0.2096	0.7897

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

Acknowledging the possible unobservable factors in the pre-period, and following Chetty et al. [38], this research conducts a counterfactual estimation using a placebo test as a robustness check. We randomly drew fake treatment groups using fake policy time and fake categories 500 times without repeat. Then, we performed the baseline regressions again with the fake treatment groups, and the 500 fake coefficients are presented in Figure 5.

To further overcome possible confounding bias, following Giang et al. [39], this paper uses the propensity score matching–difference-in-differences (PSM-DID) methodology as a robustness check. The results are presented in Table 3.

The results in Table 3 are relatively robust with the Columns (5)–(8) in Table 2. The extensive margin exhibits a weak positive impact but is only significant at the 10% level. The impacts on the intensive margin, price margin, and quantity margin are consistent.

From the results provided, China's NSP significantly reduces the import value for the waste categories involving waste products targeted by the policy. The import price increased slightly due to extra waste sorting costs caused by the regulations. On another hand, the quantity of regulated waste product imports dropped significantly, which led to a decline in the intensive margin. China's NSP's impacts mainly affect the intensive margin of China's waste product imports, which is consistent with Tran et al. [9].

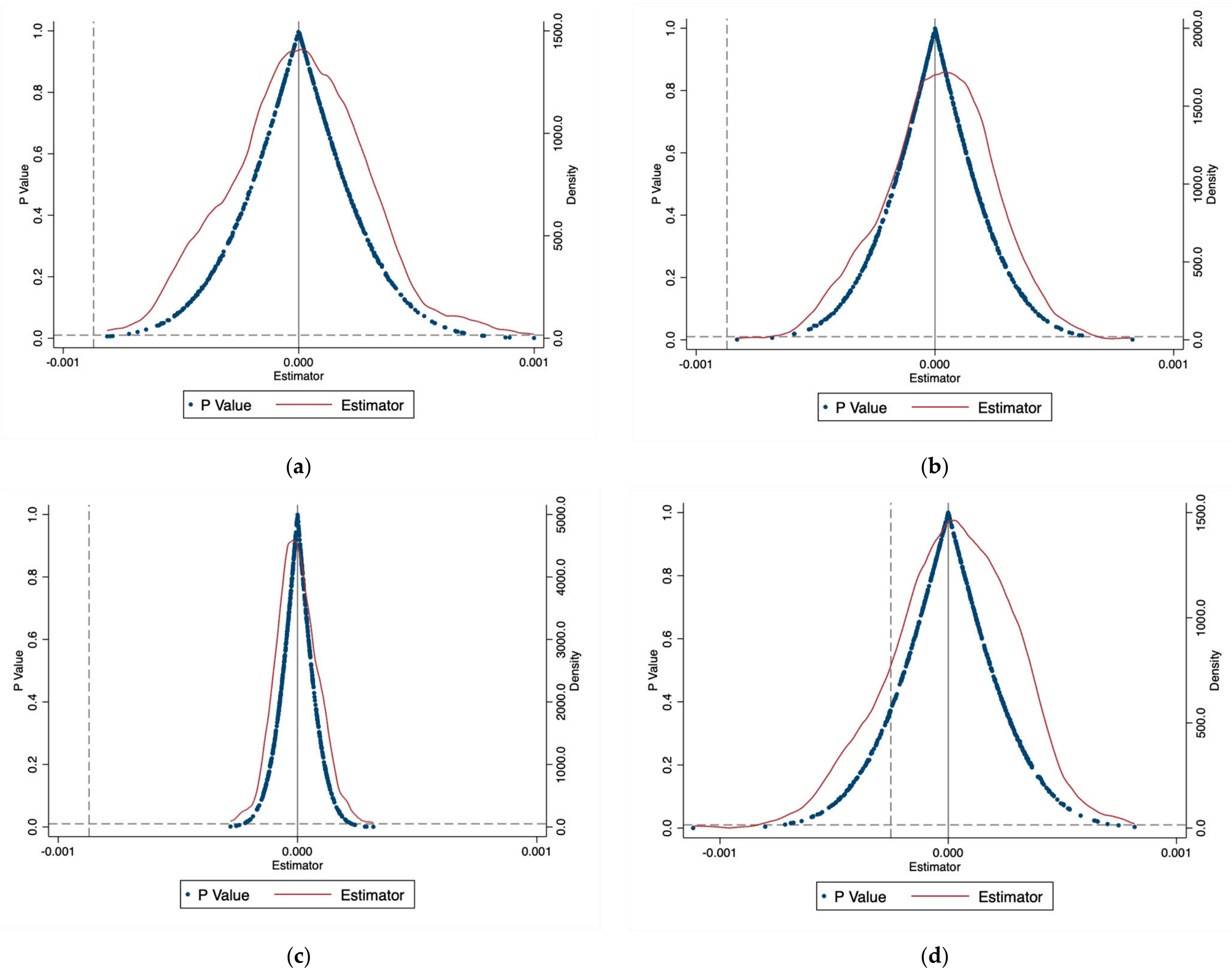

Figure 5. Placebo test for the extensive margin, intensive margin, price margin, and quantity margin. (**a**) EM, (**b**) IM, (**c**) PM, and (**d**) QM.

Table 3. PSM-DID for the baseline regressions.

	(1) EM-PSM	(2) IM-PSM	(3) PM-PSM	(4) QM-PSM
DID_{kt}	0.0009 *	−0.0027 ***	0.0005 ***	−0.0031 ***
	(1.8713)	(−6.5224)	(3.1436)	(−6.7376)
Constant	0.0667 *	0.0491	0.0212 *	0.0279
	(1.7011)	(1.4888)	(1.8120)	(0.7461)
Control variables	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country–category FE	Yes	Yes	Yes	Yes
Obs.	2800	2800	2800	2800
R-square	0.9081	0.8087	0.2061	0.7882

T statistics are in parentheses. ***, and * denote significance at 1%, and 10%, respectively. Robust standard errors are corrected.

6. Further Discussions

In this section, we study the NSP's impact on the trend in the margins of waste imports first. Then, we investigate the heterogeneous effects of the NSP on orientations with different economic development. Finally, we research the exporters' domestic environmental policies' impacts on the inhibitory effect of the NSP.

To investigate the trend in the margins of China's waste product imports after the NSP was implemented, this research involves interaction terms between the waste categories regulated by the NSP and the year dummy variable from 2016 to 2020. The estimation results are presented in Table 4. In the year 2018, which is the first year after the NSP was implemented, there existed a significant decline in the intensive margin and quantity margin and a rise in the price margin. The magnitude of the decrease in the quantity margin was larger than the increase in the price margin. These results are consistent with Table 2. In the following years, the rise in price remained almost the same as in 2018. However, the decline in the quantity margin and the intensive margin expanded. This pattern implies that China's NSP reduced the import quantity of the targeted waste products efficiently. The impacts intensified in the following years, which is consistent with Figures 1 and 2.

Table 4. Trends in the margin of waste product imports after the NSP was implemented.

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
$NSP_k * \text{time2016}$	−0.0013 **	−0.0009 *	0.0000	−0.0009 *
	(−2.3134)	(−1.7624)	(0.0106)	(−1.7331)
$NSP_k * \text{time2017}$	−0.0008	−0.0007	−0.0001	−0.0006
	(−1.4281)	(−1.4819)	(−0.7424)	(−1.0732)
$NSP_k * \text{time2018}$	−0.0001	−0.0013 **	0.0004 *	−0.0017 **
	(−0.0912)	(−2.2097)	(1.8822)	(−2.5386)
$NSP_k * \text{time2019}$	0.0009	−0.0031 ***	0.0005 **	−0.0035 ***
	(1.2740)	(−4.9736)	(2.0421)	(−5.0251)
$NSP_k * \text{time2020}$	0.0009	−0.0046 ***	0.0005 *	−0.0051 ***
	(1.1126)	(−6.5923)	(1.8589)	(−6.3944)
Constant	0.0560	0.0473	0.0192 *	0.0281
	(1.5759)	(1.5858)	(1.8070)	(0.8306)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	2983	2983	2983	2983
R-square	0.9087	0.8112	0.2086	0.7907

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

Table 5 presents the estimation results for different types of exporters categorized by income level. Following Tran et al. [9] and the World Bank [37], this paper separates orientations of waste products into high-income countries and middle- and low-income countries. The categories of countries and regions are listed in Table A2. The coefficients for the high-income countries group are consistent with the baseline results. There are negative impacts on the intensive margin and the quantity margin and a relatively small positive impact on the price margin. However, for middle- and low-income countries, all the coefficients are insignificant.

The results imply that China's NSP primarily focused on waste products with relatively high pollution levels from high-income countries. The impacts of waste product imports from middle- and low-income countries are insignificant. This conclusion is consistent with Li et al. [3]. The motivation for China to import waste products from developing countries is mainly focused on searching for resources as intermediate inputs. However, there are "Pollution Haven" motives for developed economies to export high-pollution-level waste products to China, especially for sectors such as waste plastics, which is one of the important categories regulated by China's NSP.

Following Tran et al. [9], we also separated countries and regions based on geographic location. The results are presented in Tables A4–A6. The findings indicate that the NSP mainly impacted the waste product imports from North America, Europe, and Central Asia, which are relatively high-income regions. These results are consistent with Table 5.

Table 5. The NSP's impact on different types of countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High-Income Countries				Middle- and Low-Income Countries			
	lnEM	lnIM	lnPM	lnQM	lnEM	lnIM	lnPM	lnQM
DID_{kt}	−0.0008	−0.0028 ***	0.0005 **	−0.0033 ***	−0.0001	−0.0000	−0.0001	0.0001
	(−0.5090)	(−2.7812)	(2.4052)	(−3.0448)	(−0.2902)	(−0.4368)	(−1.2295)	(0.5342)
Constant	0.0732	0.0627	0.0224	0.0403	−0.0160	0.0140	0.0069	0.0071
	(0.5489)	(0.7873)	(1.3460)	(0.4694)	(−0.5867)	(1.5092)	(0.7084)	(0.4868)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1827	1827	1827	1827	1209	1209	1209	1209
R-square	0.4316	0.4083	0.0983	0.4052	0.3678	0.2904	−0.0309	0.1696

T statistics are in parentheses. ***, and ** denote significance at 1%, and 5%, respectively. Robust standard errors are corrected.

Tables 6–9 depict the orientations' domestic environmental policies and governance's influences on the impacts of China's NSP. In Table 6, the coefficients of DID_{kt} are consistent with the main results. The interaction terms suggest that exporters adopt policies that place the responsibility for products' environmental impact, the waste products from which tend to have relatively lower pollution levels. This implies that they are less likely to be restricted by China's NSP. The positive impacts on the intensive margin and the quantity margin imply that the impacts of the NSP can be alleviated compared with the orientations without policies placing the responsibility for products' environmental impacts.

Table 6. Impact of the NSP on countries that adopt policies that place the responsibility for products' environmental impacts.

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
$DID_{kt} * EPR_{jt}$	0.0015 **	0.0025 ***	−0.0002	0.0027 ***
	(2.1444)	(4.0831)	(−1.0506)	(3.9308)
DID_{kt}	−0.0002	−0.0043 ***	0.0006 ***	−0.0049 ***
	(−0.3221)	(−7.7428)	(3.0137)	(−7.7754)
EPR_{jt}	−0.0005	−0.0006	−0.0001	−0.0005
	(−0.7769)	(−1.2002)	(−0.6516)	(−0.8533)
Constant	0.0587	0.0314	0.0324 *	−0.0010
	(0.9795)	(0.5862)	(1.6969)	(−0.0170)
Control Variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	2401	2401	2401	2401
R-square	0.9160	0.8109	0.2097	0.7903

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

Results from Table 7 also indicate that exporters with policies relating to waste segregation and sorting can reduce the negative impacts of China's NSP. For the countries without waste sorting policies, exporters must pay extra sorting costs, which led to a rise in the price margin after China's NSP was implemented. The countries with waste sorting policies already cover the sorting cost ahead. The waste product prices almost remained the same after 2017. Thus, the coefficients for the interaction term for the price margin are significantly negative for the countries with waste sorting compared with the countries without. The positive coefficients for the intensive margin and the quantity margin also indicate that waste sorting policies can reduce the negative impacts of China's NSP.

Table 7. Impacts of the NSP on countries that adopt policies that encourage circular practices relating to waste segregation and sorting.

	(5) lnEM	(6) lnIM	(7) lnPM	(8) lnQM
$DID_{kt} * Waste_{jt}$	0.0023 ***	0.0043 ***	−0.0006 **	0.0049 ***
	(2.7922)	(5.7251)	(−2.1644)	(5.7322)
DID_{kt}	−0.0013	−0.0065 ***	0.0009 ***	−0.0074 ***
	(−1.5802)	(−8.5708)	(3.4912)	(−8.6606)
$Waste_{jt}$	−0.0005	−0.0006 *	−0.0001	−0.0005
	(−1.2368)	(−1.7557)	(−0.9849)	(−1.2376)
Constant	0.0686	0.0462	0.0337 *	0.0125
	(1.1662)	(0.8805)	(1.7929)	(0.2107)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	2401	2401	2401	2401
R-square	0.9161	0.8123	0.2114	0.7921

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

Table 8. Impact of the NSP on countries that adopt national circular economy policies and sustainable development strategies.

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
$DID_{kt} * Circular_{jt}$	0.0025 ***	−0.0020 ***	0.0003	−0.0023 ***
	(3.3834)	(−2.9048)	(1.4451)	(−3.0142)
DID_{kt}	−0.0008	−0.0020 ***	0.0003	−0.0023 ***
	(−1.1846)	(−3.5050)	(1.5221)	(−3.5674)
$Circular_{jt}$	−0.0008 *	0.0011 ***	0.0003 **	0.0008 *
	(−1.7045)	(2.7181)	(2.1203)	(1.7319)
Constant	0.0585	0.0715	0.0297	0.0417
	(0.9919)	(1.3497)	(1.5791)	(0.6950)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	2401	2401	2401	2401
R-square	0.9162	0.8103	0.2132	0.7897

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

Table 8 suggests that countries with circular economy policies and sustainable development strategies will export a lower value and quantity of waste products compared with the countries without these strategies after the NSP. For economies with circular economy policies, waste products generated will be recycled domestically first. The waste products that can be utilized as resources will be reused within orientations. The leftover waste products have either a high level of pollution or no value for recycling. These waste products are more likely to be restricted by China's NSP. The results indicate that China's NSP can reduce orientation's waste exports with the motive of searching for a "Pollution Haven", which is consistent with Li et al. [3].

Table 9 depicts similar effects as Table 8. Countries with circular practices relating to product design and manufacturing are more likely to recycle waste products domestically and export waste products with less value or higher levels of pollution, which are restricted by China's NSP. Hence, the negative impacts on the intensive margin and quantity are more intensified. These results imply that China's NSP can reduce the import of high-pollution waste products efficiently.

Table 9. Impacts of the NSP on countries that adopt policies that support circular practices relating to design and manufacturing.

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
$DID_{kt} * Product_{jt}$	0.0005	−0.0012 **	0.0004 *	−0.0016 **
	(0.7507)	(−1.9804)	(1.7341)	(−2.2915)
DID_{kt}	0.0002	−0.0023 ***	0.0002	−0.0025 ***
	(0.3366)	(−3.8186)	(1.1612)	(−3.7334)
$Product_{jt}$	−0.0006	0.0006 *	−0.0000	0.0007 *
	(−1.5141)	(1.8050)	(−0.2676)	(1.6764)
Constant	0.0808	0.0599	0.0298	0.0301
	(1.3600)	(1.1238)	(1.5721)	(0.4979)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	2401	2401	2401	2401
R-square	0.9159	0.8099	0.2101	0.7895

T statistics are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively. Robust standard errors are corrected.

In general, China's NSP reduced the quantity and value of high-pollution waste product imports efficiently. The impacts were sustained in the following years after the policy was implemented. The restrictions reduced exporters' motive to export high-pollution waste products to China in search of a "Pollution Haven", especially for developed economies. Regarding developing economies, China imports waste products as a resource for intermediate inputs, which is insignificantly impacted by the NSP. For countries adopting policies that place the responsibility for products' environmental impact and encourage waste sorting, the negative impacts of the NSP on waste product export to China can be alleviated.

7. Conclusions and Policy Implications

In the past, China was always an important participant in the global waste market. The implementation of the NSP has brought significant changes to China's waste imports. This study used the difference-in-differences method and waste product transaction data between China and 150 countries and regions from 2007 to 2021 to evaluate the marginal changes in China's waste imports and quantify the impact of the NSP on China's waste imports. This study further discusses the heterogeneous effects from the perspectives of the income levels, regions, and environmental policies of exporting countries. The main research conclusions are as follows:

First, the implementation of the NSP has led to a significant decrease in the intensive and quantity margins of regulated waste imports, while the price margin has significantly increased. This conclusion is supported by a series of robustness tests.

Second, in the years following the implementation of the NSP, the impact of the NSP on the marginal import of waste products continued to intensify, leading to a decrease in the intensive and quantity margins, as well as an increase in the price margin.

Third, the NSP has reduced the motivation for exporters to export highly polluting waste to China in search of a "pollution haven". Waste exports from high-income countries, as well as North America, Europe, and Central Asia, have been significantly affected by the NSP.

Finally, implementing EPR or encouraging waste sorting and recycling policies in exporting countries can effectively alleviate the inhibitory effect of the NSP on their waste exports.

Based on the above conclusions, the policy implications are as follows:

First, the Chinese government needs to strengthen the control of imported waste, especially for high-polluting and low-value products, to ensure that they meet environmental standards. At the same time, China should support the development of a circular economy, encourage domestic waste treatment and recycling, and promote the design of environmentally friendly products.

Second, waste-exporting countries, especially developed countries, can strengthen their supervision of enterprises, promote the implementation of product liability systems, and encourage enterprises to take responsibility for the entire lifecycle of products. At the same time, exporting countries should invest in and promote the construction of waste sorting and treatment facilities, improve the reuse rate of waste, and reduce waste exports to the international market.

Third, enterprises should strengthen the environmental impact assessment of the entire product lifecycle and consider materials that are easy to sort and recycle during the design phase to reduce the difficulty and cost of waste disposal and improve reuse efficiency.

This study has some limitations. First, limited by the availability of more detailed waste import data, we failed to focus on the heterogeneous impacts of the NSP on different categories of waste such as metals, plastics, textiles, and wood. Second, this study only focuses on the short-term impact of the NSP on China's waste imports and does not address the long-term impact of the policy on changes in waste imports globally, especially in developing countries.

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Appendix A

Table A1. Summary statistics.

Name	Obs	Mean	SD	Min	Max
$lnEM_{jckt}$	3242	−0.0033	0.0123	−0.2198	0.0000
$lnIM_{jckt}$	3242	−0.0018	0.0073	−0.1299	0.0000
$lnPM_{jckt}$	3242	0.0002	0.0013	−0.0128	0.0183
$lnQM_{jckt}$	3242	−0.0020	0.0078	−0.1392	0.0000
DID_{kt}	3242	0.0793	0.2702	0.0000	1.0000
$lnGDP_{jt}$	3203	19.4200	1.8746	12.4328	23.8586
$lnGDPcap_{jt}$	3203	2.6731	1.2508	−0.9702	4.7339
$tradesurplus_{jt}$	3242	0.0099	0.1293	−0.7691	0.8752
$lntradeopen_{jt}$	3162	4.3679	0.6127	0.3205	6.0927
FTA_{jt}	3239	0.1973	0.3980	0.0000	1.0000
$lnresource_{jt}$	3138	1.0501	1.0266	0.0000	4.1734
EPR_{jt}	2549	0.4464	0.4972	0.0000	1.0000
$Circular_{jt}$	2549	0.1565	0.3634	0.0000	1.0000
$Product_{jt}$	2549	0.4323	0.4955	0.0000	1.0000
$Waste_{jt}$	2549	0.6516	0.4765	0.0000	1.0000

SD, standard deviation.

Table A2. List of economies.

Region	High Income	Low and Middle Income
East Asia and Pacific	Australia, Brunei Darussalam, French Polynesia, Hong Kong SAR, Japan, Korea Rep., Macao SAR, New Caledonia, New Zealand, Palau, Singapore	Cambodia, Indonesia, Lao PDR, Malaysia, Mongolia, Myanmar, Papua New Guinea, Philippines, Rep. of Korea DPR, Solomon Islands, Thailand, Tonga, Vietnam
Europe and Central Asia	Austria, Belgium, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom	Albania, Azerbaijan, Belarus, Bosnia Herzegovina, Bulgaria, Georgia, Greece, Kazakhstan, Kyrgyzstan, Romania, Russian Federation, Serbia, Macedonia, Turkmenistan, Turkey, Ukraine, Uzbekistan
Latin America and the Caribbean	Aruba, Bahamas, Barbados, Chile, Panama, Trinidad and Tobago, Uruguay	Antigua and Barbuda, Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominica, Dominican Rep., Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Paraguay, Peru, St. Lucia, St. Vincent and the Grenadines, Suriname, Venezuela
Middle East and North Africa	Bahrain, Israel, Kuwait, Malta, Oman, Qatar, Saudi Arabia, United Arab Emirates	Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, Yemen
North America	Canada, United States	-
South Asia	-	Afghanistan, Bangladesh, India, Pakistan, Sri Lanka
Sub-Saharan Africa	Mauritius	Benin, Cameroon, Congo, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritania, Mozambique, Namibia, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Togo, Uganda, Tanzania, Zambia

Source: Tran et al. [9] and the World Bank [37].

Table A3. List of 6-digit HS codes for waste products.

Categories	Waste Products Banned by the NSP	Other Waste Products
Waste mineral	261900, 262011, 262019, 262021, 262029, 262030, 262040, 262060, 262091, 262099	251720, 252530, 261900, 262110
Waste chemical	-	300692, 382510, 382530, 382541, 382549, 382550, 382561, 382569
Waste plastic	391510, 391520, 391530, 391590	400400, 411520
Waste wood	470790	450190, 470710, 470720, 470730
Waste textile	510310, 510320, 510330, 520210, 520299, 550510, 550520	500300, 510400, 520291, 631010, 631090
Waste metal	-	711230, 711299, 720410, 720421, 720429, 720430, 720441, 720449, 740400, 750300, 760200, 780200, 790200, 800200, 810197, 810297, 810330, 810420, 810530, 810730, 810830, 810930, 811020, 811213, 811222, 811252, 811300, 854810

Source: Kellenberg [4] and Lin et al. [21].

Table A4. The NSP's impact on different types of regions (North America).

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
DID_{kt}	−0.0072	−0.0236 ***	0.0030 **	−0.0265 ***
	(−0.5765)	(−3.0477)	(2.1174)	(−3.3096)
Constant	−10.4648	−7.1863	−0.4113	−6.7750
	(−0.4713)	(−0.5222)	(−0.1654)	(−0.4749)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	145	145	145	145
R-square	0.5939	0.5403	0.0846	0.5378

T statistics are in parentheses. ***, and ** denote significance at 1%, and 5%, respectively. Robust standard errors are corrected.

Table A5. The NSP's impact on different types of regions (Europe and Central Asia).

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
DID_{kt}	0.0008	−0.0011 ***	0.0003 *	−0.0014 ***
	(0.9432)	(−2.6611)	(1.7532)	(−2.6655)
Constant	0.0648	0.0011	−0.0144	0.0155
	(0.5537)	(0.0202)	(−0.6307)	(0.2223)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	1184	1184	1184	1184
R-square	0.4147	0.5812	0.1452	0.5243

T statistics are in parentheses. ***, and * denote significance at 1%, and 10%, respectively. Robust standard errors are corrected.

Table A6. The NSP's impact on different types of regions (the rest of the world).

	(1) lnEM	(2) lnIM	(3) lnPM	(4) lnQM
DID_{kt}	0.0003	0.0000	0.0000	−0.0000
	(0.3206)	(0.0438)	(0.2041)	(−0.0145)
Constant	0.0372	0.0102	0.0414 ***	−0.0311
	(0.6120)	(0.2486)	(3.3579)	(−0.6391)
Control variable	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country-HS2 FE	Yes	Yes	Yes	Yes
Obs.	1708	1708	1708	1708
R-square	0.5158	0.3141	0.0671	0.2953

T statistics are in parentheses. *** denote significance at 1%. Robust standard errors are corrected.

Appendix B

Following Hummels and Klenow [32] and Shi [33], we calculate the extensive margin, intensive margin, price margin, and quantity margin for China's waste imports in sequence.

$$EM_{jckt} = \frac{\sum_{i \in k_{jc}} (Q_{wcit} * P_{wcit})}{\sum_{i \in k_{wc}} (Q_{wcit} * P_{wcit})} \tag{A1}$$

where j represents exporting country j, c represents China as the importer, and i represents a waste product on the HS6 level that belong to the HS2 level category k. Q_{wcit} represents the quantity of waste product i that the world exports to China at time t. P_{wcit} represents the price of waste product i that the world exports to China at time t.

$$IM_{jckt} = \frac{\sum_{i \in k_{jc}} (Q_{jcit} * P_{jcit})}{\sum_{i \in k_{jc}} (Q_{wcit} * P_{wcit})} \tag{A2}$$

where Q_{jcit} represents the quantity of waste product i that country j exports to China at time t. P_{jcit} represents the price of waste product i that country j exports to China at time t.

$$PM_{jckt} = \prod_{i \in k_{jc}} \left(\frac{P_{jcit}}{P_{wcit}} \right)^{\omega_{jcit}} \tag{A3}$$

$$QM_{jckt} = \prod_{i \in k_{jc}} \left(\frac{Q_{jcit}}{Q_{wcit}} \right)^{\omega_{jcit}} \tag{A4}$$

where $\omega_{jcit} = \frac{\frac{s_{jcit} - s_{wcit}}{lns_{jcit} - lns_{wcit}}}{\sum_{i \in k_{jc}} \frac{s_{jcit} - s_{wcit}}{lns_{jcit} - lns_{wcit}}}$, $s_{jcit} = \frac{Q_{jcit} * P_{jcit}}{\sum_{i \in k_{jc}} (Q_{jcit} * P_{jcit})}$, $s_{wcit} = \frac{Q_{wcit} * P_{wcit}}{\sum_{i \in k_{jc}} (Q_{wcit} * P_{wcit})}$.

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