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What Drives the Global Waste Trade? Pollution Haven or Resource Hunting

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Abstract:

In recent decades, the cross-border flow of waste has become increasingly active globally, with existing research primarily attributing this trend to the pollution haven hypothesis. This study re-examines the drivers of global waste trade and explores their implications for sustainability. Using panel data from 117 countries between 1996 and 2020, we find that both developed and developing economies import waste products as resources. However, the resource hunting motive declines and shifts toward higher-value waste when importers adopt recycling policies. When developed exporters implement such policies, importers increase trade value due to lower matching costs. The pollution haven motive drives some waste exports from developed to developing economies, but trade value declines when destination countries strengthen recycling policies. This study deepens understanding of global waste trade and provides empirical insights for policymaking to better balance resource utilization and environmental sustainability.

Keywords: global waste trade; resource demand; pollution haven; environmental regulation; developing economies; developed economies

JEL classification: Q56, Q58, F18, P28

1. Introduction

Since the 1990s, globalization has not only fueled the expansion of international trade but has also contributed to the transboundary spread of environmental pollution. Among the various channels, the international trade in waste has become a significant vector for the cross-border transfer of pollutants (Liu and Lai, 2021; Martínez et al., 2022). Since the Basel Convention entered into force in 1995, the transboundary movement of hazardous waste has been subject to stringent controls, yet trade in non-hazardous waste has continued to expand. According to our calculations, the total value of global waste trade increased from USD 18.08 billion (73.78 million metric tons) in 1996 to USD 74.84 billion (177.51 million metric tons) in 2020 (see Figures A1 and A2). Of this total, approximately 50% of waste flows occurred between high-income countries, while 28% flowed from high-income economies to middle- and low-income economies. What explains the continued expansion of cross-border waste flows, particularly when viewed through the lens of sustainability? The key to answering the question lies in whether waste should be regarded as a pollutant with negative externalities or a resource that can turn waste into treasure.

On the one hand, the pollution haven hypothesis (hereafter PHH) is frequently used in theoretical frameworks to elucidate the drivers of international waste trade (Liu and Lai, 2021). This hypothesis posits that waste presents a type of pollution that incurs high disposal costs, especially under stringent environmental regulations (Levinson, 1999). If middle- and low-income economies with weaker environmental standards are inclined to import such waste, exporters from countries with stricter regulations can reduce compliance and disposal costs (Kellenberg, 2015). Empirical studies have documented the flow of waste exports to these economies over the past decades, supporting this hypothesis (Cotta, 2020; Kellenberg, 2012).

On the other hand, the resource hunting hypothesis (hereafter RHH) frames waste not as pollution but as a misallocated resource. From a life cycle assessment perspective, imported waste can be composted, landfilled, incinerated, or reused as raw materials in manufacturing processes (Yoshida, 2022). For developing economies with limited natural resources and high demand for industrial inputs, importing low-cost waste represents a strategic approach to resource acquisition (Gregson and Crang, 2015; Thakur, 2022). Although both pollution haven and resource-hunting offer plausible theoretical explanations and are supported by empirical evidence across various contexts, few studies have integrated these two perspectives to jointly model the determinants of global waste trade.

This paper investigates the influence of pollution-haven and resource-hunting motivations on the trade flows of 34 categories of waste products across 117 countries over the period 1996–2020. The analysis is further disaggregated by importer and exporter income levels as well as by industry classifications, allowing for a detailed assessment of heterogeneity. In addition, this paper examines how the adoption of waste management and recycling policies by both importing and exporting countries moderates the relationship between trade flows and the two motivations.

Using a panel dataset, we apply a gravity model of trade and interaction effects models to estimate the key drivers of international waste trade. The primary findings are as follows: (1) Global waste trade is predominantly driven by both resource hunting and pollution haven motivations. The relationship between resource hunting and waste trade is particularly robust across countries with different income levels and across various product sectors. (2) Waste management and recycling policies implemented by importers tend to dampen the resource hunting motive, shifting demand toward higher-value waste products. Moreover, waste exported from countries that also adopt such policies is more favored by importers, likely due to reduced matching and processing costs from prior sorting and regulation, thereby reinforcing the resource-driven motive. (3) The relationship between pollution haven incentives and waste trade is only statistically significant in specific contexts. In particular, this relationship is observed in waste exports from high-income to middle- and low-income economies, and in the trade of scrap metal and wastepaper.

The contribution of this study is to focus on a neglected part of international trade. First, this paper investigates the motivation of waste trade from the perspective of resource hunting, whereas the existing literature has predominantly emphasized the pollution haven hypothesis as the primary explanation. While the pollution haven hypothesis offers important insights, it fails to fully explain instances in which high-income economies act as major waste importers. In contrast, this study highlights the heterogeneous effects of resource hunting and pollution-haven motives across economies with different income levels and across different industrial sectors. Second, we construct a novel, globally comparable dataset on waste management and recycling policies, enabling us to analyze how bilateral regulatory measures shape waste trade dynamics. This perspective offers new policy implications for promoting both economic development and environmental protection in developing economies. Third, this study provides a comprehensive empirical assessment of the drivers of the global waste trade using an extensive HS 6-digit panel dataset spanning 25 years and covering all exporting and importing economies worldwide.

The rest of the paper is organized as follows: Section 2 provides a literature review. Section 3 presents the theoretical background and hypotheses. Section 4 outlines the methodology and data. Sections 5 and 6 present empirical results, and the final section summarizes the conclusions.

2. Literature review

In recent decades, the rapid growth of global waste trade has garnered significant attention from scholars. Researchers have primarily analyzed the driving forces behind waste trade through the lenses of the pollution haven and resource hunting hypotheses. The emergence and widespread acceptance of pollution-haven have led to a focus on how differences in environmental regulations influence the global flow of production factors (Walter and Ugelow, 1979). According to the pollution haven hypothesis, economies with strict environmental regulations may seek to transfer polluting industries and products to economies with more relaxed environmental standards to reduce costs. Currently, empirical research on FDI location selection and international trade between the developed and developing economies has partially validated (Antweiler et al., 2001; Copeland and Taylor, 2004).

Several studies have attempted to align global waste trade with the pollution haven hypothesis. For instance, Baggs (2009) utilized self-reported data from hazardous waste importing countries and conducted an empirical analysis using the gravity model. This model revealed a substantial flow of hazardous waste from high-income to middle- and low-income economies, suggesting that global hazardous waste trade adheres to the pollution haven hypothesis (Baggs, 2009). Similarly, Kellenberg (2012) constructed comprehensive cross-border panel data on waste, using 62 six-digit Harmonized System codes from the United Nations Commission on Commodity Trade database. Using PPML to estimate the gravity model, he found that waste typically flows from economies with stringent environmental regulations to those with laxer ones.

However, when considering the income levels of bilateral economies and waste types, the support for the pollution haven hypothesis is less compelling, although some evidence can still be found in waste exports to developed economies like Japan (Okubo et al., 2016) and the European Union (Wang et al., 2023). For instance, Balkevicius et al. (2020) empirically found that China's waste import restrictions policy did not result in significant waste dumping in developing countries with the weakest environmental regulations, thus challenging the pollution haven hypothesis. Li et al. (2021) empirically found only weak

support for the pollution haven hypothesis in waste plastics and textiles imported from developed economies to China, given the relatively low trade value of these waste types. Moreover, no empirical evidence was found in imported samples of waste metals from India (Sawhney and Majumder, 2015).

As the concept of circular economic development and recycling technology improves, the recycling value of waste is becoming increasingly recognized. Economies with scarce resources and high demand for resources due to rapid economic growth have an incentive to seek and import waste from around the world, a concept aligned with the resource hunting hypothesis. Terazono et al. (2004) suggested that the Asian waste circulation, centered around China and Japan, might be driven by China's substantial resource demand. Higashida and Managi (2014) developed a gravity model from the perspective of global supply and demand for recyclable waste. The model suggests that the higher the manufacturing wages in the importing economy, the greater the import volume of recyclable waste. This indicates that the expansion of manufacturing and economic growth in developing economies creates a demand for resources, with recyclable waste supplementing the resource demand of importing countries (Gregson and Crang, 2015; Higashida and Managi, 2014) and promoting green development (Yu et al., 2023).

Several studies on waste imports in developing economies have also provided support for the resource hunting hypothesis. For example, Li et al. (2021) integrated both the pollution haven and resource hunting perspectives to examine China's motivation for importing a large quantity of recyclable waste. Their findings indicate that China actively sought recyclable waste as an intermediate input to support industrial upgrading and manufacturing expansion. As China's economic growth began to slow, the volume of waste imports declined accordingly (Li et al., 2021). More recent research on China's import restrictions and their effects on the Asian waste recycling industry further suggests that waste trade dynamics are consistent with resource hunting behavior (Kojima, 2020; Yoshida, 2022).

According to the theory of pollution externalities, the adverse impacts of waste on the environment (Cotta, 2020), public health (Fazzo et al., 2017), and waste recycling systems (Yoshida, 2022) in importing countries necessitate government intervention through policy and regulation (Baumol and Bradford, 1972). Numerous studies have assessed the effectiveness of both multilateral agreements and unilateral policies. Initially, early literature predominantly focused on multilateral environmental agreements, with Kellenberg and Levinson (2014) expressing skepticism regarding the efficacy of the Basel Convention. Recently, substantial literature has concentrated on China's unilateral policies

aimed at restricting waste imports. Using quasi-natural experiments methodology, certain studies have found that policies such as Operation Green Fence and National Sword Policy have significantly curtailed China's waste imports (Balkevicius et al., 2020; Lin et al., 2023; Sun, 2019). Furthermore, other studies have conducted quantitative analyses of the global ramifications of China's import ban on waste plastic trade (Kumamaru and Takeuchi, 2021; Wen et al., 2021), waste metals (Tian et al., 2021), waste paper (Shang et al., 2020), and related areas (Liang et al., 2021).

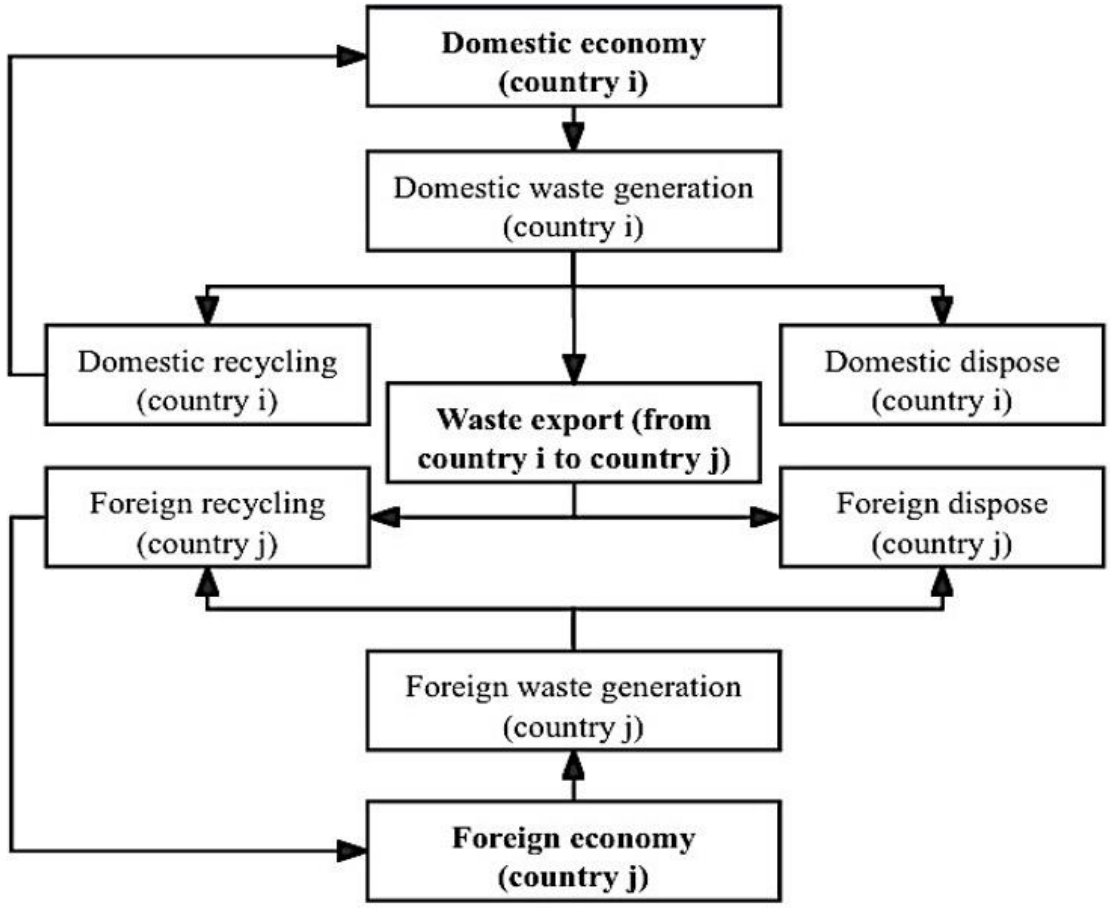
In recent years, the rapid expansion of the global waste trade and its underlying drivers have attracted growing scholarly attention. However, much of the existing literature has focused primarily on waste flows from high-income to middle- and low-income economies. Some scholars have applied the pollution haven hypothesis to explain this phenomenon, arguing that emerging economies import waste from developed countries by capitalizing on weaker environmental regulations, thereby enabling exporters to reduce disposal costs. Other researchers have emphasized the role of resource demand, suggesting that the manufacturing sectors in emerging economies require substantial inputs of natural resources, and importing recyclable waste from developed countries offers a cost-effective alternative. In addition, several studies have explored the design and impacts of national and international policies on waste management. Nevertheless, the existing literature suffers from several important limitations. First, few studies have simultaneously incorporated both pollution-haven and resource-hunting motivations into a unified analytical framework to explain global waste trade. Second, there is a lack of comprehensive analysis of the drivers of global waste flows, particularly regarding trade between developed economies. Third, research on the impact of waste management policies remains fragmented and lacks cross-country comparability.

3. Theoretical background and hypotheses

Based on Kellenberg (2012), this section introduces a two-country framework to analyze transboundary waste flows, incorporating both domestic and foreign waste generation. As illustrated in Figure 1, waste management in the domestic economy (country i) and the foreign economy (country j) involves the following processes: (1) Waste generated through domestic production and consumption can be managed through three primary channels: domestic recycling, domestic disposal, or export to a foreign economy. (2) A portion of this waste is recycled within the domestic economy and reintroduced as renewable resources. Another portion is treated through conventional methods such as incineration, landfilling, or uncontrolled dumping. (3) Alternatively, waste can be exported to foreign

economies, where it is either recycled and reintegrated into production as secondary resources or disposed of, potentially imposing environmental externalities on the importing country. (4) Similarly, waste generated in the foreign economy enters its own recycling and disposal systems, creating competition with imported waste for recycling capacity.

Figure 1. Two-country model of waste flow Diagram



As illustrated in Figure 1, waste imported by country i may follow one of two main pathways: it can either be treated as a pollutant, through incineration, landfilling, and dumping, or be regarded as a potential resource for recycling. This study seeks to investigate the primary motivation behind country j's decision to import waste from country i. Firstly, the pollution haven hypothesis suggests that waste-importing countries generally have lax environmental regulations. By accepting waste from exporting countries, they can gain economic benefits despite the resulting environmental pollution (Kellenberg, 2012). Although the pollution haven hypothesis is theoretically plausible, empirical stud-

ies using global samples have not consistently supported it (Balkevicius et al., 2020). Secondly, the Resource Hunting Hypothesis posits that the motivation for importing waste is to obtain recyclable resources (Li et al., 2021). Waste imported from abroad can be recycled and reused as raw materials for manufacturing development. Countries with scarce resources or rapidly developing manufacturing sectors are motivated to search globally for waste with recycling value. This hypothesis has been partially supported by empirical evidence (Higashida and Managi, 2014; Li et al., 2021). Building on this theoretical foundation, we argue that the expansion of global waste trade is largely driven by importing countries' efforts to secure affordable and reusable material inputs to sustain their manufacturing growth. Accordingly, we propose the following hypothesis:

H1. The global waste trade is mainly driven by resource-hunting motivation.

As illustrated in Figure 1, the recycling sector in country j sources waste from both domestic generation and imports from country i. This creates competition between domestically generated and imported waste, with selection determined by factors such as material quality and recycling efficiency. In recent years, an increasing number of countries have adopted waste management and recycling policies aligned with circular economy principles and sustainable development goals (Ren et al., 2020). These policies promote improved practices across the waste lifecycle, including generation, sorting, transportation, classification, treatment, recycling, and final disposal. Compared to countries lacking such regulations, those with established waste management frameworks tend to generate waste that is more efficiently sorted and has higher recycling value. As a result, these countries gain a competitive advantage in the global waste market (Li and Mu, 2024). When an importing country implements waste management and recycling policies, the quality of domestically produced waste typically improves. Consequently, the domestic recycling sector shifts toward greater reliance on local waste sources, reducing demand for low-value imports and favoring the procurement of high-value recyclable waste. Conversely, when an exporting country adopts such policies, the quality and consistency of its waste exports improve, lowering information and matching costs for importers and enhancing the attractiveness of its waste in international markets. Based on this logic, we propose the following hypotheses:

H2. Importing countries adopting waste management and recycling policies will reduce the resource-hunting motivation for waste imports.

H3. Exporting countries adopting waste management and recycling policies will strengthen the resource motivation for waste exports.

4. Methodology and Data

Previous studies mainly offer two hypotheses regarding the motivations for waste exports. According to Higashida and Managi (2014) and Li et al. (2021), importers have the motivation to search for waste products as intermediate inputs, hence generating demand for waste imports. As pointed out by Kellenberg (2012), the difference in environmental regulations among countries will cause the countries with stringent environmental restrictions to export waste products to countries with lax ones. This study analyzes the motivations for waste trade. The econometric specification is as follows:

$$lnX_{ijkt} = \alpha_0 + \alpha_1 RHH_{jkt} + \alpha_2 PHH_{ijt} + \gamma C_{ijt} + I_{ij} + I_k + I_t + \varepsilon_{ijkt} \quad (1)$$

The subscripts *i, j, k*, and *t* denote the exporting country, importing country, product, and year respectively. Where X_{ijkt} represents the waste exports from country *i* to country *j*, for product k at time *t.* The variable RHH_{jkt} captures the resource hunting motive, reflecting the extent to which exporting and importing activities are driven by the demand for recyclable materials as input resources. Following Li et al. (2021), we measure the resource-seeking motive using the logarithm of country *j*'s import value of intermediate goods, excluding waste products under the same HS2 code[1]. The rationale behind this measure is that higher intermediate input demand signals a stronger incentive to seek alternative or lower-cost resource substitutes, among which recyclable waste may serve as a viable option.

The variable PHH_{jit} represents the pollution haven motive, which is theorized to arise when exporters relocate pollution-intensive activities and waste disposal toward destinations with less stringent environmental regulations. Consistent with Wen and Dai (2020) and Ma et al. (2021), we proxy the pollution haven motive using the logarithmic ratio of CO_2 emissions per unit of GDP between countries *i* and *j*. A higher value indicates that country *i* is subject to more stringent environmental constraints compared to country *j*, which increases the likelihood that waste trade is driven by the incentive to avoid environmental compliance costs.

1 A descriptive comparison from 1996 to 2020 shows that although both intermediate goods and waste imports increased, the faster price growth of intermediate goods suggests recyclable waste has become a relatively cheaper resource input, supporting the rationale behind our proxy choice.

Table 1. Data source and description of variables

VarName	Descriptions	Data source
ln *value*$_{ijkt}$	The logarithm waste trade value from country *i* to country *j* for product *k* at time *t*.	CEPII-BACI Database
ln *quantity*$_{ijkt}$	The logarithm of waste trade quantity from country *i* to country *j* for product *k* at time *t*.	CEPII-BACI Database
***RHH*$_{jkt}$**	The logarithm of country *j*'s import value of intermediate materials, excluding waste imports classified under the same HS2 code. A higher value reflects greater demand for resource inputs.	CEPII-BACI Database
***RHHrevers*$_{jkt}$**	The share of a country's exports of resource-related products excluding waste products relative to its total exports within the same HS2 code. A higher proportion indicates a relatively lower domestic demand for resource inputs, as more resource products are directed toward external markets.	CEPII-BACI Database
***PHH*$_{ijt}$**	The relative environmental stringency between countries, measured as the logarithmic ratio of CO_2 emissions per unit of GDP between country *i* and *j*. A higher value suggests a stronger incentive for pollution haven behavior.	World Bank WDI
***PHHalter*$_{ijt}$**	The logarithm of the exporter's Environmental Performance Index (EPI) minus the logarithm of the importer's EPI. A higher value reflects a greater likelihood that exports are motivated by environmental regulation avoidance.	NASA's Socioeconomic Data and Application Center
***Recycle*$_{it}$**	A dummy variable equal to 1 if the exporting country *i* has implemented waste management and recycling policies in year *t*, and 0 otherwise.	Chatham House's circulareconomy. earch
***Recycle*$_{jt}$**	A dummy variable equal to 1 if the importing country *j* has implemented waste management and recycling policies in year *t*, and 0 otherwise.	Chatham House's circulareconomy. earch
ln *GDP*$_{it}$	The logarithm of GDP for country *i* at time *t*.	World Bank WDI
ln *GDP*$_{jt}$	The logarithm of GDP for country *j* at time *t*.	World Bank WDI
***FTA*$_{ijt}$**	A dummy variable equal to 1 if countries *i* and *j* have an active free trade agreement (FTA) in year *t*, and 0 otherwise.	WTO Database
ln *surplus*$_{ijt}$	The trade surplus of country *i* relative to country *j* in year *t*, capturing the reverse haulage logistics effect.	CEPII-BACI Database
ln *openness*$_{ijt}$	The sum of the logarithmic ratios of trade value to GDP for both the exporting and importing countries, reflecting bilateral trade orientation and economic scale.	World Bank WDI

The construct of each variable in the study and the data source.

The vector C_{ijt} represents the control variables. Following Kellenberg (2012), Petridis et al. (2020), and Li et al. (2021), we include exporters' GDP, importers' GDP, and free trade agreements. As pointed out by Kellenberg (2010) and Sun (2019), importers utilize the capacity of empty containers on the "back-haul" routes to ship waste products. Therefore, we adopt a trade surplus orientation to control the existence of "reverse haulage". Following Sun (2019), we also include the summation of the logarithm of the ratio between trade value and GDP for orientation and destination to measure the trade openness. I_{ij} denotes the importer-exporter fixed effect, which absorbs the bilateral effects like distance, language, and contiguity. I_k represents the product fixed effect. I_t is the time fixed effect. ε_{cjkt} is the error term. Table 1 presents the descriptions and sources of variables.

To examine whether waste management and recycling policies impact the influence of the pollution haven and resource hunting motivations on waste trade, we consider policies that encourage recycling practices related to waste management, including generation, separation, transfer, classification, treatment, recycling, and disposal. Following Henderson and Millimet (2007) and Li and Mu (2024), we include interaction terms between recycling policies and the motives of importers and exporters ($Recycle_{it}$ and $Recycle_{jt}$). The econometric specification is as follows:

$$\begin{aligned} lnX_{ijkt} = {} & \beta_0 + \beta_1 RHH_{jkt} + \beta_2 PHH_{ijt} + \beta_3 Recycle_{it} + \beta_4 Recycle_{jt} \\ & + \beta_5 RHH_{jkt} \times Recycle_{it} + \beta_6 RHH_{jkt} \times Recycle_{jt} + \beta_7 PHH_{jkt} \times Recycle_{it} \\ & + \beta_8 PHH_{jkt} \times \text{Recycle}_{jt} + \gamma C_{ijt} + I_{ij} + I_k + I_t + \varepsilon_{ijkt} \end{aligned} \tag{2}$$

This study constructs an annual panel dataset including 117 economies, 34 waste products from 1996 to 2020 [2*]. The lists of economies and waste products are provided in Table A1 and Table A2, respectively. We adopt the trade value and trade quantity to measure the waste trade. Table 2 presents the summary statistics.

2 * The Harmonized System 1996 version forms the basis of our product classification, and consistent international trade data based on this coding scheme are available beginning in 1996. Since the impact of Covid-19 pandemic deepened after 2020 due to anti-epidemic trade regulations, the global trade pattern had changed, including waste trade. We chose the data up to 2020 to avoid the trade shock from Covid pandemic.

Table 2. Summary statistics

VarName	Obs.	Mean	SD	Min	Max
ln $value_{ijkt}$	89025	6.804	2.452	−6.908	15.056
ln $quantity_{ijkt}$	88892	7.094	2.845	−6.908	15.845
RHH_{jkt}	89025	14.355	1.924	3.637	19.173
$RHHrevers_{jkt}$	79793	0.337	0.359	0.000	1.000
PHH_{ijt}	88850	−0.179	1.056	−4.919	4.981
$PHHalter_{ijt}$	23204	0.045	0.224	−1.267	1.051
$Recycle_{it}$	75936	0.422	0.494	0.000	1.000
$Recycle_{jt}$	77616	0.460	0.498	0.000	1.000
ln GDP_{it}	88690	20.498	1.836	11.979	23.785
ln GDP_{jt}	88819	20.638	1.463	13.103	23.785
FTA_{ijt}	89025	0.626	0.484	0.000	1.000
ln $surplus_{ijt}$	89025	0.026	0.586	−8.610	8.610
ln $openess_{ijt}$	88402	8.415	0.851	5.818	12.012

Notes: Summary statistics of variables used in the study. Obs., number of observations. SD, standard deviation.

5. Results

5.1 Baseline Results

Tables 3 and 4 report the baseline results from pooled regressions analyzing the drivers of international waste trade. The columns labeled "value" present the effects on the monetary value of waste flows, while the "quantity" columns reflect the results for trade volumes. Specifically, Columns 1 and 3 in Table 3 indicate that two distinct forces, demand for recyclable materials and differences in environmental regulation stringency, are both statistically significant determinants of waste trade, whether measured by value or quantity. Countries with a strong demand for low-cost secondary raw materials tend to increase their waste imports, reflecting a resource-hunting motive. Conversely, countries with

more stringent environmental regulations are more likely to export waste to jurisdictions with laxer standards, thereby reducing domestic disposal costs. Both dynamics contribute positively to the scale and value of cross-border waste flows. Importantly, when bilateral fixed effects are included in Columns 2 and 4 to control for unobserved, time-invariant characteristics specific to country pairs, the results remain robust and consistent.

Following Nunez-Rocha and Martínez-Zarzoso (2019), this study classifies both importers and exporters into two groups: high-income economies and middle- and low-income economies. Columns 1 to 4 of Table 4 show that across all income categories, countries tend to import waste products for their resource value. In contrast, the motivations related to environmental regulation disparities exhibit more variation depending on the income classification of trading partners. Specifically, high-income economies are more inclined to export waste to developing economies, reflecting incentives to externalize environmental costs due to stricter domestic regulations. However, the coefficient becomes negative and weakly significant when both importers and exporters are high-income countries. Similarly, the relationship is either statistically insignificant or only marginally significant when the exporting countries are developing economies. To further verify the robustness of these findings, Columns 5 to 8 of Table 4 replicate the analysis using trade volume rather than trade value as the dependent variable. The results remain consistent, reinforcing the reliability of the observed patterns.

Table 3. Effects of resource hunting and pollution haven motives on waste trade

Variables	Value	Value	Quantity	Quantity
RHH_{jkt}	0.505*** (39.609)	0.543*** (41.650)	0.566*** (38.387)	0.607*** (40.246)
PHH_{ijt}	0.297*** (6.107)	0.234*** (5.322)	0.396*** (7.201)	0.321*** (6.451)
ln GDP_{it}	0.299*** (7.404)	0.398*** (10.819)	−0.110** (−2.438)	−0.007 (−0.169)
ln GDP_{jt}	0.061 (1.347)	0.153*** (3.709)	−0.108** (−2.097)	−0.004 (−0.090)
FTA_{ijt}	0.927*** (37.332)	−0.064* (−1.941)	1.074*** (37.736)	−0.016 (−0.436)
ln $surplus_{ijt}$	−0.035** (−2.418)	0.010 (0.514)	−0.036** (−2.409)	0.040** (1.968)
ln $openess_{ijt}$	0.800*** (17.998)	0.707*** (17.559)	0.560*** (11.030)	0.458*** (9.949)
Year FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
Exporter FE	Yes	No	Yes	No
Importer FE	Yes	No	Yes	No
Exporter-Importer FE	No	Yes	No	Yes
Obs.	87925	87925	87798	87798
R-squared	0.394	0.523	0.417	0.540

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

Taken together with the results from Table 3, the analysis indicates that the demand for recyclable materials is a widespread driver of international waste trade, cutting across all income groups. Both developed and developing countries engage in waste imports to access secondary raw materials. However, the role of environmental regulation strin-

gency appears to be more limited. It significantly influences waste exports from developed to developing economies but does not play a meaningful role in shaping waste trade flows between countries at similar income levels.

Table 4. Heterogeneous effects of resource hunting and pollution haven motives by income levels

Variables	Value				Quantity			
Exporter´s income	**High**	**High**	**Middle & low**	**Middle & low**	**High**	**High**	**Middle & low**	**Middle & low**
Importer´s income	**High**	**Middle & low**	**High**	**Middle & low**	**High**	**Middle & low**	**High**	**Middle & low**
RHH_{jkt}	0.656*** (33.764)	0.365*** (16.254)	0.288*** (6.029)	0.624*** (12.263)	0.697*** (32.108)	0.452*** (16.258)	0.230*** (4.604)	0.585*** (10.399)
PHH_{ijt}	–0.128* (–1.849)	0.931*** (8.756)	0.173* (1.958)	–0.126 (–0.947)	0.039 (0.489)	0.926*** (7.434)	0.129 (1.355)	–0.245* (–1.711)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter–Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	56500	16191	9970	5264	56422	16159	9954	5263
R–squared	0.529	0.596	0.560	0.552	0.555	0.586	0.557	0.542

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

5.2 Robustness Check

Due to the absence of waste trade in certain waste products between some exporters and importers, there are instances of zero-value trade in the data. Following Kellenberg (2012), Higashida and Managi (2014), we adopt PPML estimation and repeat the baseline regression. Table 5 presents the results which are aligned with the results in Table 3. The variables RHH and PHH have positive impact on both trade value and trade quantity. Economies import waste products for resources. Meanwhile, countries with more stringent environmental regulations have higher motivation to export waste.

Table 5. PPML estimation of impact of resource hunting and pollution haven motives on waste trade

Variables	Value	Quantity
RHH_{jkt}	0.507*** (17.936)	0.621*** (20.079)
PHH_{ijt}	0.303*** (4.008)	0.772*** (8.060)
Control Variables	Yes	Yes
Year FE	Yes	Yes
Product FE	Yes	Yes
Exporter-Importer FE	Yes	Yes
Obs.	87925	87798
R-squared	0.697	0.683

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

To test the robustness of the findings, this study also employs alternative proxy variables to capture the motivations behind international waste trade. To approximate the role of resource availability, we use the share of a country's exports of non-waste resource-based products (Lall, 2000) relative to its total exports within the same HS2 classification. This measure serves as an inverse indicator of demand for recyclable waste: countries with abundant resource endowments are presumed to have less incentive

to import waste as a substitute for raw materials. To proxy for differences in environmental regulation stringency, we use the logarithmic difference between the exporters' and importers' Environmental Performance Index (EPI) scores. A greater gap indicates a higher likelihood that waste is being exported from environmentally stringent countries to those with looser regulations. Table 6 presents the regression results using these alternative specifications. The findings remain broadly consistent with the baseline analysis, confirming the reliability of the two hypothesized mechanisms.

Table 6. Robustness check using alternative proxies for resource hunting and pollution haven motives

Variables	Value	Quantity
$RHHrevers_{jkt}$	–1.273*** (–9.411)	–1.124*** (–7.308)
$PHHalter_{ijt}$	0.312*** (2.741)	0.330*** (2.689)
Control Variables	Yes	Yes
Year FE	Yes	Yes
Product FE	Yes	Yes
Exporter-Importer FE	Yes	Yes
Obs.	20570	20562
R-squared	0.577	0.612

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

Overall, the empirical results provide support for both resource-driven and regulation-avoidance motivations in international waste trade. Notably, the incentive to import waste as a recyclable resource appears more pervasive across all income groups. Regardless of their level of economic development, both high-income and low- to middle-income countries demonstrate a consistent pattern of importing waste materials for reuse in production. These findings remain robust across alternative model specifications and when

substituting different proxy variables for the core explanatory factors. Thus, the results lend empirical support to Hypothesis 1.

6. More Discussion

6.1 Environmental Polices' Effect

Table 7 examines the effects of waste management and recycling policies on the determinants of international waste trade, focusing on motivations related to both resource acquisition and regulatory avoidance. For policies implemented by exporting countries, stricter domestic regulations promote recycling and reduce the volume of waste available for export. These policies also diminish the incentive to shift pollution to countries with more lenient environmental standards. However, because recycling policies typically improve the separation, classification, and overall quality of waste materials, they reduce matching and processing costs for importing countries. As a result, importers are more inclined to source recyclable waste from exporters that have adopted such policies.

On the import side, the adoption of waste management and recycling regulations encourages the reuse of domestically generated waste and raises the threshold for import-worthy materials. High-value recyclable waste becomes more attractive, while low-value waste is more readily substituted with domestic alternatives. This pattern is reflected in the regression results, which show a significant positive effect on trade value but an insignificant effect on trade quantity. A similar pattern emerges in the interaction terms related to regulatory stringency, indicating that improved domestic recycling capacity reduces the demand for foreign waste as a resource.

In sum, when importing countries adopt recycling and waste management policies, their demand for recyclable imports shifts toward higher-value products, leading to a decline in the volume of low-value waste imports. Conversely, when exporting countries implement such policies, the relative attractiveness of their waste exports increases, due to improved quality and reduced processing costs. These findings offer empirical support for Hypotheses 2 and 3.

Table 7. Effects of waste management and recycling policies on waste trade motives

Variables	Value	Quantity
RHH_{jkt}	0.494*** (37.101)	0.535*** (29.369)
PHH_{ijt}	0.269*** (5.125)	0.336*** (5.465)
$Recycle_{it}$	–1.557*** (–9.434)	–2.244*** (–10.763)
$Recycle_{jt}$	0.623*** (3.842)	0.331 (1.590)
$RHH_{jkt} \times Recycle_{it}$	0.118*** (10.852)	0.142*** (10.338)
$RHH_{jkt} \times Recycle_{jt}$	–0.039*** (–3.637)	–0.028** (–2.027)
$PHH_{ijt} \times Recycle_{it}$	–0.136*** (–5.780)	–0.071*** (–2.678)
$PHH_{ijt} \times Recycle_{jt}$	0.135*** (6.470)	0.004 (0.178)
Control Variables	Yes	Yes
Year FE	Yes	Yes
Product FE	Yes	Yes
Exporter-Importer FE	Yes	Yes
Obs.	67983	67895
R-squared	0.532	0.552

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

6.2 Heterogeneous Effects of Environmental Policies on Different Economies

Table 8 splits the orientations and destinations into high-income economies and middle- and low-income economies, and the results are largely consistent. However, the incentive for importing countries to import waste products for their resource value is amplified when developed exporting economies implement waste management and recycling policies. This is because such policies reduce the matching costs associated with resource separation and classification, thereby encouraging all types of importing countries to increase their waste imports driven by the resource-hunting motive.

For developing economies as exporters, the coefficients present the opposite results. Developing countries tend to export more waste products when adopting environmental regulations. The majority of the export flows are aimed at other developing countries. For waste trade between middle- and low-income economies, the interaction term with RHH is negative, and the interaction term with PHH is positive. These results indicate that the motive is not caused by the destination's resource hunting, but by developing exporters' dumping pollution. When developing economies are destinations, importers with waste management and recycling policies will reduce the motive to import waste products as resources. It also reduces high-income economies' motive for searching "pollution-haven" and exporting wastes to developing economies.

In general, countries tend to import waste products as resources from developed economies, especially when developed exporters adopt waste management such as waste separation and classification. Developing economies with environmental regulations tend to search for other developing economies to dump waste. On the other hand, as destinations, all types of economies can protect themselves from the origins' motive of pollution haven when adopting waste management and recycling policies. Adopting environmental regulations is more significant for developing economies since they are usually victims of waste dumping. The empirical evidence supports Hypothesis 2 across both high-income and middle- and low-income economies. However, Hypothesis 3 is mainly validated for high-income economies.

Table 8. Moderating role of waste management and recycling policies by income levels

Variables	Value				Quantity			
Exporter´s income	**High**	**High**	**Middle & low**	**Middle & low**	**High**	**High**	**Middle & low**	**Middle & low**
Importer´s income	**High**	**Middle & low**	**High**	**Middle & low**	**High**	**Middle & low**	**High**	**Middle & low**
RHH_{jkt}	0.690*** (35.795)	0.246*** (10.349)	0.398*** (6.920)	0.645*** (7.130)	0.682*** (26.065)	0.293*** (8.635)	0.349*** (5.586)	0.564*** (5.531)
PHH_{ijt}	−0.113 (−1.301)	1.018*** (7.892)	0.271** (2.176)	−0.787*** (−3.766)	−0.020 (−0.201)	0.938*** (5.902)	0.142 (1.078)	−0.800*** (−3.412)
$Recycle_{it}$	−1.535*** (−6.070)	−1.037*** (−3.479)	0.881* (1.723)	2.121*** (2.670)	−2.665*** (−7.509)	−2.065*** (−5.843)	0.965 (1.576)	2.434*** (2.943)
$Recycle_{jt}$	0.411 (1.638)	−0.119 (−0.421)	1.783*** (3.418)	2.587*** (3.871)	0.296 (0.837)	−0.475 (−1.375)	1.631** (2.535)	2.349*** (3.619)
$RHH_{jkt} \times Recycle_{it}$	0.116*** (7.060)	0.081*** (4.343)	−0.044 (−1.298)	−0.158*** (−2.915)	0.169*** (7.380)	0.097*** (4.340)	−0.059 (−1.437)	−0.188*** (−3.248)
$RHH_{jkt} \times Recycle_{jt}$	−0.011 (−0.695)	−0.041** (−2.359)	−0.127*** (−3.743)	−0.201*** (−4.576)	−0.005 (−0.215)	−0.031 (−1.431)	−0.122*** (−2.926)	−0.174*** (−4.082)
$PHH_{ijt} \times Recycle_{it}$	−0.439*** (−8.663)	−0.028 (−0.476)	−0.066 (−1.118)	0.392*** (4.016)	−0.351*** (−5.653)	−0.091 (−1.391)	−0.010 (−0.154)	0.448*** (4.452)
$PHH_{ijt} \times Recycle_{jt}$	0.414*** (8.720)	−0.206*** (−3.894)	0.095* (1.663)	0.103 (1.313)	0.293*** (4.825)	−0.315*** (−4.984)	0.083 (1.424)	0.065 (0.920)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	45960	12544	7230	2249	45903	12524	7219	2249
R-squared	0.532	0.638	0.536	0.627	0.558	0.623	0.530	0.625

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

6.3 Heterogeneous Analysis on Different Waste Products

According to Li et al. (2021), we split the waste products into four sectors: waste plastic, waste paper, waste textile, and waste metal, which cover 99.67% of the value and 98.00% of the quantity of waste products' trade. According to the results in Table 9, resource hunting motivation exists across all sectors. Meanwhile, the pollution-haven motivation is mainly revealed in the waste paper sector and the waste metal sector. The results are generally consistent with baseline results.

Waste product imports are typically regarded as an undesirable form of trade, owing to the environmental burdens they impose on importing countries. Nevertheless, the import and utilization of waste products as a resource input remain prevalent across various economic sectors. In fact, countries of all income types import waste products across nearly all sectors, driven by the resource-hunting motive. These empirical results are consistent with Hypothesis 1.

Table 9. Sectoral heterogeneity in the effects of trade motives on waste trade

Variables	Value				Quantity			
Sectors	**Waste plastic**	**Waste paper**	**Waste textile**	**Waste metal**	**Waste plastic**	**Waste paper**	**Waste textile**	**Waste metal**
RHH_{jkt}	0.959***	0.604***	0.403***	0.535***	1.046***	0.846***	0.437***	0.540***
	(13.764)	(16.305)	(7.303)	(26.810)	(13.341)	(18.642)	(7.333)	(23.873)
PHH_{ijt}	0.143	0.507***	−0.236*	0.120**	0.184*	0.862***	−0.070	0.172***
	(1.486)	(4.703)	(−1.731)	(2.118)	(1.679)	(6.164)	(−0.481)	(2.731)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-Importer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	14549	15246	7512	46599	14544	15213	7511	46517
R-squared	0.648	0.602	0.481	0.559	0.627	0.618	0.570	0.585

Notes: T values are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels. Robust standard errors corrected.

Source: Authors' calculations.

7. Conclusion and policy implications

This study empirically examines the underlying drivers of global cross-border waste trade using annual panel data covering 117 countries over the period 1996 to 2020. The findings provide empirical support for two primary mechanisms: the pursuit of recyclable resources and the evasion of stringent environmental regulations. Specifically, countries with strong demand for raw materials tend to import waste as a secondary resource input, whereas countries subject to more rigorous environmental regulations are inclined to export waste to those with less stringent regulatory frameworks.

These motivations, however, are not uniformly manifested across all trade flows and industrial sectors. First, the resource-hunting incentive is evident across both developed and developing economies, suggesting that the import of recyclable waste is a broadly accepted strategy for securing affordable production inputs. In contrast, the regulatory avoidance motive is primarily observed in exports from high-income economies to lower-income ones; it is not statistically significant in other bilateral trade flows. Second, the resource-driven incentive is consistently present across a wide range of industries, underscoring its systemic role in global waste circulation. By comparison, the influence of regulatory avoidance is more sector-specific and episodic in nature.

When importers adopt waste management and recycling policies, resource-hunting incentives will decline, and demand will shift to higher-value waste products. Due to the decrease in the matching cost of resource demand after waste separation, importers tend to import waste as resources from developed economies with recycling policies. For developing economies, the adoption of waste management and recycling policies can not only mitigate the incentive to import waste for resource purposes, but also significantly curb the motivation to import waste from developed countries driven by disparities in environmental regulatory standards. Hypotheses 1 and 2 are aligned with empirical results, and hypothesis 3 fits the developed economies.

Based on the empirical findings, this study offers the following implications. First, countries aiming to participate in the global waste trade, particularly as exporters, should invest in domestic waste classification and pretreatment infrastructure. As our analysis demonstrates, importers exhibit a distinct preference for better-sorted, more recyclable waste, largely attributable to the associated reductions in matching and processing costs. Strengthening waste management systems at the source can therefore improve a country's competitiveness in the international waste market. Second, importing countries are encouraged to enhance domestic recycling capacity and develop localized resource

circulation systems. Our results indicate that the implementation of recycling policies reduces reliance on low-value imported waste and redirects demand toward domestically processed materials or high-value recyclable imports. This shift contributes to greater resource security and environmental sustainability. Third, given the evidence that waste exports from high-income to lower-income countries are partially driven by regulatory asymmetries, developing economies should improve their import inspection procedures and environmental oversight. Such measures will help mitigate the risk of becoming destinations for waste exports motivated by environmental regulatory arbitrage.

Since this study does not incorporate data beyond 2020, several recent developments in global waste trade fall outside the scope of the current analysis. First, China has significantly tightened its import regulations on solid waste since 2018, culminating in a comprehensive ban. This policy shift has had profound implications for global waste trade patterns, prompting several middle- and low-income countries to adopt similar restrictions. Consequently, many high-income economies now face mounting pressure to manage and upgrade their domestic recycling systems, which had previously relied on export-based disposal channels. Second, the intensification of geopolitical risks in recent years has elevated the strategic importance of critical mineral recovery. As a result, the recycling of waste metals has emerged as a key avenue for securing resource supply chains, particularly among high-income countries. This trend is likely to reshape the motivations underpinning international waste trade, especially by reinforcing the demand-driven pursuit of recyclable resources.

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Data Availability Statement: This study relies on publicly available datasets. The WDI database is accessible via the World Bank Data portal at https://datatopics.worldbank.org/world-development-indicators. Bilateral trade data are obtained from the BACI database developed by CEPII, available at https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37.

Conflicts of Interest: The authors declare no conflicts of interest.

References

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is free trade good for the environment? *American Economic Review*, *91*(4), 877–908. https://doi.org/10.1257/aer.91.4.877

Baggs, J. (2009). International trade in hazardous waste. *Review of International Economics*, *17*(1), 1–16. https://doi.org/10.1111/j.1467-9396.2008.00778.x

Balkevicius, A., Sanctuary, M., & Zvirblyte, S. (2020). Fending off waste from the west: The impact of China's Operation Green Fence on the international waste trade. *The World Economy*, *43*(10), 2742–2761. https://doi.org/10.1111/twec.12949

Baumol, W. J., & Bradford, D. F. (1972). Detrimental externalities and non-convexity of the production set. *Economica*, *39*(154), 160–176. https://doi.org/10.2307/2552639

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature*, *42*(1), 7–71. https://doi.org/10.1257/002205104773558047

Cotta, B. (2020). What goes around, comes around? Access and allocation problems in Global North–South waste trade. *International Environmental Agreements: Politics, Law and Economics*, *20*(2), 255–269. https://doi.org/10.1007/s10784-020-09479-3

Fazzo, L., Minichilli, F., Santoro, M., Ceccarini, A., Della Seta, M., Bianchi, F., Comba, P., & Martuzzi, M. (2017). Hazardous waste and health impact: A systematic review of the scientific literature. *Environmental Health*, *16*(1), 107. https://doi.org/10.1186/s12940-017-0311-8

Gregson, N., & Crang, M. (2015). From waste to resource: The trade in wastes and global recycling economies. *Annual Review of Environment and Resources*, *40*, 151–176. https://doi.org/10.1146/annurev-environ-102014-021105

Henderson, D. J., & Millimet, D. L. (2007). Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States: A Nonparametric Reassessment. *Review of Economics and Statistics*, *89*(1), 178–183. https://doi.org/10.1162/rest.89.1.178

Higashida, K., & Managi, S. (2014). Determinants of trade in recyclable wastes: Evidence from commodity-based trade of waste and scrap. *Environment and Development Economics*, *19*(2), 250–270. https://doi.org/10.1017/S1355770X13000533

Kellenberg, D. (2010). Consumer waste, backhauling, and pollution havens. *Journal of Applied Economics*, *13*(2), 283–304. https://doi.org/10.1016/S1514-0326(10)60013-X

Kellenberg, D. (2012). Trading wastes. *Journal of Environmental Economics and Management*, *64*(1), 68–87. https://doi.org/10.1016/j.jeem.2012.02.003

Kellenberg, D. (2015). The economics of the international trade of waste. *Annual Review of Resource Economics*, *7*(1), 109–125. https://doi.org/10.1146/annurev-resource-100913-012639

Kellenberg, D., & Levinson, A. (2014). Waste of effort? International environmental agreements. *Journal of the Association of Environmental and Resource Economists*, *1*(1/2), 135–169. https://doi.org/10.1086/676037

Kojima, M. (2020). The Impact of Recyclable Waste Trade Restrictions on Producer Recycling Activities. *International Journal of Automation Technology*, *14*(6), 873–881. https://doi.org/10.20965/ijat.2020.p0873

Kumamaru, H., & Takeuchi, K. (2021). The impact of China's import ban: An economic surplus analysis of markets for recyclable plastics. *Waste Management*, *126*, 360–366. https://doi.org/10.1016/j.wasman.2021.03.027

Lall, S. (2000). The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-1998. *Oxford Development Studies*, *28*(3), 337–369. https://doi.org/10.1080/713688318

Levinson, A. (1999). State Taxes and Interstate Hazardous Waste Shipments. *The American Economic Review*, *89*(3), 666–677. https://doi.org/10.1257/aer.89.3.666

Li, B., Alleyne, A., Zhang, Z., & Mu, Y. (2021). Sustainability and Waste Imports in China: Pollution Haven or Resources Hunting. *Sustainability*, *13*(2), 932. https://doi.org/10.3390/su13020932

Li, B., & Mu, Y. (2024). Impact of China's National Sword Policy on Waste Import Margins: A Difference-in-Differences Approach. *Sustainability*, *16*(2), 772. https://doi.org/10.3390/su16020776

Liang, Y., Tan, Q., Song, Q., & Li, J. (2021). An analysis of the plastic waste trade and management in Asia. *Waste Management*, *119*, 242–253. https://doi.org/10.1016/j.wasman.2020.09.049

Lin, C., Paengsri, P., & Yang, Y. (2023). Impact of China's National Sword Policy on waste import: A difference-in-differences approach. *Economic Analysis and Policy*, *78*, 887–903. https://doi.org/10.1016/j.eap.2023.04.033

Liu, Y., & Lai, X. (2021). EKC and carbon footprint of cross-border waste transfer: Evidence from 134 countries. *Ecological Indicators*, *129*, 107961. https://doi.org/10.1016/j.ecolind.2021.107961

Ma, Z., Yang, Y., Chen, W.-Q., Wang, P., Wang, C., Zhang, C., & Gan, J. (2021). Material Flow Patterns of the Global Waste Paper Trade and Potential Impacts of China's Import Ban. *Environmental Science & Technology*, *55*(13), 8492–8501. https://doi.org/10.1021/acs.est.1c00642

Martínez, J. H., Romero, S., Ramasco, J. J., & Estrada, E. (2022). The world-wide waste web. *Nature Communications*, *13*(1), 1615. https://doi.org/10.1038/s41467-022-28810-x

Nunez-Rocha, T., & Martínez-Zarzoso, I. (2019). Are international environmental policies effective? The case of the Rotterdam and the Stockholm Conventions. *Economic Modelling*, *81*, 480–502. https://doi.org/10.1016/j.econmod.2018.04.013

Okubo, T., Watabe, Y., & Furuyama, K. (2016). Export of Recyclable Materials: Evidence from Japan. *Asian Economic Papers*, *15*(1), 134–148. https://doi.org/10.1162/ASEP_a_00414

Petridis, N. E., Petridis, K., & Stiakakis, E. (2020). Global e-waste trade network analysis. *Resources, Conservation and Recycling*, *158*, 104742. https://doi.org/10.1016/j.resconrec.2020.104742

Ren, Y., Shi, L., Bardow, A., Geyer, R., & Suh, S. (2020). Life-cycle environmental implications of China's ban on post-consumer plastics import. *Resources, Conservation and Recycling*, *156*, 104699. https://doi.org/10.1016/j.resconrec.2020.104699

Sawhney, A., & Majumder, P. (2015). Is India becoming a waste haven of metal scrap? *MPRA Paper No. 67186*. https://mpra.ub.uni-muenchen.de/67186/

Shang, D., Diao, G., & Zhao, X. (2020). Have China's regulations on imported waste paper improved its quality. *Forest Policy and Economics*, *119*, 102287. https://doi.org/10.1016/j.forpol.2020.102287

Sun, M. (2019). The effect of border controls on waste imports: Evidence from China's Green Fence campaign. *China Economic Review*, *54*, 457–472. https://doi.org/10.1016/j.chieco.2019.02.009

Terazono, A., Yoshida, A., Yang, J., Moriguchi, Y., & Sakai, S. (2004). Material cycles in Asia: Especially the recycling loop between Japan and China. *Journal of Material Cycles and Waste Management*, *6*(2), 82–96. https://doi.org/10.1007/s10163-004-0115-0

Thakur, P. (2022). Welfare Effects of International Trade in Waste. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4216639

Tian, X., Zheng, J., Hu, L., Liu, Y., Wen, H., & Dong, X. (2021). Impact of China's waste import policy on the scrap copper recovery pattern and environmental benefits. *Waste Management*, *135*, 287–297. https://doi.org/10.1016/j.wasman.2021.09.008

Walter, I., & Ugelow, J. L. (1979). Environmental policies in developing countries. *Ambio*, *8*(2/3), 102–109. https://www.jstor.org/stable/4312437

Wang, Y., Liu, Y., Feng, W., & Zeng, S. (2023). Waste Haven Transfer and Poverty-Environment Trap: Evidence from EU. *Green and Low-Carbon Economy*, *1*(1): 41-49. https://doi.org/10.47852/bonviewGLCE3202668

Wen, H., & Dai, J. (2020). Trade openness, environmental regulation, and human capital in China: Based on ARDL cointegration and Granger causality analysis. *Environmental Science and Pollution Research*, *27*(2), 1789–1799. https://doi.org/10.1007/s11356-019-06808-1

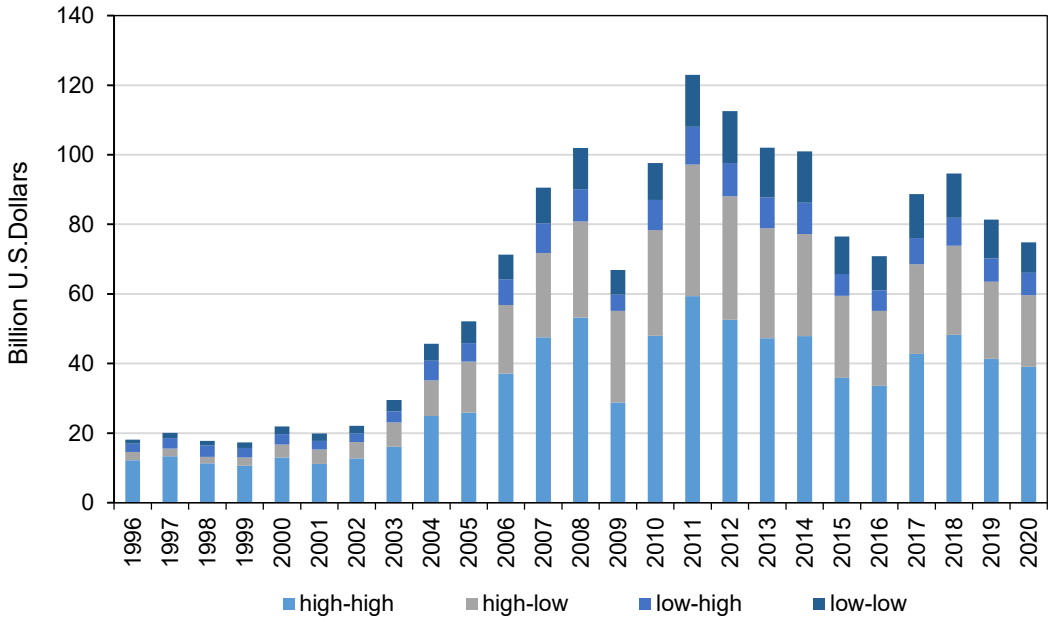
Wen, Z., Xie, Y., Chen, M., & Dinga, C. D. (2021). China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. *Nature Communications*, *12*(1), 425. https://doi.org/10.1038/s41467-020-20741-9

Yoshida, A. (2022). China's ban of imported recyclable waste and its impact on the waste plastic recycling industry in China and Taiwan. *Journal of Material Cycles and Waste Management*, *24*(1), 73–82. https://doi.org/10.1007/s10163-021-01297-2

Yu, S., Wang, X., Liu, J., & Wei, F. (2023). Role of mining waste trade on green development in China: Policy implications for circular economy. *Resources Policy*, *86*, 104147. https://doi.org/10.1016/j.resourpol.2023.104147

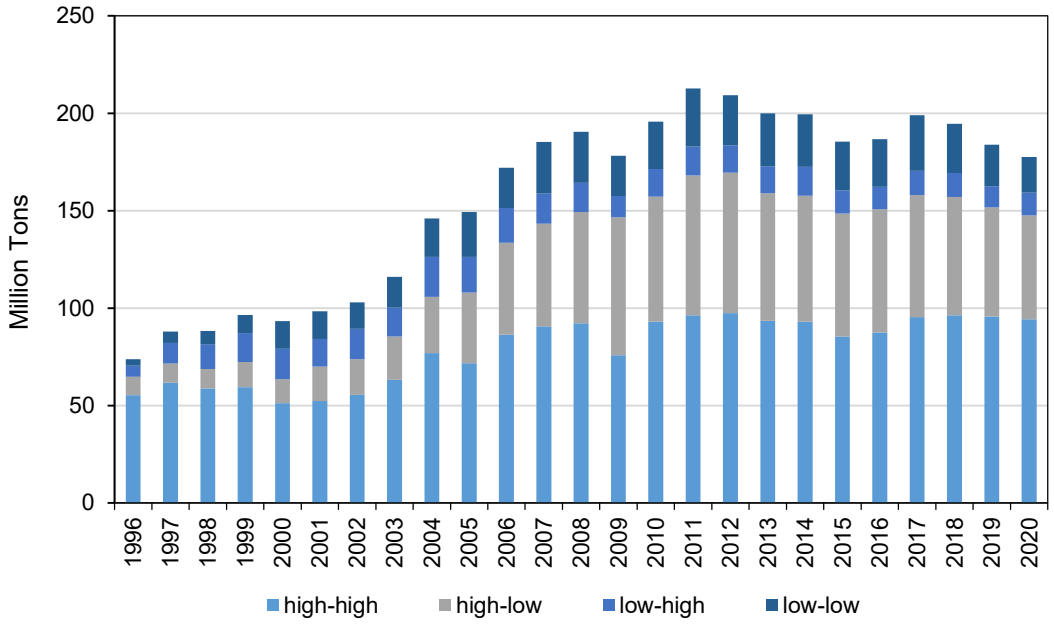
Appendix A

Figure A1. Value of waste trade between countries with different incomes



Source: CEPII-BACI database.

Figure A2. Quantity of waste trade between countries with different incomes



Source: CEPII-BACI database.

Table A1. Names of countries and regions used in the study

Albania	Algeria	Andorra
Angola	Argentina	Australia
Austria	Bahamas	Bahrain
Bangladesh	Barbados	Belarus
Bolivia	Bosnia and Herzegovina	Brazil
Bulgaria	Cabo Verde	Canada
Cayman Islands	Chile	China
Colombia	Congo, Rep.	Costa Rica
Croatia	Cuba	Cyprus
Czech Republic	Denmark	Dominican Republic
Ecuador	Egypt, Arab Rep.	El Salvador
Estonia	Fiji	Finland
France	French Polynesia	Georgia
Germany	Ghana	Gibraltar
Greece	Guatemala	Guinea
Guyana	Haiti	Honduras
Hong Kong SAR, China	Hungary	Iceland
India	Indonesia	Ireland
Israel	Italy	Jamaica
Japan	Jordan	Kazakhstan
Kenya	Korea, Rep.	Kuwait
Latvia	Lebanon	Liberia
Lithuania	Macao SAR, China	Madagascar
Malaysia	Maldives	Malta
Mauritius	Mexico	Moldova
Morocco	Netherlands	New Caledonia
New Zealand	Nicaragua	Nigeria
North Macedonia	Norway	Oman
Pakistan	Panama	Papua New Guinea
Peru	Philippines	Poland
Portugal	Qatar	Romania
Russian Federation	Saudi Arabia	Senegal
Singapore	Slovak Republic	Slovenia
Solomon Islands	Spain	Sri Lanka
Suriname	Sweden	Switzerland
Thailand	Trinidad and Tobago	Tunisia
Turkey	Ukraine	United Arab Emirates
United Kingdom	United States	Uruguay
Venezuela, RB	Vietnam	Yemen, Rep

Table A2. HS codes and waste products' name

HS code	Description
251720	Macadam of slag/dross/sim. industrial waste
252530	Mica waste
261900	Slag, dross (excl. granulated slag), scalings and other waste from manufacture
391510	Waste, parings and scrap, of polymers of ethylene
391520	Waste, parings and scrap, of polymers of styrene
391530	Waste, parings and scrap, of polymers of vinyl chloride
391590	Waste, parings and scrap, of plastics n.e.s. in 39.15
400400	Waste, parings and scrap, of rubber (excl. hard rubber)
450190	Waste cork; crushed/granulated/ground cork
470710	Recovered (waste and scrap) unbleached kraft paper/paperboard
470720	Recovered (waste and scrap) paper/paperboard mainly of bleached chem.
470730	Recovered (waste and scrap) paper/paperboard made mainly of mechanical pulp
470790	Recovered (waste and scrap) paper/paperboard (excl. of 4707.10-4707.30)
500390	Silk waste (incl. cocoons unsuit. for reeling, yarn waste and garnetted stock)
510320	Waste of wool/of fine animal hair, incl. yarn waste
520210	Yarn waste (incl. thread waste), of cotton
520299	Cotton waste other than yarn waste
550510	Waste (incl. noils, yarn waste and garnetted stock) of synth. fibers
550520	Waste (incl. noils, yarn waste and garnetted stock) of art. Fibers
720410	Waste and scrap of cast iron
720421	Waste and scrap of stainless steel
720429	Waste and scrap of alloy steel other than stainless steel
720430	Waste and scrap of tinned iron/steel
720441	Ferrous turnings, shavings, chips, milling waste, sawdust, filings
720449	Ferrous waste and scrap (excl. of 7204.10-7204.41)
740400	Copper waste and scrap
750300	Nickel waste and scrap
760200	Aluminum waste and scrap
780200	Lead waste and scrap
790200	Zinc waste and scrap
800200	Tin waste and scrap
810420	Magnesium waste and scrap
810600	Bismuth and arts. There of, incl. waste and scrap
854810	Waste and scrap of primary cells, primary batteries