An Unhealthy Trade Surplus?

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Abstract

Recognizing that trade imbalance can generate a difference in the unit shipping cost, we show that countries with a large trade surplus (deficit) tend to systematically import (export) more of goods that are heavy relative to their value. We report cross-country evidence and evidence from ports across China that is consistent with this prediction. A particular example of goods that are relatively heavy is solid industrial waste such as scrap metals and scrap glass. We report evidence that countries with a trade surplus such as systematically import more of such goods. If pollution externality associated with industrial waste is not properly corrected by a tax, a trade surplus is also translated into more health hazard associated with imported waste. We then propose a quantitative model to evaluate and compare several public policies that are meant to address this problem.

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1 Introduction

This paper explores the implications of trade imbalance for the composition of a country's imports and exports, and potential welfare effect if the altered comparative advantage interacts with a weak environmental standard.

As an example, China is the largest importer of wasted products in the world, with 45 million tons of scrap metal, used textile and fibers, waste paper, and used plastics, worth over $18 billion in 2016. At the same time, the United States is one of the largest exporters of such solid industrial waste. We study whether such trade patterns are connected to the fact that China consistently runs a large trade surplus, and the United States a large deficit over many years.

Figure 1 plots China's bilateral trade surplus against all its trading partners, and its imports of industrial waste from them. We can see a significantly positive relationship between the two variables. As far as we know, there is no existing theory that explains this pattern.

This paper proceeds in two parts. In the first part, we explore how a country's trade surplus affects the shipping cost of inbound trade, and how that in turn changes the composition of the country's imports. In particular, we provide evidence that a country with a greater trade surplus tends to import more of relatively heavy goods (i.e. goods with a relatively high weight-to-value ratio). In the second part, we show that a trade surplus tends to induce the country to import more of scrap metals and other industrial waste, since industrial waste is a major part of the goods that have a relatively high weight-to-value ratio. Since the recycling process generates pollution, especially in countries with a weak environmental standard, and can lead to a deterioration of health outcomes. We then construct a model to evaluate and compare various policy options, including a doubling of tariffs on imports of industrial waste, a ban on imports of industrial waste, a forced elimination of trade imbalance, and a higher tax on pollution.

Here is more detail on the first part. A key insight is that a trade surplus from Country A to Country B makes it more likely for ships returning to A to be under their full carrying capacity (De Palma et al. (2011) and De Oliveira (2014)). This imbalance reduces the unit shipping cost for Country A's imports, making it relatively cost effective for the surplus countries to import goods that are heavy relative to their value (and solid industrial waste happens to be a main item in this category). Conversely, deficit countries have a comparative advantage in exporting relatively heavy goods. Note that a country's trade balance - a major part of current account balance - is largely determined by its savings and investment balance, and not affected much by shipping costs. This suggests that the unit shipping cost (per weight or size) is likely to be lower going from a deficit country to a surplus country than in the reverse direction.

In Figure 2, we plot the relative difference between the outbound and inbound shipping costs for a country pair against their trade imbalance in percentage term measured by logarithm of exports over imports. It is clear that the greater the bilateral trade surplus, the lower the inbound shipping cost relative to the outbound cost for the surplus country. To our knowledge, this is the first paper that explores its implications of trade imbalance for the composition of imports (and its health implications).

We estimate an augmented gravity equation that incorporates shipping costs and goods features in terms of weight to value ratio. We collect a good's weight to value ratio from Colombia's customs data. In the regressions, we exclude all country pairs involving Colombia. Under the assumption that the weight to value ratio is an exogenous physical characteristics, we examine whether imports of relatively heavy goods rise more than those of other goods as shipping costs become lower. We find that the magnitude of import elasticity with respect to the shipping cost is about 1.69% higher for good i than for good j if the weight per value of good i is 10% heavier than for good j.

Since inbound shipping cost and trade surplus are negatively associated (a 10% increase in the trade imbalance against a country leads to a 0.7% decrease in the shipping cost from the country), import elasticity with respect to the trade imbalance is about 1.2% higher for good i than for good j if the weight per value of good i is 10% heavier than for good j.

There might be unobserved components that affect both the composition of imports and trade imbalance. To address this possibility, we use a shock to a country's trade balance. Right after the currency attack in December 1994, Mexico's Peso depreciated over 50%, producing a large trade surplus. As the currency depreciation is less likely to affect directly the composition of imports, this event provides a useful case study. The data shows that with a sharp improvement in Mexico's trade balance (from deficit to surplus), the imports of heavy goods as a share of total imports rose significantly as well.

To further address the endogeniety issue, we go to data across different ports in China. While the country as a whole runs a trade surplus against the rest of the world, the extent of the difference between exports and imports is uneven across different ports. For example, if Shanghai runs a larger trade surplus than Qingdao, out theory predicts the former would import proportionally more heavy goods than the latter. By using the port level data, we can control the country-pair fixed effect and exploit the variation across ports within China. We find that the port level data indeed confirms such a prediction.

We apply our theory to the waste goods import. The weight per value of waste goods is significantly higher than that of other goods. We first show that the magnitude of import elasticity with respect to shipping cost is higher for waste goods than for other goods. More importantly, this difference decreases substantially once we control for the weight per value of each good, suggesting that the high import elasticity with respect to shipping cost for waste goods is likely explained by our theory.

A possible connection also exits between trade imbalance and health hazard. Wasted products often involve more pollution and more associated unsanitary consequences for health than other imports. For example, imported waste products are often dirty, poorly sorted, or contaminated with hazardous substances. Most importantly, they are not always recycled properly. A film, “Plastic China,” shows the environmental damage caused by the country’s plastic-recycling industry, which is dominated by many small-scale outfits that often lack proper pollution controls. Indeed, one of our regression results suggests that, after controlling for the city-fixed effect, an increase in waste goods import of a chinese city is significantly associated with the level of pollution in the city.

If environmental regulation is not properly enforced in countries with a large trade surplus, our mechanism could generate a negative externality through increase in pollution. In the second part of the paper, we show evidence that developing countries tend to have *less* stringent environmental standard than developed countries, while often running a large trade surplus against developed countries. Assuming pollution generated by waste goods imports is not properly taxed, we quantify externality generated by waste goods imports by using a calibrated model based in part on the Chinese data. Holding the environmental standard as it is, our simulation results suggest that China’s trade surplus generates about a welfare cost through the waste import. Various policies might be contemplated to address this problem, including a ban on the imports of industrial waste (which China has considered), a forced elimination of trade imbalance, and a higher tax on pollution. We use the model to evaluate and compare these alternative policies.

Our paper relates to several strands of literature. First, the existing literature on the welfare effect of the trade imbalance focuses almost exclusively on the terms of trade channel (Dekle et al. (2007) and Epifani and Gancia (2017)). Our paper highlights a new channel: a trade imbalance alters the composition of imports towards heavier goods, notably including scrap metals and other industrial waste. If domestic pollution control is weak, a trade surplus can result in welfare cost by increasing the imports of pollution intensive industrial waste.

Second, Hummels and Skiba (2004) and Lashkaripour (2015) already emphasize that unit weight is an important feature in the international shipping. whereas Djankov et al. (2010) and Hummels and Schaur (2013) study the effect of shipping time on trade cost. However, these papers do not consider trade imbalance as a determinant of shipping cost. While other papers point out trade balance as a determinant of shipping cost[1], we go beyond this point and study the effects on the composition of imports and consequences for environment and health.

Third, while there is a large literature on trade and environment (see surveys by Frankel (2009), Kellenberg (2009), Kellenberg (2012) and Lan et al. (2012)), it does not make a connection among trade imbalance, import composition, and the environment. Our contribution is to propose a possible interaction between trade imbalance and weak pollution control: Those developing countries that simultaneously have a weak pollution control regime and a trade surplus might experience especially adverse pollution effects.

The paper is structured in two parts after this introduction. In the first part, we aim to establish a relationship between a country's trade imbalance (against the world) and the tendency for it to import relatively heavy goods. In the second part, we show that a country with a surplus tends to import more of industrial waste with adverse health outcomes.

2 Trade Imbalance and Import Composition

In the first part of this section, we show that if shipping cost depends on a good's weight, but not on its value, the standard gravity equation predicts that the import elasticity with respect to shipping cost systematically differs depending on the weight-per-value of a good.

[1]See, for example, Behrens and Picard (2011), Friedt and Wilson (2015), Jonkeren et al. (2010), and Wong (2017)

2.1 The logic

The reasoning can be explained via two equations. We use i to denote goods, n and d to denote the origin and destination country. We start from the following gravity equation at the good level:

$$X_{i,nd} = \frac{(\tau_{i,nd} p_{i,nd})^{1-\sigma_{i,d}}}{A_{i,n}} E_{i,d}$$

$X_{i,nd}$ is the amount of import of good i from country n by country d. $p_{i,nd}$ is the free on board (FOB) price in country d of good i from country n, and $\tau_{i,ndt}$ is the corresponding trade cost per value of good i from country n to country d. Hence $\tau_{i,nd} p_{i,nd}$ is the price per unit of good i paid by a consumer in the destination country. $1 - \sigma_{i,d}$ is the demand elasticity of good i in the destination country. $E_{i,d}$ is the total expenditure of the destination country on good i. $A_{i,nt}$ captures "capabilities" of exporter of i in country n as a supplier to all destinations.

The trade cost per value $\tau_{i,nd}$ therefore can be written as

$$\begin{aligned} \tau_{i,nd} &= 1 + t_{i,nd} + \frac{c_{i,nd}}{p_{i,nd}} \\ &= 1 + t_{i,nd} + \lambda_{nd} \left(\frac{w_{i,nd}}{p_{i,nd}} \right) \end{aligned}$$

The trade cost per value is assumed to have two components: an iceberg component $t_{i,ndt}$, which includes the trade tariff, and a non-iceberg cost. Let $c_{i,nd}$ denote the shipping cost of delivering one unit of good i from n to d. We assume that

$$c_{i,nd} = \lambda_{nd} w_{i,nd}$$

where $w_{i,nd}$ is the weight per unit of good i, and λ_{nd} is the shipping cost per unit of weight when delivering good from n to d.[2]

[2]Hummels (2004) have pointed out that the shipping cost is correlated with the goods weight per unit.

The second component suggests that the per value shipping cost equals to per weight shipping cost times weight to value ratio. We assume that the weight to value ratio is an exogenous property of the goods. In this case, we can get the following proposition.

Proposition 1. *If λ_{nd} decreases, the import of heavy goods (high weight to value goods) will increase relative more than the import of light goods (low weight to value goods) because heavy goods will enjoy a dis-proportionally large decline in the trade cost.*

The shipping cost per weight λ_{nd} is decreasing when the extra shipping capacity of the route from n to d increases.[3] Suppose a ship departs from country d for country n must come back from country n to country d. Then, if country d runs a large trade surplus against country n, the backhaul ship's extra capacity will increase.[4] Under this assumption, if the country d runs a large trade surplus against country n, the shipping cost per weight from country n to country d (λ_{ndt}) will decrease. As a result, we have the following corollary.

Corollary 1. *A country tends to import more heavy goods if it runs a larger trade surplus.*

2.2 Empirical Evidence

We test the prediction of Proposition 1 as well as the assumption behind Corollary 1. We first see whether the key assumption for Corollary 1, a negative relationship between trade surplus and the backhaul ship's cost is supported in the data. Next, we test whether the elasticity of imports with respect to shipping cost is systematically different as a function of the product's weight-to-value ratio.

[3]The micro-foundation of this negative relationship is shown in the old version of this paper as well.

[4]Similar to our argument, Behrens and Picard (2011) develop a model in which trade imbalance generates asymmetric freight rate for the opposite direction.

Shipping Cost and Trade Imbalance

We first consider the following equation:

$$\ln(\text{Shipping cost})_{ndt} = \alpha_0 + \alpha_1 \ln(\text{Imbalance})_{ndt} + \Omega_{\overleftrightarrow{ndt}} + e_{ndt}, \tag{1}$$

where n and d are the origin and destination countries respectively. Imbalance_{ndt} is the trade surplus country d runs against country n in year t, measured by $\text{Import}_{dnt}/\text{Import}_{ndt}$, where Import_{dnt} is country d's import from country d and Import_{ndt} is country n's import from country d. $\Omega_{\overleftrightarrow{ndt}}$ is an origin-destination specific component which affects the shipping cost for both directions. e_{ndt} is an i.i.d random component with a zero mean.

Equation (1) tests whether the shipping cost per weight decreases as the trade imbalance increases, the key assumption for Corollary 1. To generate trade imbalance, we use the UN Comtrade Database in between 2010 and 2017. The UN data provides the origin-destination country specific bilateral trade volume, measured by USD, of each HS6 good. By aggregating the bilateral trade volume of each HS6 good, we can also generate origin-destination country specific trade imbalance in a given year. To capture shipping cost, we use 20 foot dry container freight rate from Drewry as a proxy. Drewry is a shipping consulting firm, providing port-to-port freight rates for all major routes.[5] We use a country-by-county freight rate as the minimum freight rate of port-to-port route between the two countries.[6] We use 64 country-pairs for which both bilateral trade volume and bidirectional shipping cost information are available.[7]

[5] For a detailed discussion of Drewry data, see Wong (2017).

[6] We use the freight rate in July as the freight rate in that year. The year in which the freight rate information was first available differs across routes. For example, the freight rate from Canada to Korea was first available in 2010, while the freight rate from Korea to Canada was first available in 2012.

[7] The ISO country codes for these 64 country-pairs are as follows: ARE-CHN, CAN-AUS, AUS-CHN, AUS-GBR, AUS-JPN, AUS-KOR, AUS-USA, BRA-CAN, BRA-CHN, BRA-GBR, BRA-IND, BRA-JPN, BRA-KOR, BRA-USA, BRA-ZAF, CAN-CHN, CAN-GBR, CAN-IND, CAN-KOR, CAN-ZAF, CHN-CHL, CHL-GBR, CHN-COL, CHN-EGY, CHN-GBR, CHN-IND, CHN-IDN, CHN-JPN, CHN-KOR, CHN-MYS, CHN-NZL, CHN-PHL, CHN-RUS, CHN-SAU, CHN-THA, CHN-TUR, CHN-USA, CHN-VNM, CHN-ZAF, GBR-COL, CBR-IND, GBR-JPN, GBR-KOR, GBR-TUR, GBR-USA, GBR-SZF, JPN-IND, JPN-IDN, IND-

The regression results for equation (1) are shown in Table 2. The first column of Table 2 shows the benchmark regression result for equation (1). α_1 is estimated at -0.071, implying that a 10% increase in the trade imbalance against a country is associated with a 0.71% decrease in the shipping cost from the country.

A ship might stop by at a few countries to fill up its load before returning to the first exporting country. This multi-port route arrangement by shipping companies may mitigate the negative relationship between trade imbalance and the shipping cost differential between two countries. Nonetheless, the negative estimates for α_1 suggests that even with such a possibility, the trade imbalance still has a significant and negative relationship with the shipping cost.

A particular route's trade volume may be affected by the average shipping cost it faces. For example, a lower shipping cost from country n to d may cause country d to increase its imports from n, leading country d to have a trade deficit against country n. If this is the dominating factor in determining the relationship between trade imbalance and shipping cost between country n to d, we would have observed a *positive* coefficient for α_1.

Even though trade cost may not be a dominating factor in determining trade imbalance, a lower shipping cost from country n to d may increase d's import from n, and thus influence the trade imbalance. Also, an unobserved component which affects both trade imbalance ans shipping cost might exist. To mitigate these issue, we use the following instrumental variable for Imbalance_{ndt}:

$$\Big\{\Big(\frac{\text{Import}_{dn2000}}{\text{Import}_{d2000}}\Big) \times \text{Gov}_{dt}\Big\} \Big/ \Big\{\Big(\frac{\text{Import}_{nd2000}}{\text{Import}_{n2000}}\Big) \times \text{Gov}_{nt}\Big\},$$

where Import_{dn2000} is country d's import from country n in 2000, Import_{d2000} is country d's aggregate import in 2000, and Gov_{dt} is government expenditure of county d in year t.

KOR, IND-USA, KOR-JPN, JPN-NZL, JPN-THA, JPN-USA, KOR-USA, KOR-ZAF, MEX-USA, MYS-USA, NZL-USA, PHL-USA, RUS-USA, THA-USA, TUR-USA, USA-ZAF. We exclude two European ports (Genoa, Rotterndam) and two east Asian hub ports (Singapore, Hong Kong) for which mapping between nationwide bilateral trade volume and bidirectional shipping cost information is not clear.

Import_{nd2000}, Import_{n2000} and Gov_{nt} are similarly defined. Since a country's multilateral current balance is determined by its savings and investment balance, a shock to savings and investment can be a shock to trade surplus. We consider government expenditure as a measure of fiscal policy shock. The government expenditure can change the trade imbalance but is assumed to be not directly correlated with shipping costs. We interact this government expenditure with the import share of the partner country in 2000 to construct the partner specific measure. The result with the IV regression is reported in the second column of Table 2. The negative relationship between shipping cost and imbalance still holds with the IV regression. The magnitude of the coefficient has increased from -0.071 to -0.126, suggesting a potential downward bias the OLS estimate.

Import Elasticity with respect to Shipping Cost

The novel prediction in Proposition 1 is that the import of heavy goods will increase relatively more than that of less heavy goods when the shipping cost decreases. To test this prediction, we consider the following equation:

$$\begin{aligned} \ln(\text{Import})_{i,ndt} =& \beta_0 \ln(\text{Shipping cost})_{ndt} + \beta_1 \ln(\text{Shipping cost})_{ndt} \times \ln\left(\frac{w_i}{p_i}\right) \\ &+ \eta_{i,nt} + \eta_{i,dt} + \epsilon_{i,ndt}, \end{aligned} \tag{2}$$

where n and d are the origin and destination countries respectively. i refers to a good in HS6 code. $\frac{w_i}{p_i}$ is the weight-to-value ratio of good i. $\eta_{i,nt}$ ($\eta_{i,dt}$) is the origin-good-year (destination-good-year) fixed effect. $\varepsilon_{i,ndt}$ is an random component with a zero mean. We allow $\varepsilon_{i,ndt}$ to be possibly correlated among the same good across countries, different goods in the same destination country, different goods in the same origin country.

The weight-to-value ratio for a particular route could be endogenous as the unobserved component $\varepsilon_{i,ndt}$ may affect the import volume of good i. To address this possibility, we use the weight-to-value ratio from the transaction level data on Colombian imports in 2007-2013 period. The data has been collected and made available by the National Tax Agency of Colombia.[8] For each transaction, the data reports the goods FOB value as well as the weight.[9] We assume that the Columbia's weight-to-value ratio is highly correlated with import good i's weight-to-value ratio of a country but is not correlated with other fundamental economic conditions which may affect the country's import value. Unfortunately, most countries do not collect the weight information by goods. So we can only test whether the correlation between Columbia import's weight-to-value ratio is quite similar with China import's weight-to-value ratio. In the Chinese custom data, 3,349 goods have weight-to-value ratio as well. We find the correlation between the Columbia and China's weight-to-value ratio is as high as 0.75.

Finally, We exclude all bilateral trade involving Colombia for our main regression.

Table 3 shows the regression results for equation (2). The first column shows the benchmark regression estimates for equation (2). β_0 is estimated at -0.732, meaning that the import of good i from Country A is about 7.3% larger than from Country B if the shipping cost from Country A is 10% smaller than from Country B. More importantly, β_1 is estimated at -0.069, suggesting that the absolute value of import elasticity with respect to the shipping cost is about 0.7% higher for good i than for good j if the weight per value of good i is 10% heavier than for good j.

In the second column of Table 3, we use log value of equation (**??**) as an instrumental variable for log shipping cost in year t. The result in the benchmark regression becomes more pronounced. For example, the magnitude of the estimate for β_1 increases from -0.069 to -0.169 in the IV regression. Even though we control for a shipping cost, other trade cost (e.g., tariff) may be destination-origin specific. In the third column of Table 3, we further control destination-origin-year fixed effect to absorb those pair specific components. The coefficient

[8]We thank Ahmad Lashkaripour for sharing this data.

[9]To give readers a better understanding of the weight-to-value ratio, we present five most heavy and light goods per value in In Table 1.

for the interaction term rarely changes from the benchmark estimate.

If importing a particular goods requires a fixed cost, the import value response less to a temporary shipping-cost change comparing to a persistent one. In the fourth column of Table 3, we include another interaction term with "Persist" dummy. It is a dummy variable indicating country pairs whose sign of bilateral trade imbalance never changed from 2015 to 2017. The shipping-cost channel is more pronounced among country-pairs in which the trade imbalance is rather persistent.

In the fifth column of Table 3, we use log imbalance as a proxy for log shipping cost. The coefficient for ln(imbalance) $\times \ln\left(\frac{w}{p}\right)$ is estimated at 0.0134. Imbalance may affect the import of a particular good by other mechanism than our shipping-cost channel. The shipping-cost channel ($\hat{\alpha}_1 \times \hat{\beta}_1$=-0.071×-0.169=0.012) explains more than 90% ($\frac{0.012}{0.0134} \times 100$) of the estimate for ln(imbalance) $\times \ln\left(\frac{w}{p}\right)$. This finding implies that the shipping-cost channel explain a substantial part of the differential effect of trade imbalance on import value with respect to the good's weight.

To summarize, the shipping cost is indeed negatively related with trade imbalance. Moreover, the import elasticity with respect to the trade imbalance, induced by the shipping-cost channel, is higher for good i than for good j if the weight per value of good i is heavier than for good j, as predicted by Proposition 1. This conclusion holds with a variety of fixed effects, and with an instrumental variable approach. Finally, the shipping-cost channel explains most of the import elasticity with respect to the trade imbalance.

2.2.1 The Case of the Mexican Trade

The Mexican case provides useful insight on an endogeneity issue with respect to trade imbalance. First, we use Mexico's peso depreciation as a shock to trade imbalance. Second, we use the port-level trade imbalance to alleviate an endogeneity concern raised by country-pair trades.

In the 1990s, Mexico experienced a high inflation, but maintained the peso's value using an exchange rate peg to the U.S. dollar. At the same time, the Mexican government undertook several reforms in the early 1990s, including the reform on the financial sector. Several years of large capital inflows, the peso came under attach in December 1994.[10] Mexico's Peso depreciated over 50% in 1994 causing a large trade surplus.

Figure 3 shows the Mexican trade surplus to GDP (solid line) and the exchange rate (dashed line) from 1993 to 1997. As we can see, the trade surplus to GDP ratio increases by 0.5% following the exchange rate depreciation. We view the large depreciation of peso following the currency attach as an exogenous shock to the trade imbalance, which does not directly correlate with heavy goods import.

Unfortunately, there is no shipping cost information for Mexico during the currency crisis. We use the change in the trade imbalance as a proxy for the change in shipping costs, and estimate the following gravity equation:

$$\ln(\text{Import})_{i,nt} = \beta_1 \ln(\text{Imbalance}_{nt}) \times \ln\left(\frac{w_i}{p_i}\right) + \eta_{i,t} + \eta_{nt} + \epsilon_{i,nt}, \tag{3}$$

where variable definitions are similar to equation (2). $\eta_{i,t}$ and η_{nt} are good-year and origin-year fixed effect, respectively. Mexico is the only destination, and, hence, the subscript d is dropped. Due to the Peso depreciation, Mexico exported more and ran a larger trade surplus, and our theory predicts that Mexico will import more heavy goods than the light goods following the Peso depreciation.

Table 4 shows the results from the UN Comtrade data. We use two years' observations before and after the exchange rate shock with a 5-year window between 1992 and 1996. The first column of Table 4 presents the benchmark estimates. β_1 is estimated at 0.0595, meaning

[10]For a detailed description on the Mexican peso crisis, see Aguiar (2005).

that the import elasticity with respect to the trade imbalance is about 0.6% higher for good i than for good j if the weight per value of good i is 10% heavier than for good j. In the second column of Table 4, we use the goods present both in 1992 and 1996 by subtracting equation (3) across years. β_1 is estimated at 0.0145. Note that the estimate in the fifth column of Table 3 (0.0134) is within the range of the estimates for Mexican data.

Port-level Evidence from China

For a given country, comparative advantage should be similar across different ports. As a robustness check, we use the port-level trade balance data from the Chinese custom database from 2000 to 2006. Besides information on the HS6 code, trade volume, destination or origin countries, we know the exact port used in the transactions. For a given port and HS6 good pair and a given trading partner, we sum up all bilateral imports and bilateral exports in a year, respectively. For example, we know Shanghai port's total exports to the United States by product, and the same port's total imports from the United States by product.

Figure 4 plots the export and import of each port in year 2006.[11] The x-axis and y-axis are the export and import values in logs. There is a large variation on the export and import values. Shanghai, the largest port in China, is ten times larger in trading volume, than the smallest port in terms of either imports or exports.

The gravity equation to be estimated is as follows

$$\begin{aligned} \ln(\text{Import})_{i,mnt} = & \beta_0 \ln(\text{Imbalance})_{mnt} + \beta_1 \ln(\text{Imbalance})_{mnt} \times \ln\left(\frac{w_i}{p_i}\right) \\ & + \eta_{i,mt} + \eta_{i,nt} + \varepsilon_{i,mnt} \end{aligned} \tag{4}$$

where m is a port in China. $I_{i,mnt}$ is good i's import of port m from country n. Imbalance_{mnt}

[11]Although we use the word port, we are actually meaning a custom city. For instance, Xining is not a coastal city, but there is still export and import by land. Given our story does not only hold for maritime trade, we include those inland cities in the analysis.

is the export from port m to country n divided by the total import of port m from country n. $\eta_{i,mt}$ and $\eta_{i,nt}$ are port-product-year and origin-product-year fixed effects, respectively.

We can interpret the above equation as follows: Suppose ships are more likely to return to the same port when they are back China.[12] If more ships leave for country n from port m than port h, the port m will import more heavy goods from country n than the port h. Potential endogeneity of trade imbalance is mitigated because the ports are within a common country and the export country is fixed. Trade imbalance across different ports are less likely to be affected by heavy goods trade volume difference.

Table 5 reports the estimation results. The first column shows the benchmark estimate. β_1 is estimated at 0.0098, indicating the import elasticity with respect to the trade imbalance is about 0.01% higher for good i than for good j if the weight per value of good i is 10% heavier than for good j. In the second column, we further control port-origin fixed effect. The estimate for β_1 decreases. Nevertheless, the estimates for β_1 are positive and significant, suggesting our mechanism holds even with a port-level trade imbalance.

Comparing to the estimate in the fifth column of Table 3 (0.0134), the coefficient for β_1 is rather small. We conjecture this is because within a country, multi-shipment across the country is easier to arrange, and therefore, the impact of trade imbalance for a port can be to some extent mitigated.

3 Imports of Industrial Waste

The story from the previous section provides important insight on the international movement of industrial waste. The waste good is defined as a good including either "waste" or "scrap" in its name.

[12] A ship usually has regular travel routine and takes a few ports as its home ports.

3.1 Some data patterns

Waste goods are one particular heavy goods. Figure 5 plots the density of weight (kg)/US dollar ratio of each good. The solid line is the weight-to-value ratio of waste goods and the dashed line is the ratio of other goods. On average, the weight-to-value ratio of other goods is very low, about 0.1 kg/USD. However, the wasted good is much heavier. The peak of the density is about 1 kg/USD. Since the wasted goods are much heavier than other goods, our theory predicts that surplus country should import more wasted goods.

To investigate whether the trade pattern of waste goods import is related to the mechanism in Section 2, we first estimate the following equation:

$$\begin{aligned}\ln(\text{Import})_{i,ndt} =&\beta_0 \ln(\text{Shipping cost})_{ndt} + \beta_1 \ln(\text{Shipping cost})_{ndt} \times \text{Waste} \\ &+ \eta_{i,nt} + \eta_{i,dt} + \epsilon_{i,ndt}.\end{aligned} \tag{5}$$

Note that equation (5) is identical to equation (2) except that we replace the value-to-weight variable with the waste-goods dummy.

The estimation results are presented in Table 6. In the first column, we present the benchmark estimate. β_1 is estimated at -0.058, suggesting that the absolute value of import elasticity with respect to the shipping cost is higher for waste goods. To see whether the higher elasticity for waste goods is because of its heavy weight per value rather than other properties of waste goods, we further include $\ln(\text{Shipping cost})_{ndt} \times \ln\left(\frac{w_i}{p_i}\right)$ into equation (5). The estimates are presented in the second column of Table 6. Once the weight per value is controlled, the elasticity with respect to waste goods is reduced about half (from -0.058 to 0.027). In the third and fourth column of Table 6, we re-estimate the first and second regression with the log value of equation **??** as an instrumental variable for log shipping cost. The result still holds.

These findings suggest that a part of the reason why countries with higher trade imbalance tend to import more waste goods is due to the shipping-cost channel discussed in Section 2.

3.2 Trade Surplus and Externality

Trade surplus can reduce incoming shipping cost per weight, and thus increase the heavy goods import relatively more. Because most waste goods are heavy per value, trade surplus can increase waste goods import relatively more than other goods through this shipping cost channel. If environmental regulation is strong in countries with a trade surplus, which may import substantial waste goods, our mechanism may not result in a significant welfare loss. However, we find that the pollution induced by waste goods processing seems not to be properly taxed in those countries.

To show this point, we use the environmental regulation stringency index (ERS) collected by OECD Statistics. The ERS is a country-specific and internationally-comparable measure of the stringency of environmental policy. Stringency is defined as the degree to which environmental policies place an explicit or implicit tax on polluting or environmentally harmful behaviour. The index ranges from 0 (not stringent) to 6 (highest degree of stringency). The index covers 28 OECD and 6 BRIICS countries. The index is based on the degree of stringency of 14 environmental policy instruments, primarily related to climate and air pollution. OECD Stat also releases in stringency of all these 14 policy instruments as well.[13]

Table 7 lists all countries ERS index. The left panel are indexes of BRIICKS and the right panel are indexes of other OECD countries. Note that developing countries often run a large trade surplus against developed countries. The ERS is significantly lower in BRIICKS. In table 8, we regress different measures of environmental regulation indexes on waste goods import, including the ERS index, environment tax index and the regulation standard index. At the same time, we control for the countries' GDP level, corruption level as well as government

[13]The BRIICS denote Brazil, Russia, India, Indonesia and China. The details of the data can be found at https://stats.oecd.org/Index.aspx?DataSetCode=EPS.

efficiency.[14] In all specifications, we do not find a significant correlation between trade surplus and environmental regulation policy.

To further investigate the welfare implication driven by the trade imbalance through the waste goods import channel, we use information from China. There are several reasons why we focus on Chinese economy. First, China is one of the largest waste goods importing countries, and did not impose a particular tax or regulation on imported waste goods in early 2000s. Second, as already shown in Figure 1, Chinese waste goods import from a country strongly correlates with the trade surplus that China runs against the country, as our theory predicts. To add to this point, we show the top 10 imported goods of China from US and Germany in Table 9. While both US and Germany are developed countries, China runs a particularly high trade surplus against US. In line with our theoretical prediction, relatively more waste goods are imported from US.

To gauge to what extent the waste import is associated with pollution in China, we regress the yearly pollution index of Chinese cities on the city's waste goods import between 2003 and 2006. The data of city total pollutant emissions coming from China city yearly statistics book (2000-2006). The book reports three measures for pollutants including total waste water emission, total dust emission and total SO2 emission. All of them are measured in terms of weights. Regarding waste goods import, we focus three types of waste goods: (1) plastic waste, (2) textile waste, and (3) metal waste. Out of 109 waste goods that we consider, these three waste goods consist of more than 98% in terms of weight.[15] For example, in 2006, plastic, textile, and metal waste imports account for 13%, 37%, and 48% of all waste goods imports measured by weight, respectively.

Table 12 shows the estimation results. In all the regressions, we control log city population,

[14]The corruption index and regulation quality index are collected from World Bank Governance Indicator data set. The data can be found at http://databank.worldbank.org/data/reports.aspx?source=worldwide-governance-indicators.

[15]The way we classify these three types of wastes goods are presented in Table 11 and 10.

log manufacture sector output and log GDP of the city. We also control city and year fixed effect. The first column shows the estimation result for log(so2). The impact of textile waste import is pronounced. A 10% increase in textile waste import is associated with about 1% increase in so2. The second column shows the estimation result for log dust emission. The impact of plastic and textile waste import are relatively large, but the coefficients are rather insignificant. First column shows the estimation result for log(so2). The third column shows the estimation result for log water pollution. The impact of textile and metal waste import are more pronounced. A 10% increase in textile and metal waste import leads to 0.5% and 0.4% increase in the water pollution, respectively. Overall, our regression results suggest a positive relationship between waste goods imports and pollution in China.

4 A Quantitative Model and Policy Evaluations

In this section, we present a model, calibrate it with Chinese data, and use it to evaluate and compare several policies meant to address the inefficiency. The key counter-factual that the regression equations cannot address is a possibility that domestic waste good production would adjust endogenously in response to a policy-induced change in the waste goods imports. We apply a flexible specification between domestic waste good production and waste goods imports in the model, and pin down the substitutability (or complementarity) between the two by using Chinese data.

We use our model to assess the recent ban of waste good imports imposed by Chinese government. Recognizing a large negative effect on their environment, Chinese government recently banned importing waste goods. Our framework can be used to evaluate this type of policy on Chinese economy.

4.1 Consumer problem

We model a small open economy. The home country is populated by identical consumers of measure Lff0c each to live two periods. Each agent has one unit of labor and supplies it inelastically. He can save through the international capital market at an exogenous interest rate R.

The representative consumer's one period utility, $U(c, x)$, comes from consumption c and home country pollution x. $U_c > 0$ and $U_x < 0$. In the process of consumption, some q_{st} amount of scrapped goods are generated, where subscript s is used to denote the scrap goods:

$$q_{st} = \phi c_t \tag{6}$$

In other words, the scrapped goods are assumed to be a fixed proportion $\phi > 0$ of the final consumption goods. The scrapped goods can be used as an intermediate input to produce the normal goods g or can be exported abroad. We denote p_{hhs} as the price of the scrapped goods in the home country and $\tau_{hfs} > 1$ is the iceberg cost of exporting 1 unit of scrap goods. Then the export price for the scrap good is

$$p_{hfs} = \tau_{hfs} p_{hhs} \tag{7}$$

The consumer's problem is as follows:

$$\max U(c_1, x_1) + \rho U(c_2, x_2) \tag{8}$$

$$s.t. \quad P_t c_t + S_t = w_t L + R_t S_{t-1} + p_{hhst} q_{hhst} + p_{hhst} q_{hfst} + \Pi_t, \quad t = 1, 2 \tag{9}$$

$$q_{hhst} + \tau_{hfst} q_{hfst} \leq q_{st} \tag{10}$$

$\rho \in (0,1)$ is the discount factor. P_t is the price of the final consumption goods. w_t is the wage per unit of labor in the home country. S_t is the saving of the country or the current account surplus. q_{hhs} and q_{hfs} denote the quantity of scrap goods sold domestically and internationally. The left hand side of equation (9) is the expenditure of consumption plus the saving in period t. The right hand side of equation (9) is the income of the household, including labor income, saving in the last period and income from selling the scrap goods. In the two periods model, we assume $S_0 = S_2 = 0$. Π_t is the lump-sum transfer.

The second constraint says that the total amount of scrap goods sold on the domestic market and foreign market should be less than q_{st}. τ_{hfst} is the ice-berg cost of exporting scrap goods, which will depend on the trade imbalance.

$$\tau_{hfst} = \bar{\tau}_{hfst} \left(1 + \frac{S_t}{w_t}\right)^{\upsilon} I(S_t < 0) \tag{11}$$

where $I(.)$ is an indicator function. $\bar{\tau}_{hfst}$ is the level of the trade cost if $S = 0$. When the country runs a trade deficit, it is less expensive to ship the scrap goods outside the country. υ measures the elasticity with respect to the trade imbalance.

Moreover, we assume $U(c,x) = \ln c - \eta x$, where η measures the utility loss due to pollution. The solution of the consumer problem is

$$c_1 = \frac{1}{1+\rho} \frac{I_1 + \frac{I_2}{R_1}}{P_1 - \phi p_{hhs1}} \tag{12}$$

$$c_2 = \frac{\rho R_1}{1+\rho} \frac{I_1 + \frac{I_2}{R_1}}{P_2 - \phi p_{hhs2}} \tag{13}$$

$$S_1 = \frac{\rho}{1+\rho} I_1 - \frac{1}{1+\rho} \frac{I_2}{R_1} \tag{14}$$

where $I_t = w_t L + \Pi_t$ as the income of the household excluding the saving.

4.2 Final Goods Producer

There is a representative final good producer who uses a combination of domestic intermediate goods c_{hhg} and imported intermediate goods c_{fhg} to produce c_t amount of final consumption goods. We use subscript g to denote the intermediate goods sector. The technology of the final good producer is

$$c_t = \left(\omega_g^{\frac{1}{\varepsilon}} c_{hhgt}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega_g)^{\frac{1}{\varepsilon}} c_{fhgt}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{15}$$

where ε is the elasticity of substitution between home and foreign goods, ω_g measures the preference on home product. We assume that the imported goods price is exogenous. We also assume that the intermediate goods is not as heavy as the scrap goods so that the transportation cost is exogenous and does not depend on the trade imbalance. We use p^*_{fhgt} to denote the exogenous foreign goods price on the domestic market. The solution of the final goods producer is

$$c_{hhgt} = \omega_g c_t \left(\frac{p_{hhgt}}{P_t} \right)^{-\varepsilon} \tag{16}$$

$$c_{fhgt} = (1-\omega_g)\, c_t \left(\frac{p^*_{fhgt}}{P_t} \right)^{-\varepsilon} \tag{17}$$

where P_t is the the price of final goods

$$P_t^{1-\varepsilon} = \omega_g p_{hhgt}^{1-\varepsilon} + (1-\omega_g)\, p_{fhgt}^{*1-\varepsilon} \tag{18}$$

4.3 Intermediate Goods Producer

The country has a representative firm in the goods sector which uses labor and the scrap to produce intermediate goods

$$y_{gt} = A_t L_{gt}^{\theta} Q_{st}^{1-\theta}, \qquad t = 1, 2 \tag{19}$$

where A_t is the productivity, θ is the labor input elasticity. L_{gt} is the labor allocated in the production. Q_{st} is the scrap goods bundle defining as

$$Q_{st} = [\omega_s^{\frac{1}{\beta}} q_{hhst}^{\frac{\beta-1}{\beta}} + (1-\omega_s)^{\frac{1}{\beta}} q_{fhst}^{\frac{\beta-1}{\beta}}]^{\frac{\beta}{\beta-1}} \tag{20}$$

where β is the elasticity between domestic and foreign scrapped goods. ω_s is the home preference over home scrapped goods. q_{hhst} and q_{fhst} are the domestic scrap and the imported scrap respectively.

The FOB price of the foreign scrap, p_{fhst}^{*}, is assumed to be exogenous. The trade cost of the imported scrap τ_{fhst} is endogenously determined by the trade surplus, similar to equation (11).

$$\tau_{fhst} = \bar{\tau}_{fhst} \left(1 + \frac{S_t}{w_t}\right)^{-v} I(S_t > 0) \tag{21}$$

where $\bar{\tau}_{fhst}$ controls the level of the trade cost and v measures the elasticity with respect to the trade imbalance. $I\,(.)$ is an indicator function. The above equation says that the scrapped goods trade cost is decreasing with respect to the trade surplus.

In the production procedure, it will generate by_{gt} amount of pollution, where b is the pollution per unit of output. Let $\bar{x}_t$ denote the amount of pollution the firm chooses to eliminate and $x_t = by_{gt} - \bar{x}_t$ is the pollution emission. The pollution abatement cost rises non-linearly with the quantity of pollution that is eliminated and can be described by $\frac{\xi w_t}{2}\bar{x}_t^2$. We assume that the government imposes a pollution tax of T_t for each unit of pollution emission.

The firm's optimization problem can be written as

$$\max[p_{hhgt}y_{hhgt} + p_{hfgt}y_{hfgt} - w_t L_{gt} - p_{hhs}q_{hhst} - \tau_{fhst}p^*_{fhst}q_{fhst} \tag{22}$$
$$-\frac{\xi w_t}{2}\bar{x}_t^2 - T_t(by_{gt} - \bar{x}_t)]$$

$$s.t.\ by_{hhgt} + by_{hfgt} - \bar{x}_t \geq 0 \text{ and } (19)$$

The first two terms in the equation (22) are the revenues from selling the products to the home country and the foreign country. The cost of the firm is the sum of production cost, abatement cost and the penalty on pollution.

The FOCs will yield the follows:

$$\bar{x}_t = \frac{T_t}{\xi w_t} \tag{23}$$

$$p_{hfgt} = \tau_{hfgt}p_{hhgt} \tag{24}$$

$$p_{hhgt} = \frac{1}{A_t}\left(\frac{w_t}{\theta}\right)^{\theta}\left(\frac{p_{st}}{1-\theta}\right)^{1-\theta} + bT_t \tag{25}$$

$$L_{gt} = \theta\frac{(p_{hhgt} - bT_t)y_{gt}}{w_t} \tag{26}$$

$$q_{hhst} = (1-\theta)\,\omega_s\frac{(p_{hhgt} - bT_t)y_{gt}}{p_{st}}\left(\frac{p_{hhst}}{p_{st}}\right)^{-\beta} \tag{27}$$

$$q_{fhst} = (1-\theta)\,(1-\omega_s)\frac{(p_{hhgt} - bT_t)y_{gt}}{p_{st}}\left(\frac{\tau_{fhst}p^*_{fhst}}{p_{st}}\right)^{-\beta} \tag{28}$$

where p_{st} is the price index of Q_{st}

$$p_{st}^{1-\beta} = \omega_s p_{hhst}^{1-\beta} + (1-\omega_s)\,(\tau_{fhst}p^*_{fhst})^{1-\beta} \tag{29}$$

Equation (24) says that the price charged to the foreign market is higher than domestic price because of the trade cost. Equation (25) suggests that the domestic price equals to the marginal cost. And the marginal cost has two components: the production cost including labor cost and the input cost; and the environmental regulation cost. If $T_t = 0$, the marginal cost will equal to production cost only and the pollution reduction $\bar{x}_t = 0$ from equation (23). Equations (26) to (28) are the demand functions of labor, domestic scrap goods and foreign scrap goods.

4.4 Equilibrium

The Lump sum transfer Π_t comes from firm government tax and firm profit: $\Pi_t = T_t(by_{gt} - \bar{x}_t) + T\bar{x}_t - \frac{\xi w_t}{2}\bar{x}_t^2$. The first term is the environmental tax and the second term is the firm's profit. Imposing the optimality condition (23), we have $\Pi_t = T_t by_{gt} - \frac{1}{2}\frac{T_t^2}{\xi w_t}$.

A competitive equilibrium is defined as a vector of prices $\{w_t, p_{hhgt}, p_{hhst}\}$, final goods consumption and saving $\{c_t, S_t\}$, intermediate goods $\{c_{hhgt}, c_{fhgt}, y_{gt}\}$, trade cost of scrap goods τ_{fhst}, pollution reduction $\bar{x}$, and scrapped goods demand in the production $\{q_{hhst}, q_{fhst}\}$ such that (i) Given the prices, all individual optimality conditions are satisfied; (ii) The labor market clears, $L_{gt} + \frac{\xi}{2}\bar{x}_t^2 = L$; (iv) The scrapped goods market clears, $q_{hhst} + \tau_{hfst}q_{hfst} = \phi c_t$.

4.5 Calibrations

We assume that in both periods, all parameters remain the same. We ignore the subscripts of the parameters. Following Broda and Weinstein (2006), we choose $\varepsilon = \beta = 5$ so that the elasticity of substitution between home and foreign goods is 4. $\omega_g = 0.92$ and $\omega_s = 0.45$ are calibrated to match the expenditure share of imported normal goods (8%) and scrapped goods (55%) respectively. θ is set to 0.97 to match the scrap goods share in the China input-output table. We set $\phi = 0.05$ so that 5% of the goods will be scrapped.

We normalize the labor force $L = 1$ and calibrate the sector productivity A to normalize the wage to be 1. We calibrate ρ to match the trade surplus/GDP ratio (4%). We set all the trade costs to 1.2, suggesting that the trade cost are around 20% of the trade prices, according to the Anderson and Van Wincoop (2004).

Foreign aggregate demand D_g and D_s are set to match the goods export/GDP ratio and scrapped goods export/GDP of China. Import prices p_{fhg} and p^*_{fhs} are set to match the normal and scrapped goods import/GDP. The elasticity of scrapped goods trade costs with respect to the trade surplus υ is set to 0.4, according to our previous analysis.

We set T to 0 in the benchmark. In our model, we choose 1 unit of pollutant emission as 1,000 tons of pollutant. b is set to 1.8 to match the thousand ton pollutant emission per GDP.[16] We set ξ to 20 to match the SO2 emission trade price.[17] We set $R = 10\%$ (including the depreciation).

Finally, we assume the utility is $U(c, x) = \ln(c) - \eta x$. Following Cervellati and Sunde (2011) and Ebenstein et al. (2017), we set $\eta = 0.06$, suggesting that a 1000 ton increase of the pollutant equals to 6% consumption drop.[18]

4.6 Policy Evaluations

We are interested at three counter-factual analysis: (1) Increasing the import barrier of scrapped goods. For instance, starting from 2018, Chinese government implemented a scrap import ban. (2) Erasing the trade surplus; (3) Increasing the pollution regulation to the optimal level.

Ex ante, we know that Policy (3) should achieve the first best (if it is feasible). So our goal

[16] From the China city statistical yearbook, we aggregate all pollutants including air pollutants, solid pollutants and water pollutants. We then divide it by the total GDP.

[17] The SO2 emission trade price in US is 1,600,000 usd per thousands ton (Burtraw and Szambelan (2009)) or around 200% of the annual wage of US. We assume the abatement technology is the same in US and China.

[18] Cervellati and Sunde (2011) estimates a 1 year decline of life expectancy decreases income by around \$200. And Ebenstein et al. (2017) estimates that 1 $\mu g/m^3$ increase of PM_{10} will result in 0.064 years life expectancy drop. We assume that a 1000 ton emission will increase the density by 10 $\mu g/m^3$. So a 1000 ton emission will decrease the income by $0.064 * \$200 * 10 = \$128$, which is about 6% of Chinese average annual consumption.

is to evaluate how close Options (1) and (2) approximates (3), respectively.

To separate the effect of trade surplus, we add one column: imposing the trade cost=0 but the import cost still keeps low.

Table 13 summarizes the result. In the first column, we report the benchmark calibrated result. The first row reports the pollution level, which we normalize the benchmark level to be 100. The second and the third row report the scrap import/total import in the two periods respectively. The third row reports the trade surplus/GDP. This three numbers are calibrated to match the data moments in the benchmark economy. The fifth row shows the utility change (in terms of consumption equivalent) relative to the benchmark economy. The last two rows show the consumption levels in the two periods. We normalize the first period consumption to be 100. Because China runs a trade surplus, the second period consumption will be higher.

We start our experiment by banning all the scrap import, a policy that Chinese government implemented from 2018. The scrap import in both periods will sharply decline to 0. The trade surplus will slightly decline from 4% to 3.96%. The consumption in both periods will decline because the scrap tariff will drive up the production cost. However, pollution will decline by about 7-10% so the utility (consumption equivalent) actually increases by 0.38%, despite the fact of rising production cost.

In the third column, we erase the trade surplus. The scrap import will decrease due to the increase of the import cost. However, the pollution level nearly does not change. This is because firms try to use domestic scrap goods to support the production. On the other hand, the utility will slightly increase. There are a few effects going on: first, shutting down the consumption-smoothing may decrease the welfare. For instance, in the fifth column, we only show down the surplus and impose the import cost does not change, then the utility goes down by 0.14% since the consumption-smoothing channel is shut down. Second, when the import cost goes up after removing the surplus, the utility will only decrease by 0.1%. This is because the production cost goes up will push the production and, and especially, pollution go down.

In the last column, we show the optimal regulation case. We find that when $T = 20.4\%$, the consumer's welfare will be maximized. In this case, the wage will be pushed up because firms need to hire workers to reduce the emission and the consumption will slightly increase by 1% to 3.8%. However, the pollution nearly does not change due to firms choose to control the emission. So the utility will increase by 2.09%.

To summarize, we demonstrate two observations in this calibration exercise: (1) trade surplus brings about 0.04% welfare cost through the scrap goods import; (2) Imposing a trade barrier on the scrap import can improve the welfare by about 0.38% but the most significant policy is to impose the pollution regulation efficiently.

5 Conclusion

This is the first paper that explores how a trade imbalance can affect import/export compositions. Consistent with our theory, we find that trade surplus countries import more heavy goods, especially scrap metals and other industrial waste. We apply our theory to explain why China imports so much waste goods. The mechanism we study suggests a concrete channel for a trade surplus to generate a welfare loss, especially in developing countries that have a lax environmental standard.

References

M. Aguiar. Investment, devaluation, and foreign currency exposure: The case of mexico. *Journal of Development Economics*, 78(1):95–113, 2005.

J. E. Anderson and E. Van Wincoop. Trade costs. *Journal of Economic literature*, 42(3): 691–751, 2004.

K. Behrens and P. M. Picard. Transportation, freight rates, and economic geography. *Journal of International Economics*, 85(2):280–291, 2011.

C. Broda and D. E. Weinstein. Globalization and the gains from variety. *The Quarterly journal of economics*, 121(2):541–585, 2006.

D. Burtraw and S. J. Szambelan. Us emissions trading markets for so2 and nox. *Permit Trading in Different Applications*, pages 15–45, 2009.

M. Cervellati and U. Sunde. Life expectancy and economic growth: the role of the demographic transition. *Journal of economic growth*, 16(2):99–133, 2011.

G. F. De Oliveira. Determinants of european freight rates: The role of market power and trade imbalance. *Transportation Research Part E: Logistics and Transportation Review*, 62:23–33, 2014.

A. De Palma, R. Lindsey, E. Quinet, and R. Vickerman. *A handbook of transport economics*. Edward Elgar Publishing, 2011.

R. Dekle, J. Eaton, and S. Kortum. Unbalanced trade. *The American Economic Review*, 97 (2):351–355, 2007.

S. Djankov, C. Freund, and C. S. Pham. Trading on time. *The Review of Economics and Statistics*, 92(1):166–173, 2010.

A. Ebenstein, M. Fan, M. Greenstone, G. He, and M. Zhou. New evidence on the impact of sustained exposure to air pollution on life expectancy from china's huai river policy. *Proceedings of the National Academy of Sciences*, page 201616784, 2017.

P. Epifani and G. Gancia. Global imbalances revisited: The transfer problem and transport costs in monopolistic competition. *Journal of Journal of International Economics*, 108(5): 99–116, 2017.

J. A. Frankel. Environmental effects of international trade. *Working Paper*, 2009.

F. Friedt and W. W. Wilson. Trade, transportation and trade imbalances: An empirical examination of international markets and backhauls. *Working Paper*, 2015.

D. Hummels and A. Skiba. Shipping the good apples out? an empirical confirmation of the alchian-allen conjecture. *Journal of Political Economy*, 112(6):1384–1402, 2004.

D. L. Hummels and G. Schaur. Time as a trade barrier. *The American Economic Review*, 103 (7):2935–2959, 2013.

O. Jonkeren, E. Demirel, J. van Ommeren, and P. Rietveld. Endogenous transport prices and trade imbalances. *Journal of Economic Geography*, 11(3):509–527, 2010.

D. Kellenberg. Trading wastes. *Journal of Environmental Economics and Management*, 64(1): 68–87, 2012.

D. K. Kellenberg. An empirical investigation of the pollution haven effect with strategic environment and trade policy. *Journal of international economics*, 78(2):242–255, 2009.

J. Lan, M. Kakinaka, and X. Huang. Foreign direct investment, human capital and environmental pollution in china. *Environmental and Resource Economics*, 51(2):255–275, 2012.

A. Lashkaripour. Worth its weight in gold: Product weight, international shipping and patterns of trade. *Working Paper*, 2015.

W. F. Wong. The round trip effect: Endogenous transport costs and international trade. *Working Paper*, 2017.

Tables and Figures

Table 1: Five Most Heavy and Light Goods

Heavy Goods	Light Goods
Bitumen and asphalt	Diamond
Limestone flux	Precious metal
Wasted Granulated slag from iron	Gold
Ceramic building bricks	Halogenated derivatives
Scrap of glass	Watch

NOTE: This table shows 5 goods which have the highest (lowest) weight-to-value ratio from the transaction level data on Colombian imports in 2007-2013 period.

Table 2: Estimates for the Main Regressions: Shipping Cost

	(1) $\ln \lambda_{ndt}$	(2) $\ln \lambda_{ndt}$
$\ln(\text{Imbalance})_{ndt}$	-0.071***	-0.126***
	(0.024)	(0.0349)
Country-pair-year FE	Y	Y
IV		Y
Obs.	596	434
R-squared	0.82	0.83

Notes: This table shows the estimation results of equation (1). λ_{ndt} is the shipping cost from an origin country (n) to a destination country (d) in year t. Imbalance means bilateral trade imbalance between a country-pair in a year, measured by the total export of d to n divided by the total import of d from n. We use the variable in (**??**) for an instrumental variable for Imbalance_{ndt} *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Estimates for the Main Regressions: Log Import Value

	(1) $\ln(\text{Import})_{i,ndt}$	(2) $\ln(\text{Import})_{i,ndt}$	(3) $\ln(\text{Import})_{i,ndt}$	(4) $\ln(\text{Import})_{i,ndt}$	(5) $\ln(\text{Import})_{i,ndt}$
$\ln \lambda_{ndt}$	-0.732***	-1.493***		-0.734***	
	(0.017)	(0.034)		(0.017)	
$\ln \lambda_{ndt} \times \ln\left(\frac{w_i}{p_i}\right)$	-0.069***	-0.169***	-0.066***	-0.058***	
	(0.007)	(0.013)	(0.006)	(0.007)	
$\ln \lambda_{ndt} \times \ln\left(\frac{w_i}{p_i}\right) \times$ Persist				-0.017***	
				(0.001)	
$\ln(\text{Imbalance})_{ndt} \times \ln\left(\frac{w_i}{p_i}\right)$					0.0134***
					(0.005)
Origin-good-year FE	Y	Y	Y	Y	Y
Destination-good-year FE	Y	Y	Y	Y	Y
Destination-Origin-year FE			Y		Y
IV		Y			
Obs.	1,867,062	873,074	1,867,062	1,867,062	1,867,062
R-squared	0.81	0.82	0.75	0.81	0.71

Notes: This table shows the estimation results of equation (2). $\text{Import}_{i,ndt}$ is the import of good i from an origin country (n) to a destination country (d) in year t. λ_{ndt} is the shipping cost from an origin country (n) to a destination country (d) in year t. Imbalance means bilateral trade imbalance between a country-pair in year t, measured by the total export of d to n divided by the total import of d from n. "w/p" is the weigh-to-value ratio from the Colombian data. "Persist" is the dummy variable indicating one partner within a pair runs a persistent trade surplus to the other partner. We use the log value of equation (**??**) for an instrumental variable for $\ln \lambda_{ndt}$. Standard errors are clustered at goods, destination, origin level. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Estimates for the Event Study with Mexican Peso Crisis

	(1) $\ln(\text{Import})_{i,nt}$	(2) $\Delta\ln(\text{Import})_{i,nt}$
$\ln(\text{Imbalance})_{nt} \times \ln\left(\frac{w_i}{p_i}\right)$	0.0595***	
	(0.003)	
$\Delta\ln(\text{Imbalance})_{nt} \times \ln\left(\frac{w_i}{p_i}\right)$		0.0145***
		(0.005)
Good-year FE	Y	Y
Origin-year FE	Y	Y
Obs.	192,356	133,459
R-squared	0.5	0.2

Notes: This table shows the estimation results for the Mexican data. $\text{Import}_{i,ndt}$ is the import of good i from an origin country (n) to Mexico in year t. Imbalance means bilateral trade imbalance between a country-pair in year t, measured by the total export of d to n divided by the total import of d from n. "w/p" is the weigh-to-value ratio from the Colombian data. Standard errors are clustered at goods, origin level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Estimates for the Chinese Port data

	(1) $\ln(\text{Import})_{i,nmt}$	(2) $\ln(\text{Import})_{i,nmt}$
$\ln(\text{Imbalance})_{nmt}$	0.051***	0.002
	(0.002)	(0.002)
$\ln(\text{Imbalance})_{nmt} \times \ln\left(\frac{w_i}{p_i}\right)$	0.0098***	0.0057***
	(0.001)	(0.001)
Port-good-year FE	Y	Y
Origin-good-year FE	Y	Y
Port-origin FE		Y
Obs.	4,970,457	4,970,457
R-squared	0.79	0.81

Notes: This table shows the estimation results for the Mexican data. $\text{Import}_{i,nmt}$ is the import of good i from an origin country (n) to a Chinese port (m) in year t. Imbalance means bilateral trade imbalance between a Origin-port pair in year t, measured by the total export of d to m divided by the total import of m from n. "w/p" is the weigh-to-value ratio from the Colombian data. Standard errors are clustered at goods, origin level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Estimates for Waste-Goods Regressions

	(1) $\ln(\text{Import})_{i,ndt}$	(2) $\ln(\text{Import})_{i,ndt}$	(3) $\ln(\text{Import})_{i,ndt}$	(4) $\ln(\text{Import})_{i,ndt}$
$\ln \lambda_{ndt}$	-0.593***	-0.733***	-1.136***	-1.484***
	(0.009)	(0.017)	(0.018)	(0.034)
$\ln \lambda_{ndt} \times$ Waste	-0.058	-0.027	-0.718***	-0.511**
	(0.111)	(0.112)	(0.203)	(0.204)
$\ln \lambda_{ndt} \times \ln\left(\frac{w_i}{p_i}\right)$		-0.069***		-0.166***
		(0.007)		(0.0133)
Origin-good-year FE	Y	Y	Y	Y
Destination-good-year FE	Y	Y	Y	Y
IV			Y	Y
Obs.	1,860,951	1,860,606	870,119	870,044
R-squared	0.81	0.81	0.82	0.82

Notes: This table shows the estimation results for waste goods in the UN data. $\text{Import}_{i,ndt}$ is the import of good i from an origin country (n) to a destination country (d) in year t. λ_{ndt} is the shipping cost from n to d in year t. Imbalance means bilateral trade imbalance between a country-pair in year t, measured by the total export of d to n divided by the total import of d from n. "w/p" is the weigh-to-value ratio from the Colombian data. "Waste" is the dummy variable for waste goods. We use the log value of equation (**??**) for an instrumental variable for $\ln \lambda_{ndt}$. Standard errors are clustered at goods, destination, origin level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: ERS Index

BRIICKS	ERS	OECD	ERS
Brazil	0.42	Turkey	0.88
Indonesia	0.44	USA	1.05
South Africa	0.44	Slovak Republic	1.10
India	0.60	Australia	1.17
Russian Federation	0.65	Poland	1.27
China	0.85	Norway	1.42
		Ireland	1.46
		Italy	1.49
		Canada	1.58
		Czech Republic	1.63
		Switzerland	1.69
		Greece	1.73
		United Kingdom	1.73
		Japan	1.90
		Netherlands	1.90
		Belgium	1.98
		France	2.13
		Portugal	2.13
		Hungary	2.33
		Korea, Rep.	2.33
		Austria	2.40
		Finland	2.48
		Denmark	2.59
		Germany	2.67
		Spain	2.75
		Sweden	2.75

Notes: This table lists the environment regulation stringency index of OECD countries and 6 BRIICKS countries in in 2004. High index denotes high regulation.

Table 8: Results of Regulation and Waste Imports

	(1) ERS	(2) Environment tax	(3) Regulation Standard
ln(Waste Import)	-0.011	-0.015	-0.017
	(0.013)	(0.042)	(0.012)
$\ln GDP$	-0.199	-5.089	5.351***
	(1.311)	(4.243)	(1.184)
Corruption	-0.727**	-1.017	-0.098
	(0.339)	(1.069)	(0.306)
Regulation Quality	0.187	-1.005	0.451*
	(0.279)	(0.901)	(0.252)
Country FE	Y	Y	Y
Year FE	Y	Y	Y
Obs.	93	96	93
R-squared	0.94	0.85	0.96

Notes: This table shows the estimation results of the regulation stringency. The three columns use EPS index, environment tax index and pollution regulation standard index as independent variables respectively. ***, ** and * denote the coefficient is significant at 1%, 5% and 10% levels.

Table 9: Top 10 imported goods of China

	China-US	China-Germany
1	Monolithic integrated circuit	Bus
2	Soy bean	Transmission
3	Aircraft	Aircraft
4	Car	Electric Sunroof
5	Copper scrap	Coupe
6	Waste cotton	Wine
7	Waste cardboard	Radioactive compactors
8	Brewing residue	Heavy goods vehicles
9	Aluminum scrap	Copper scrap
10	Turbojet engine parts	Antiserum

Notes: This table shows the Chinese top 10 imported goods from US and Germany in 2013.

Table 10: Three types of Waste Goods Imported by China

HS6 code	Name
	Plastic waste
391510	Waste and scrap of ethylene polymer
391520	Styrene scrap and scrap
391530	Waste and scrap of vinyl chloride polymer
391590	Other plastic waste scrap and scrap
	Textile waste
440130	Sawdust, wood waste and debris
450190	Deciduous, granular or powdered cork
470620	A fiber pulp extracted from recycled (scraped) paper or paperboard
470710	Recycled (scraped) unbleached kraft paper or corrugated paper and cardboard
470720	Recycling (waste) Bleached chemical wood pulp is made without bulk dyeing paper
470730	A paper or paperboard made mainly of mechanical pulp
470790	Recycling (scraping) of other paper and paperboard, including unselected
500300	Not comb waste silk
500310	Not comb waste silk
500390	Other waste silk
520210	Waste cotton yarn (including waste cotton)
520299	Other waste cotton
530130	Flax staple fiber and waste linen
530290	Other processed but unspecified marijuana; cannabis staple fiber and scrap
530390	Other processed but not spun and other bark fibers and staple fiber and waste Ma
530490	Other processed but unwoven agave fibers and their staple fibers and waste linen
530500	Ramie staple fiber and waste
530519	Other coconut fiber, coconut fiber staple fiber, linen and scrap
530529	Other abaca, abaca fiber staple fiber, linen and waste
530590	Ramie staple fiber and scrap
530599	Ramie staple fiber and scrap
550510	Synthetic fiber waste
550520	Man - made fiber waste
631010	Has been sorted textile fabric broken fabric and waste rope rope cable and its products
631090	Uncategorized Textile Materials Shredding Fabrics and waste rope rope cable and Articles

Table 11: Three types of Waste Goods Imported by China (continued)

HS6 code	Name
	Metal waste
720410	Cast iron scrap
720421	Stainless steel scrap
720429	Other alloy steel scrap
720430	Tinned steel scrap
720441	Metal scrap produced during metal cutting
720449	Iron and steel scrap
740400	Copper scrap
750300	Nickel scrap
760200	Aluminum scrap
780200	Lead scrap
790200	Zinc scrap
800200	Tin scrap
810191	Unwrought tungsten, including simple sintered strips, rods; scraps
810197	Tungsten waste scrap
810291	Unwrought molybdenum, including simple sintered bars, rods; scraps
810297	Molybdenum waste scrap
810310	Unwrought tantalum and simple sintered into bars, rods; waste scrap; powder
810330	Tantalum waste scrap
810420	Magnesium scrap
810510	Cobalt and other smelting cobalt intermediate products; not forged cobalt and waste; cobalt powder
810530	Cobalt scrap
810600	Unwrought bismuth; waste scrap; powder
810710	Unwrought cadmium; waste scrap; powder
810730	Cadmium waste scrap
810810	Titanium scrap
810830	Titanium scrap
810910	Not forging zirconium; waste scrap; powder
810930	Zirconium waste scrap
811000	Waste scrap
811020	Antimony scrap
811100	Not forging manganese; waste scrap; powder
811211	Not forging beryllium; waste scrap; powder
811213	Beryllium waste scrap
811222	Chrome scrap
811252	Thallium waste scrap
811291	Not forging gallium, hafnium, indium, rhenium, niobium, thallium; waste scrap
811292	Unwrought gallium, hafnium, indium, rhenium, niobium; waste scrap; powder
811300	Cermets and their products, including waste and scrap
700100	Broken glass and waste glass; glass block material

Table 12: Estimation Results for Pollutant

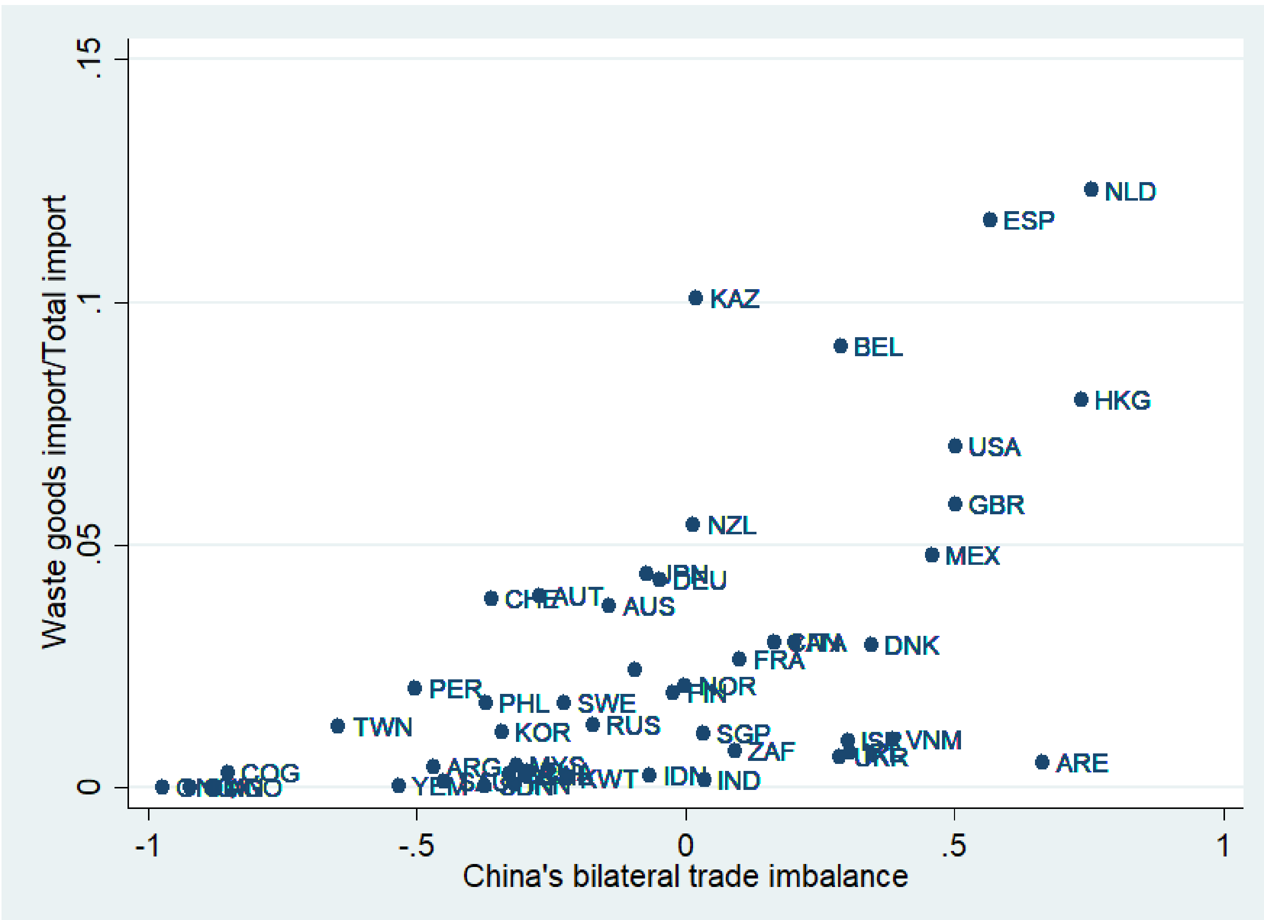
VARIABLES	(1) ln(so2)	(2) ln(dust)	(3) ln(water pollution)
ln(plastic waste import)	0.000495	0.00500	0.000328
	(0.00283)	(0.00304)	(0.00224)
ln(textile waste import)	0.00919***	0.00382	0.00543**
	(0.00299)	(0.00321)	(0.00237)
ln(metal waste import)	-0.000717	-0.00164	0.00407*
	(0.00273)	(0.00294)	(0.00217)
Contemporaneous shocks	Y	Y	Y
Year FE	Y	Y	Y
City FE	Y	Y	Y
Observations	993	994	994
R-squared	0.954	0.947	0.966

Notes: This table shows the regression results of waste pollutants across Chinese cities from 2003-2006. Contemporaneous shocks include log population, log GDP, and log manufacturing output. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 13: Calibration Results

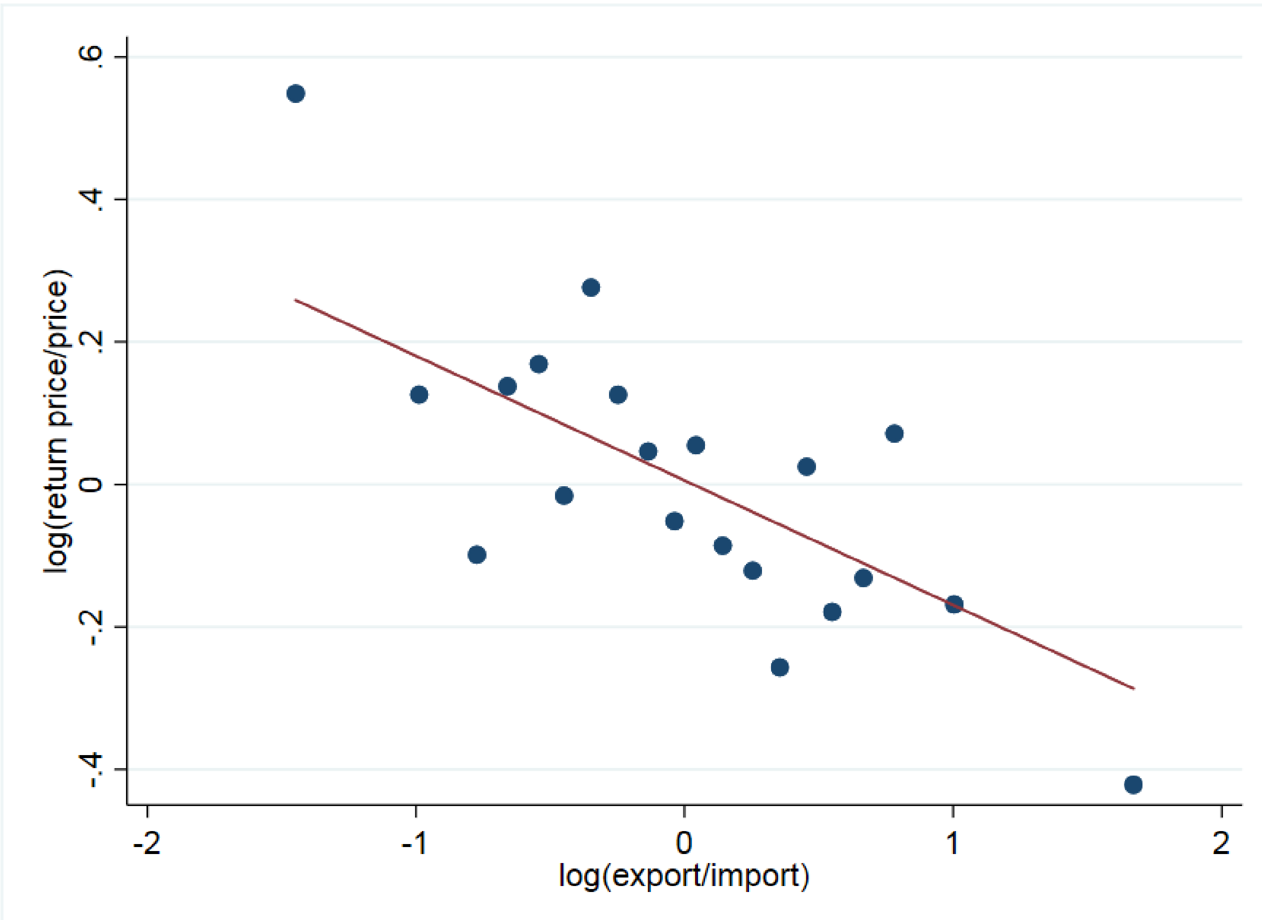
	benchmark	ban scrap imp	surplus=0	surplus=0 import cost fix	optimal pollution regulation
pollution	100	91.39	99.45	100.05	90.34
scrap imp/imp t=1 (%)	10.34	0	8.09	9.08	4.08
scrap imp/imp t=2 (%)	7.04	0	8.09	9.08	2.86
trade surplus/GDP (%)	4.00	3.96	0	0	1.76
Utility (equ C change%)	0	0.38	-0.14	-0.10	2.09
C_1	100	99.51	104.47	104.57	99.11
C_2	109.31	108.76	104.47	104.57	106.71

Figure 1: Trade Imbalance and Wasted Goods Import Share in China



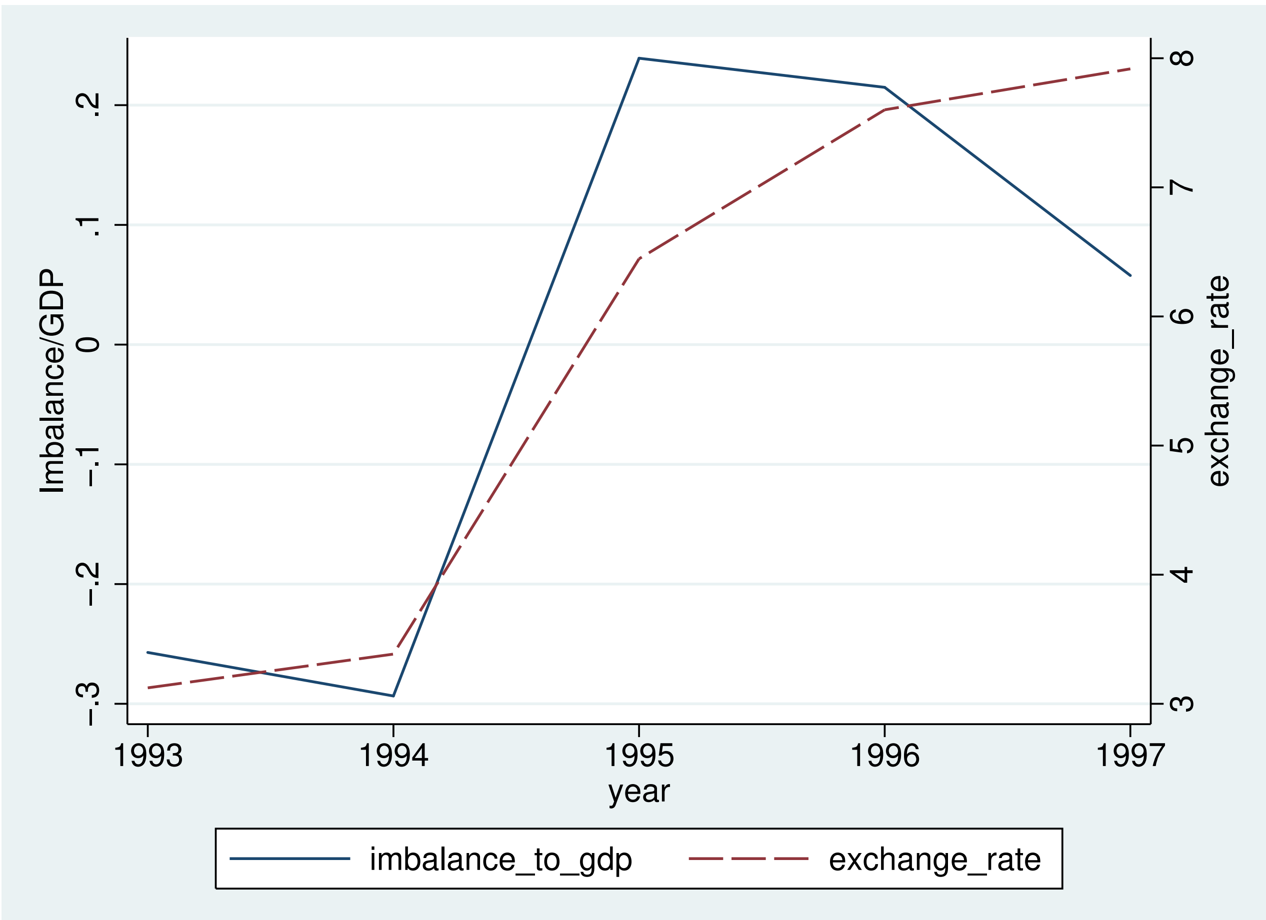
Note: This figure shows the trade imbalance and wasted goods import share of China (Data source: China custom data 2000-2006). Trade imbalance is measured by (export-import)/(export+import).

Figure 2: Trade Imbalance and Shipping Cost



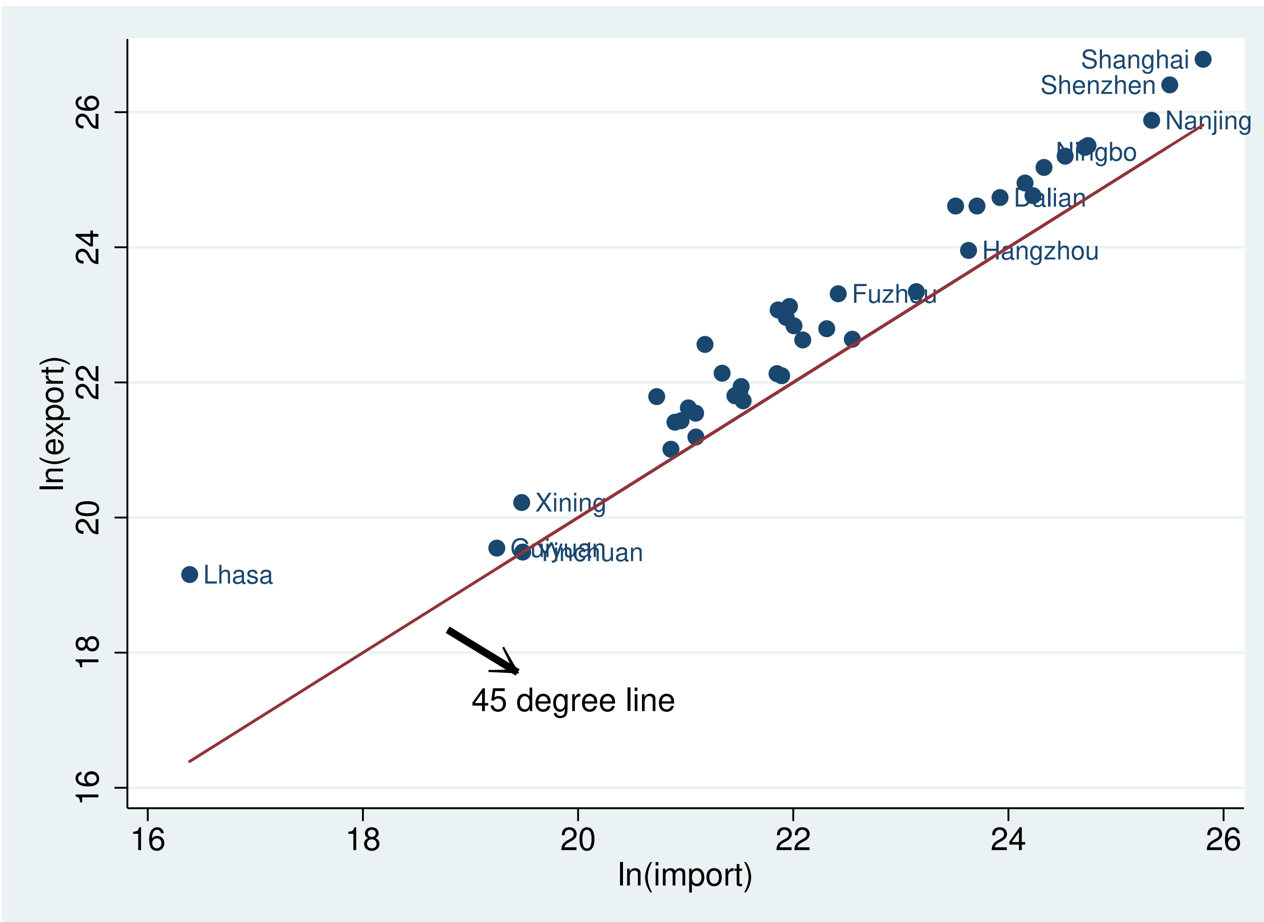
Note: This figure shows the bin-scatter plot for the regression reported in the first column of Table 2.

Figure 3: Trade Imbalance and Exchange rate of Mexico



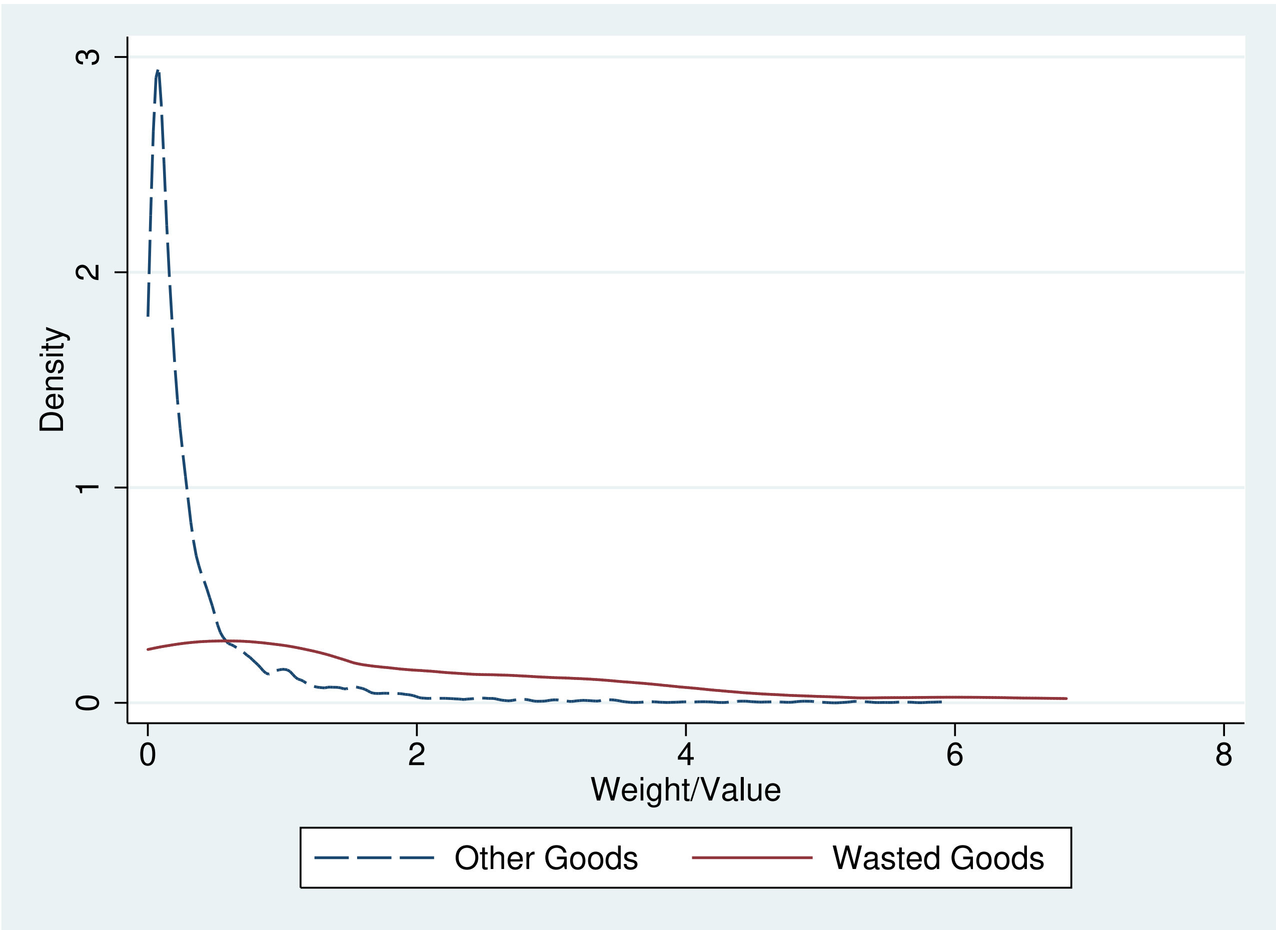
NOTE: This figure shows the trade imbalance and nominal exchange rate change of Mexico.

Figure 4: The Export and Import of Chinese Ports



NOTE: This figure shows the ln(export) and ln(import) of each Chinese port in year 2006.

Figure 5: The Density of Weight to Value (kg/usd) Ratio



NOTE: This figure shows the density of the weight to value ratio.