Trade Barriers and Import Evasion in Agricultural Markets

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Abstract: This study provides the first analysis of the magnitude and causes of import evasion in the agricultural markets based on data of 696 agricultural products at the Harmonized-System six-digit level from 1990 to 2019. I first document import evasion across countries and commodities over time and then quantify the impacts of tariffs and non-tariff barriers (NTBs) on import evasion. Empirical analysis shows that a one percentage point increase in tariffs increases import evasion by 5.1%, and any NTB decreases import evasion by 6%. I also find that higher corruption and temperature increase import evasion and higher property protection in destination countries decreases import evasion. Heterogeneity analysis shows that, compared with non-WTO countries, WTO countries are more likely to use product misclassification than price underreporting to evade tariffs. Back-of-envelope analysis shows that changes in tariffs and NTBs decrease import evasion in the agricultural market by 2.32% from 1990 to 2019.

Keywords: Import evasion; Trade barriers; Price underreporting; Product misclassification; Agricultural markets

JEL codes: F13; Q17; Q18

1. Introduction

A byproduct of rapidly expanding international trade is illegal trade. Based on the Transnational Alliance to Combat Illicit Trade (TRACIT) report, illegal trade impacted around 8 and 15 percent of global GDP between 2012 and 2014 (TRACIT, 2019). A large portion of illegal trade occurred in order to evade tariffs and non-tariff barriers (NTBs). While almost no country has readily available official statistics on smuggling or import evasion, many studies use the gap between reported exports and imports to infer smuggling and tariff evasion behaviors (Fisman and Wei, 2004; Javorcik and Narciso, 2008; Mishra et al., 2008; Fisman and Wei, 2009; Bouet and Roy, 2012).[1] Compared with manufacturing sectors, import evasion in the agricultural and food sectors, such as alcohol, tobacco, and timber, could affect public health, ecosystem, and provoke violence in countries with weak enforcement and high corruption levels (Yang, 2008; Chimeli and Soares, 2017).[2] US Customs and Border Protection (CBP) initiated the Enforce and Protect Act (EAPA) in 2016 and prevented importers from evading $287 million in duties in 2020, with a large share was collected from agricultural products such as fresh garlic and preserved mushrooms from China.[3]

While many studies investigated the impact of tariffs and NTBs, including Technical Barriers of Trade (TBT) and Sanitary and Phytosanitary Measures (SPS), on trade flows (Jayasinghe et

[1] Smuggling is defined as international trade by firms or individuals that either partially or fully evade trade regulations and border duties, either by avoiding official border crossing ports (full evasion) or by resorting to illegal means like under-invoicing, misclassification, underpricing. While missing imports cannot be used to quantify smuggling precisely, they are relevant to identity correlation patterns and to uncover the causes of smuggling (Fisman and Wei, 2004; 2009).
[2] Chimeli and Soares (2017) showed that when mahogany trade was restricted and prohibited in Brazil in the 1990s, illegal activity receded in the late 2000s and so did the relative increase in violence.
[3] A large portion of antidumping/countervailing duty evasion investigated through the EAPA program in 2020 include Chinese goods transshipped through other Asian countries such as Cambodia, India, Thailand, or Vietnam. See https://www.cbp.gov/sites/default/files/assets/documents/2020-May/FY2020%20CDSOA%20Preliminary%20Amount%20Available.pdf for details.

al., 2010; Dal Bianco et al., 2016; Beckman and Arita, 2017), studies on the impacts of trade barriers on import evasion in the agricultural and food sector are limited. Given the well-documented impacts of tariffs on import evasion (Fisman and Wei, 2004; Fisman and Wei, 2009; Golub and Mbaye, 2009; Ferrantino et al., 2012; Golub, 2012; Liu and Shi, 2019) and the large import evasion in the agricultural and food sector (TRACIT, 2019), a better understanding of the magnitude of the import evasion in the agricultural and food sector and causes of this import evasion is important for accurate analysis of relevant trade policies.

This article first documents the magnitude of import evasion in the agricultural and food sector, and then quantifies the impacts of trade barriers, including both tariffs and NTBs, on import evasion.[4] There are two major challenges in addressing the research questions. First, how to measure import evasion? There is a consensus among researchers that systematic or excessive trade data discrepancies between source countries' declared exports and destination countries' declared imports could reflect smuggling and illicit activities, especially in less developed countries with high levels of corruption (Golub and Mbaye, 2009; Golub, 2012; Kellenberg and Levinson, 2019). A notable reason for the inconsistency between import and export values is that imports are reported inclusive of the Cost for Insurance and Freight (CIF) while exports are reported Free on Board (FOB).[5] There are many research efforts on estimating insurance and transportation costs (Hummels, 2001; Limao and Venables, 2001; Hummels and Lugovskyy, 2006; Gaulier and Zignago, 2010). In particular, Gaulier and Zignago (2010) explained the

[4] Other than import evasion, there is also export evasion that caused by export taxes and restrictions. Other than border policies, domestic policies could also lead to evasion behaviors. For example, Fan et al. (2020) found that Chinese firms increase exports to evade the value-added tax (VAT).

[5] Taglioni and Baldwin (2014) provided an excellent overview of the various causes of reporting gap. Other common factors include difficulty in identifying the actual trading partner, especially the export destination (customs officials pay more attention to origins of imports because these determine the level of tariffs applied); confidentiality in the trade of some products; product misclassification, different reporting year etc.

CIF/FOB ratio by a set of gravity-type explanatory variables. To test the validity of using the gap between destination countries' CIF import values and source countries' exports as the main outcome of interest, I estimate the predicted CIF/FOB value to get the predicted CIF rates and then distract it from the CIF values before calculating import evasion. I then compare the estimated impacts of tariffs and NTBs on the two measurements of import evasion.

Second, how to account for the impacts of the growing use of NTBs? A decreasing trend for tariffs has largely been compensated by the growing NTBs in the agricultural sector (Dal Bianco et al., 2016). NTBs are crucial policy barriers that impede agricultural trade and could either directly affect import evasion or affect the responsiveness of import evasion to tariffs (Bertola and Faini, 1990; Beckman and Arita, 2017). If a country's use of tariffs and NTBs are correlated and NTBs are not properly accounted for, then the estimated impacts of tariffs on import evasion might be biased. In this study, I account for both tariff and NTBs as controls when examining the impacts of trade barriers on import evasion. This is an improvement to previous studies that focus solely on the impacts of tariffs on import evasion (Fisman and Wei, 2004; = Fisman and Wei, 2009; Golub and Mbaye, 2009; Ferrantino et al., 2012; Golub, 2012; Liu and Shi, 2019).

I construct a panel dataset at the country pair by 6-digit Harmonized System (HS) code by year level from multiple sources. The sample used in the analysis is an unbalanced panel dataset of 8,075,938 observations covering 246 importing countries, 165 exporting countries, and 696 products at the six-digit HS code level from 1990 to 2019. OLS estimates of the impact of tariff and NTBs on import evasion might be biased due to endogeneity issues. For example, if a country with high import evasion decides to change its tariffs or some NTB policies, direct estimates of tariff and NTBs on import evasion will be biased. However, endogeneity is not likely to be an issue for two reasons: 1) the possibility of reverse causality that countries change tariffs or NTBs because of trends in reporting gaps is not likely because tariffs are more likely to be affected by other factors, such as a country's demand or supply conditions, rather than by trends in reporting gaps; 2) as more countries are joining multilateral trading systems or regional trade blocs, their tariffs are more likely to be negotiated, and countries are not likely to wield lots of power in tariff negotiations. I use the panel data fixed effects model to identify the impact of tariffs and NBTs on import evasion.

There are several major findings. First, the empirical analysis shows that higher tariffs lead to higher import evasion while any NTB leads to lower import evasion. Quantitatively, estimates from the preferred specifications show that a one percentage point increase in tariffs increases import evasion by 5.1%, while any NBTs decrease import evasion by 6%. The finding that a one percentage point increase in tariffs leads to a 5.1% increase in import evasion implies that for any products whose tax rates exceeding 20%, a one percentage point increase would lead to more than one percentage point reduction in reported imports. The finding that NTBs decrease import evasion is novel and is important for policy debates on substitution between quantitative restrictions and equivalent or lower tariffs. Second, I find that higher corruption and temperature lead to higher import evasion while higher property protection in destination countries leads to lower import evasion. The finding that higher temperature leads to higher import evasion is novel and could be explored in future studies. Third, compared with non-WTO countries, WTO countries significantly reduce import evasion through price underreporting and exploit product misclassification more vigorously, which could be caused by WTO's Valuation Agreement that set value standards for imported goods (Javorcik and Narciso, 2017). Moreover, I find the estimated impacts of tariffs and NTBs on import evasion are not statistically different whether predicted CIF/FOB values adjust the import values or not, which supports the validity of previous studies that use the gap between unadjusted import and export data to measure import evasion. Finally, back-of-envelope analysis shows that changes in tariffs and NTBs decrease import evasion by 2.32% from 1990 to 2019. These findings are important for better predicting trade flows' responses to trade policy changes and providing more effective governance mechanisms to address import evasion.

This article contributes to current literature in several ways. First, despite the prevalence of import evasion in the agricultural and food sector, there is very limited work analyzing them. Several exceptions include Ferrier (2008) and Ferrier (2021).[6] To the best of my knowledge, it is the first study to document the size of import evasion in the agricultural and food sector systematically and is most related to literature that estimates the impact of trade policies on import evasion (Fisman and Wei 2004, 2009; Ferrantino et al., 2012; Demir and Javorcik, 2020). I contribute to this literature by: 1) documenting the size and trend of import evasion in the agricultural sector, which is more likely to be protected by various border and domestic policies than non-agricultural sectors (Anderson et al., 2013), 2) accounting for both the impact of tariffs and NTBs, and 3) using data for a broader country and time coverage as most studies in the literature focus on specific countries, like China (Beja, 2008; Rotunno and Vézina, 2012), Tunisia (Rijkers et al., 2017), and some African countries (Golub and Mbaye, 2009; Bouet and Roy, 2012; Golub, 2012) for a shorter period.

Second, the finding that tariffs and NTBs have opposing impacts on import evasion contributes to the literature on the interaction impacts of tariff and NTBs (Bertola and Faini,

[6] Ferrier (2008) presented an equilibrium model of smuggling depending on interregional price disparities in the presence of a trade ban. Ferrier (2021) presented an approach that uses trade and production data to flag countries for possible instances of origin fraud and then compares these countries with those implicated in criminal cases and media reports.

1990; Jayasinghe et al., 2010). Note that while current literature generally agrees that tariffs impede trade, there is no consensus on whether NTBs impede or promote trade.[7] The finding that NTBs decrease import evasion suggests that policymakers should carefully weigh the interactive impacts of tariffs and NTBs for agricultural policy evaluation and recommendation. In addition, while the main finding that higher tariffs and corruption lead to higher import evasion is not new (Bouet and Roy, 2012, Dutt and Traca, 2010; Kellenberg and Levinson, 2019), the finding that higher temperature leads to higher import evasion is new and could provide some insights to studies related to climate change and import evasion.

Finally, this study checks the validity of the common practice in current literature to use the gap between source countries' imports and destination countries' exports as the dependent variable for import evasion (Fisman and Wei 2004, 2009; Ferrantino et al., 2012; Demir and Javorcik, 2020). In particular, this study removes estimated freight and insurance from imports before constructing import evasion and finds that the common practice of using the gap between unadjusted import and export data to measure import evasion does not yield statistically significant different results from measuring import evasion using adjusted import values. This finding supports the common practice of using the gap between reported exports and imports to infer smuggling and tariff evasion behaviors.

2. Empirical Methods

2.1 Detecting import evasion from trade data

There are three ways to detect import evasion. The first and the most common one uses the gap between exports reported by origin countries and imports reports reported by destination

[7] See Dal Bianco et al. (2016) for an excellent review on the impacts of tariffs and NTBs on trade flows.

countries (Fisman and Wei, 2004; Fisman and Wei, 2009; Javorcik and Narciso, 2017). The second is the excess trade method, which checks if a third country's imports and production suggest unrealistic consumption patterns that further suggest illicit trade in neighboring countries. The third checks the mechanisms via transshipping or rerouting (Liu and Shi, 2019). In particular, it checks if trade barriers lead to a stronger positive correlation between trade barriers imposing countries' imports from third countries/regions with trade barrier bearing countries' exports to third countries/regions.[8]

In this study, I use the first method and define import evasion as the gap between the logarithm of exporters' reported exports and the logarithm of importers' reported imports:

$$Gapv_{ijkt} = log\left(1 + expv_{jikt}\right) - log\left(1 + impv_{ijkt}\right), \tag{1}$$

where $i, j, k, and\ t$ denotes importer, exporter, commodity at the six-digit HS code level, and year, respectively. $expv_{jikt}$ denotes country $j's$ recorded export value of product k to i in year t, and $impv_{ijkt}$ denotes country $i's$ recorded import value of product k from country j in year t. A positive $Gapv_{ijkt}$ denotes import evasion in terms of value. A larger gap indicates greater import evasion. It is important to note that while $Gapv_{ijkt}$ is a noisy measure that captures more than smuggling activities, its systematic pattern could reflect misinvoicing and misclassification. I also construct import evasion in terms of quantity $Gapq_{ijkt}$ using[9]:

$$Gapq_{ijkt} = log\left(1 + expq_{jikt}\right) - log\left(1 + impq_{ijkt}\right), \tag{2}$$

[8] A necessary condition for rerouting is trade diversion (trade barrier imposing countries import more from third countries) and trade deflection (trade barrier bearing countries export more to third countries). The key is that third countries involved in trade diversion are not likely to be the same set of countries as involved in trade deflection (Liu and Shi, 2019).

[9] An alternative way of defining import evasion is $Gapq_{ijkt} = log\left(expq_{jikt}\right) - log\left(impq_{ijkt}\right)$. However, this measurement would exclude transactions in which exports are recorded but no counterpart import transaction is recorded.

where $expq_{jikt}$ denotes country $j's$ recorded export quantity of product k to i in year t, and $impq_{ijkt}$ denotes country $i's$ recorded import quantity of product k from country j in year t. All other notations have the same meaning as in (1).

As noted earlier, a significant reason for the gap between imports and exports is that imports are reported based on CIF, while exports are generally reported based on FOB. To test the validity of using the gap between destination countries' imports and source countries' exports as the main outcome of interest, I follow the practice of Gaulier and Zignago (2010) and estimate the predicted CIF/FOB using:

$$ln(CIF/FOB_{jikt}) = \alpha_0 + \sum_{t=1}^{6} \beta_{0t} lnDist_{ij} + \gamma_0 Contig_{ij} + \theta_i + \vartheta_j + \mu_k + \sigma_t + \epsilon_{ijkt}, \tag{3}$$

where $ln(CIF/FOB_{jikt}) = ln(\frac{impv_{ijkt}}{expv_{jikt}})$ denotes the logarithm of the ratio of import to export value. $lnDist_{ij}$ is the logarithm of the distance between the country pair. $Contig_{ij}$ is a dummy variable that denotes whether the two countries are contiguous. Given the improving transportation technology, I modify Gaulier and Zignago (2010) by assuming that the impact of distance on the CIF/FOB ratio is changing every five years (1990-1994, 1995-1999, …, 2015-2019), which is reflected by the time-variant coefficient β_{0t}. $\theta_i, \vartheta_j, \mu_k, and\ \sigma_t$ denote importer, exporter, commodity, and time fixed effects, respectively.

I use the predicted $ln(CIF/FOB_{jikt})$ from equation (3) to construct CIF rate-adjusted import value and then use the gap between this adjusted import value and export value to measure import evasion. However, as only a small portion of the ratio of CIF/FOB is greater than 1 (See section 3.2 for details), I use the adjusted import evasion as a robustness check and still use the import evasion constructed from equations (1) and (2) in the main analysis.

2.2 Empirical model

I use the following model to examine the impact of tariffs and NTBs on import evasion:

$$Gapv_{ijkt} = \alpha_0 + \beta_0 Tar_{ijkt} + \beta_1 NTM_{ijkt} + \gamma_1 X_{it} + \gamma_2 X_{jt} + \theta_i + \vartheta_j + \mu_k + \sigma_t + \epsilon_{ijkt}, \quad (4.1)$$

where $Gapv_{ijkt}$ denotes import evasion as measured in equation (1); Tar_{ijkt} denotes tariff country i imposes on country j for product k at year t; NTM_{ijkt} is a dummy variable that denotes whether country i has an NTB for product k imported from country j at year t; To leverage both importer and exporter's political and economic incentives to evade tariffs, I include vectors of country-level variables, including corruption, property rights protection, annual rainfall and temperature, and whether the country is a WTO member, for both country i and j.

$\theta_i, \vartheta_j, \mu_k,$ and σ_t denote importer, exporter, commodity, and time fixed effects, respectively. ϵ_{ijkt} is an error term. I also modify equation (4.1) into equations (4.2) and (4.3) that include different sets of fixed effects to increase the generality:

$$Gapv_{ijkt} = \alpha_0 + \beta_0 Tar_{ijkt} + \beta_1 NTM_{ijkt} + \gamma_1 X_{it} + \gamma_2 X_{jt} + \theta_{ij} + \mu_k + \sigma_t + \epsilon_{ijkt}, \quad (4.2)$$

$$Gapv_{ijkt} = \alpha_0 + \beta_0 Tar_{ijkt} + \beta_1 NTM_{ijkt} + \gamma_1 X_{it} + \gamma_2 X_{jt} + \theta_{ijt} + \mu_k + \epsilon_{ijkt}, \quad (4.3)$$

Equation (4.2) includes country pair, commodity, and year fixed effects. Equation (4.3) includes country pair-by-year and commodity fixed effects. It is important to note that because country pair fixed effects are included in the empirical specifications (4.2) and (4.3), the identification comes from within country pair variation over time and is not affected by time-invariant product, importer, and exporter characteristics. Note that in equation (4.3), the coefficients on country-level control variables cannot be estimated due to collinearity.

It's worthy of attention that given an exporting country may report exports while an importing country does not report any imports (extreme smuggling), I check if an import transaction is more likely to disappear in the mirror trade data when the tariff is high using:

$$ExpOnly_{ijkt} = \alpha_0 + \beta_0 Tar_{ijkt} + \beta_1 NTM_{ijkt} + \gamma_1 X_{it} + \gamma_2 X_{jt} + \theta_i + \vartheta_j + \mu_k + \sigma_t + \epsilon_{ijkt}, \quad (5)$$

where $ExpOnly_{ijkt}$ is a dummy variable that equals 1 if exporting country j reports exports of commodity k to country i at year t and importing country does not report corresponding imports; Otherwise, it equals 0.

A natural question is whether import evasion occurs through price underreporting or misclassification, that is, classifying high-tariff products as low-tariff ones. To examine whether importing countries underreport unit value to evade tariffs, I define unit value gap as the differences in unit values reported by exporter j and importer i of product k at year t:

$$UnitValueGap_{ijkt} = log\left(\frac{expv_{jikt}}{expq_{jikt}}\right) - log\,\left(\frac{impv_{ijkt}}{impq_{ijkt}}\right). \quad (6)$$

While the unit value gap is expected to be negative in the absence of tariff evasion, a positive $UnitValueGap_{ijkt}$ indicates price under-reporting.[10] The empirical models used to test the impact of tariffs on price underreporting are the same as in equations (4.1) – (4.3) except that the outcome is the unit value gap as defined in equation (6).

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[10] As noted by Javorcik and Narciso (2017), while unit values calculated based on national trade statistics may be imperfect proxies for product prices, they have been widely used in the literature and the analyses based on such data have produced meaningful and intuitive results. Moreover, the point of interest is not the value of the unit value gap per se but rather its responsiveness to the tariff level.

To test misclassification, I add another variable, Oth_Tar_{jiot}, to equations (4.1) - (4.3) and estimate the following model:

$$Gap_{ijkt} = \alpha_0 + \beta_0 Tar_{ijkt} + \beta_1 NTM_{ijkt} + \beta_2 Oth\_Tar_{ijot} + \gamma_1 X_{it} + \gamma_2 X_{jt} + \theta_i + \vartheta_j + \mu_k + \sigma_t + \epsilon_{ijkt}, \quad (7)$$

where Oth_Tar_{jiot} denotes country $i's$ tariffs on other products with the same first four digits of HS code as product k at year t. Other notations have the same meaning as in equations (4.1) - (4.3). The expectation is that, holding the tariff on a product constant, the lower the tariff on similar products, the greater the incentives to misclassify imports. Therefore, $\beta_2 < 0$ shows evidence of misclassification.

Another mechanism of import evasion is rerouting, which refers to indirect exporting with a change of certificate of origin illegally from the actual originating country to a third country/region, often motivated by tariff evasion.[11] However, I did not explore this mechanism in this study as it would require knowledge about the potential rerouting countries, which are likely to be different across commodities and over time.

2.3 Estimation issues

If an importer's tariffs and NTBs are endogenous to its import evasion, then OLS estimates of the impacts of tariffs and NTBs on import evasion in equations (4), (5), and (7) are biased. However, there are several reasons why endogeneity is not likely to be an issue here. First, for endogeneity to be an issue, there is a possibility of reverse causality that policymakers change

[11] Re-routing is similar but not identical to re-exports or transshipment, although those terms are used interchangeably sometimes. In particular, both re-exports and transshipment are likely to be used as legal indirect exporting through intermediaries in third countries/regions. Re-exports need to clear customs in the third countries/regions, whereas trans-shipments do not and neither involves a change of certificate of origin.

tariffs or NTBs because of trends in reporting gaps. However, this is not likely because tariffs are more likely to be affected by other factors, such as a country's demand or supply conditions that directly affect trade flows rather than trends in reporting gaps. In addition, as more countries are joining multilateral trading systems or regional trade blocs, their tariffs are more likely to be negotiated with other countries, and small countries are not likely to wield lots of power in tariff negotiations. Another reason tariffs might be endogenous is that unobserved and uncontrolled variables simultaneously affect reporting gaps and trade policy. However, this is hard to be the case after controlling for the comprehensive set of country pair, commodity, year fixed effects, and country-level control variables. By any means, if there were such a correlation, increases in tariffs would have to be positively correlated with the error term for the estimates to be biased upward (Mishra et al., 2018).

3. Data and Descriptive Statistics

3.1 Data sources

I construct a dataset from multiple sources. Appendix A presents the detailed data sources and data management process. Bilateral trade data at the six-digit HS code level come from United Nation's Commodity Trade Statistics Database (UNComtrade).[12] Tariff data come from the United Nations Conference on Trade and Development's (UNCTAD) Trade Analysis Information System (TRAINS) (UNCTAD, 2021). Non-tariff measures come from the UNCTAD global database on Non-tariff Measures (UNCTAD, 2021). Note that the UNCTAD provides data on eight types of NTBs, including SPS, TBT, pre-shipment inspection (INSP), contingent trade protective measures (CTPM), quantity control measures (QC), price control

[12] Other common trade data sources, such as CEPII, only provides one compromised trade flows between countries other than bilateral mirror trade statistics.

measures (PC), other measures (OTH) and export-related measures.[13] I exclude export-related measures from the analysis as this study focuses on import evasion.

Other than tariff and non-tariff policies, I also collect a rich set of country-level institutional and weather variables. Property rights protection and corruption levels are from the V-Dem project by Coppedge et al. (2020). Weather variables, including rainfall and precipitation, come from NOAA National Centers for Environmental Information (NOAA NCEI, 2021). Geographical variables, including the distance between two countries and whether the two countries are contiguous, are collected from CEPII's gravity database.[14]

After matching trade data with policies and country-level control variables, there is a total number of 11,333,803 observations that cover 246 importing countries, 166 exporting countries, 696 commodities at the six-digit HS code level over thirty years from 1990 to 2019. To exclude observations with potential quality problems, I drop observations with less than 5,000$ in export values and drop the top and bottom 1% of observations in import evasion from the analysis. The final sample is an unbalanced panel dataset of 8,075,938 observations covering 246 importing countries, 165 exporting countries, and 696 products at the six-digit HS code level from 1990 to 2019.

3.2 Missing imports across commodities and countries

Figure 1 illustrates the ratio of import to export value in the analysis. In the full sample, 43.7% of observations are extreme smuggling in which the export value is positive without recorded

[13] Quantity control measures include non-automatic import licensing, quotas, prohibitions, quantity-control measures and other restrictions other than SPS and TBT measures. Price-control measures include additional taxes and charges.
[14] The CEPII database contains various distance measures, including distance between capitals and weighted average distance between most populated cities. I use the weighted-distance between most populated cities in the analysis.

corresponding import value. In addition, only 27.8% of the observation have a CIF/FOB value greater than 1, and the rest 28.5% has a CIF/FOB value smaller than 1, which is suggestive of import evasion. Given only 27.8% of the observations have a CIF/FOB value greater than 1, I use import evasion constructed from freight and insurance adjusted import value as a robustness check and use the import evasion constructed from equations (1) and (2) in the main analysis.

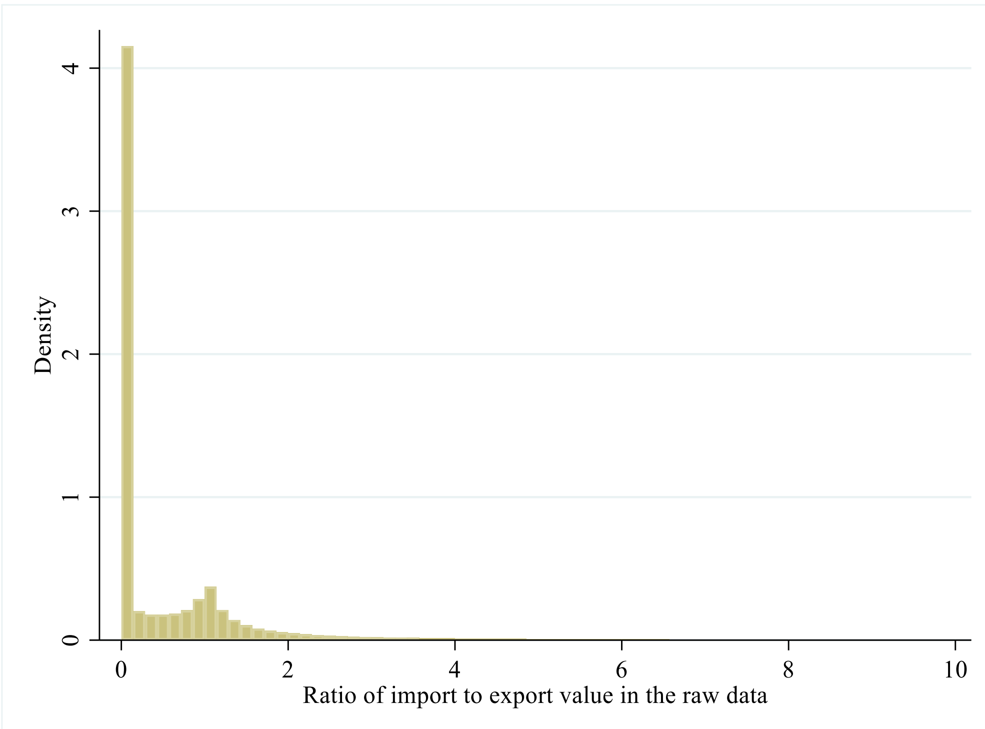

Figure 1. Distribution of the ratio of import to export value.

Note: This figure illustrates the distribution of the ratio of import to export value in the sample. Note 1.7% of the observations have a CIF/FOB ratio greater than ten, and I only include observations with a CIF/FOB ratio smaller than ten in this figure. The final sample in the analysis is an unbalanced panel dataset of 8,075,938 observations covering 246 importing countries, 165 exporting countries, and 696 products at the six-digit HS code level from 1990 to 2019.

Figure 2 shows the import evasion in terms of value for bulk, intermediate, consumer-oriented, and agricultural-related products from 1990 to 2019. The average import evasion increased from 1990 to 1997, slightly declined from 1997 to 2001, and gradually increased. In addition, the import evasion for agricultural-related products is much higher than that for bulk products, which aligns with the findings that bulk products are less differentiated and more difficult to evade (Mishra et al., 2008; Ferrantino et al., 2012).

The two panels in Figure A1 in the appendix present the average import evasion across 54 agricultural commodities in 1990 and 2019. The ranks of the import evasion for the 54 agricultural commodities have changed significantly from 1990 to 2019. The two panels in Figure A2 in the appendix present the average import evasion across seven regions in 1990 and 2019. From 1990 to 2019, import evasion in North America declined significantly, and East Asia and the Pacific saw the largest increase in import evasion.

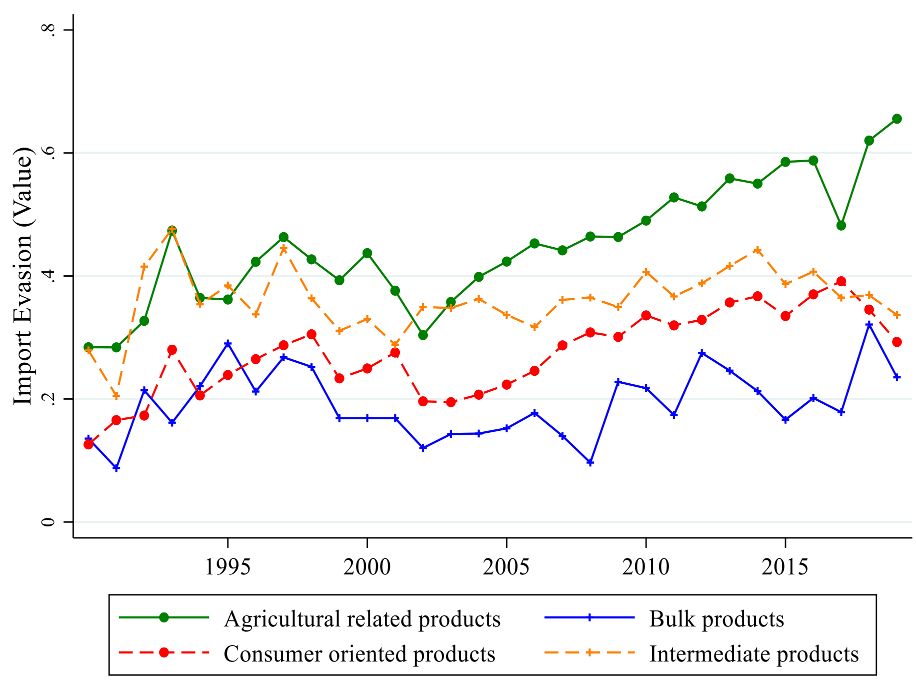

Figure 2. Export value-weighted import evasion in terms of value: 1990-2019.

Note: This figure presents the export value-weighted average import evasion for four types of agricultural products: bulk, intermediate, consumer-oriented, and agricultural-related products. I use USDA's definition of the four agricultural product categories. Import evasion is defined using equation (1). Observations where exports have no corresponding imports are excluded.

3.3 Descriptive statistics

Table 1 summarizes the main variables in the analysis. It should be noted that 43.7% of the transactions in which exports cannot be matched with imports (extreme smuggling), with the share for bulk products slightly smaller than non-bulk products.[15] There are several points worthy of attention. First, when I exclude observations where exports have no corresponding imports, the average import evasion in terms of value is 31.2% and the average import evasion in terms of quantity is 33.4%. When I include observations of extreme smuggling, the average import evasion in terms of value reached 497% and the average import evasion in terms of quantity reached 457%. Second, compared with bulk products, non-bulk products are imposed higher tariffs and more NTBs and have higher import evasion, suggesting that higher tariffs lead to higher import evasion.

Table 2 provides statistics of the main variables in 1990 and 2019. The simple average import evasion declined from 1990 to 2019. Over this period, the average tariff has declined by around 2.2%, while the probability of NTBs increased from 0.4% to 37.6%.

[15] Bulk products, like soybeans and corn, are less differentiated than non-bulk products, such as frozen meat. It's expected that it is easier to spot underreporting of bulk products than for non-bulk products.

Table 1. Summary statistics of trade, import evasion, and policies for bulk and non-bulk products.

	Entire sample			Bulk products			Non-bulk products			Difference between bulk and non-bulk
	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
Panel A: Trade data										
A.1 Excluding extreme values										
Export value (Million $)	3.572	38.781		8.307	117.46		3.23	24.78		5.077
Import value (Million $)	3.58	41.661		8.837	128.86		3.2	25.67		5.637
Evasion gap (Value)	0.312	1.611		0.286	1.676		0.313	1.606		-0.027
Export quantity (Million Kg)	3.964	90.797	4,549,192	23.47	321.81	306,580	2.555	36.43	4,242,612	20.917
Import quantity (Million Kg)	3.81	110.63		22.59	326.86		2.453	73.32		20.138
Evasion gap (Quantity)	0.334	2.394		0.386	2.428		0.33	2.392		0.056
Unit value gap	-0.02	0.98		-0.086	0.974		-0.01	0.98		-0.075
A.2 Including extreme values										
Export value (Million $)	2.186	29.174		5.008	89.052		1.986	18.68		3.022
Import value (Million $)	2.016	31.319		5.068	97.686		1.8	19.32		3.268
Evasion gap (Value)	4.973	5.548		4.929	5.661		4.976	5.54		-0.047
Export quantity (Million Kg)	2.416	68.271	8,075,938	14.07	244.22	534,542	1.59	27.45	7,541,396	12.48
Import quantity (Million Kg)	2.146	83.051		12.96	247.79		1.38	55		11.577
Evasion gap (Quantity)	4.575	5.357		4.892	5.763		4.553	5.326		0.339
Share of products reported only by exporting	0.437	0.496		0.426	0.495		0.437	0.496		-0.011
Panel B: Tariff and non-tariff barriers										
Tariff (%)	0.153	0.522	4,894,211	0.12	0.38	312,392	0.155	0.53	4,581,819	-0.035
Average tariff of similar products in the same	0.15	0.465		0.12	0.349		0.152	0.472		-0.032
Non-tariff	0.26	0.438		0.249	0.433		0.26	0.439		-0.011
TBT	0.161	0.367	8,075,938	0.137	0.344	534,542	0.162	0.369	7,541,396	-0.025
SPS	0.186	0.389		0.184	0.388		0.186	0.389		-0.002

Note: This table summarizes the main variables in the analysis. The unit of analysis is country pair-HS6-year. The full sample includes 8,075,938 observations covering 246 importing countries, 165 exporting countries, and 696 products at the six-digit HS code level from 1990 to 2019.

	Full sample (1)	1990 (2)	2019 (3)
Trade flows and import evasion			
Export value (Million $)	2.186	0.706	2.580
	(29.174)	(6.188)	(26.292)
Import value (Million $)	2.016	0.513	2.359
	(31.319)	(6.687)	(27.333)
Evasion gap (Value)	4.973	8.198	5.081
	(5.548)	(5.016)	(5.586)
Export quantity (Million Kg)	2.416	1.084	2.316
	(68.271)	(15.665)	(54.863)
Import quantity (Million Kg)	2.146	0.726	1.909
	(83.051)	(15.762)	(42.467)
Evasion gap (Quantity)	4.575	7.652	4.684
	(5.357)	(5.050)	(5.240)
Unit value gap	-0.016	-0.110	-0.046
	(0.980)	(0.700)	(0.867)
Share of products reported only by exporting	0.437	0.742	0.441
	(0.496)	(0.437)	(0.496)
Tariff and non-tariff policies			
Tariff (%)	0.153	0.167	0.145
	(0.522)	(0.222)	(0.503)
The average tariff of similar products in the same	0.150	0.161	0.146
	(0.465)	(0.220)	(0.509)
Non-tariff	0.260	0.004	0.376
	(0.438)	(0.060)	(0.485)
TBT	0.161	0.001	0.288
	(0.367)	(0.028)	(0.453)
SPS	0.186	0.003	0.350
Importing countries' characteristics	(0.389)	(0.055)	(0.477)
Corruption (0-1)	0.340	0.261	0.336
	(0.310)	(0.284)	(0.293)
Property rights protection (0-1)	0.775	0.766	0.759
	(0.181)	(0.216)	(0.165)
WTO member (Binary)	0.914	0.000	1.000
	(0.281)	(0.000)	(0.011)
Rain (mm)	85.798	83.807	84.156
	(62.981)	(57.111)	(59.308)
Temperature (Celsius)	15.381	15.332	16.318
	(8.801)	(8.601)	(8.655)
Exporting countries' characteristics			
Corruption (0-1)	0.243	0.215	0.244
	(0.270)	(0.286)	(0.260)
Property rights protection (0-1)	0.815	0.836	0.779
	(0.146)	(0.122)	(0.156)
WTO member (Binary)	0.821	0.000	0.914
	(0.384)	(0.000)	(0.281)
Rain (mm)	82.240	85.007	79.602

	(53.209)	(48.502)	(48.945)
Temperature (Celsius)	13.927	14.829	14.744
	(7.544)	(8.934)	(7.495)
Observations	8,075,938	55,305	333,593

Table 2. Summary statistics of main variables in 1990 and 2019.

Note: This table presents the summary statistics for the full sample, 1990, 2019, of the main variables.

Figure 3 presents the import value-weighted average tariffs across four types of commodities from 1990 to 2019. While the tariffs for bulk, intermediate, and consumer-oriented products slightly declined from 1995 till the present, the tariffs for agricultural-related products gradually increased from 1995, in line with the trend that tariffs on final products are higher than raw products.

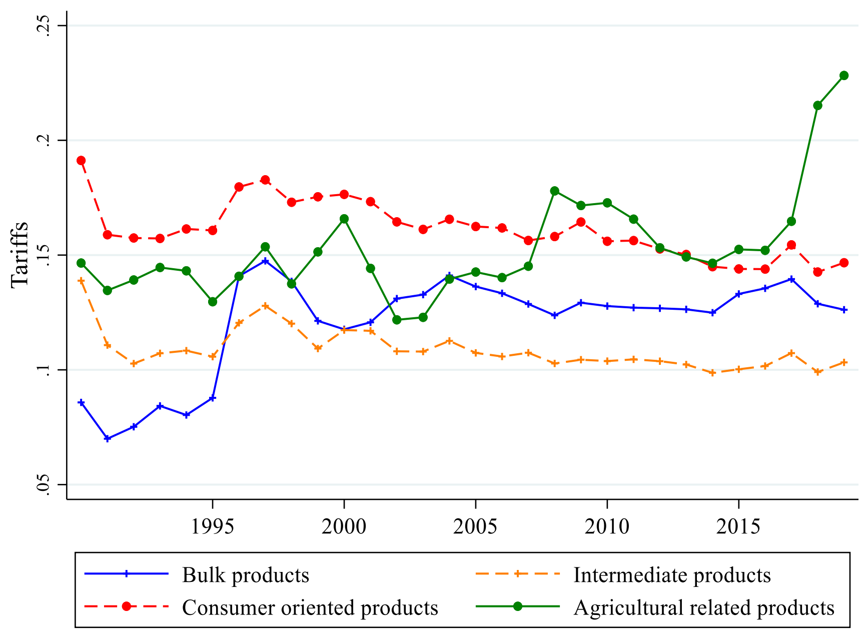

Figure 3. Import value-weighted average tariffs across all agricultural commodities, 1990-2019.

Note: This figure presents the import value-weighted average tariffs across four types of commodities from 1990 to 2019.

Figure 4 presents the share of products that have been imposed any NTBs from 1990 to 2019. The use of NTBs has increased steadily over time. The large variation of import evasion and trade policies across commodities and countries over time provides variation for identifying impacts of tariffs and NTBs on import evasion.

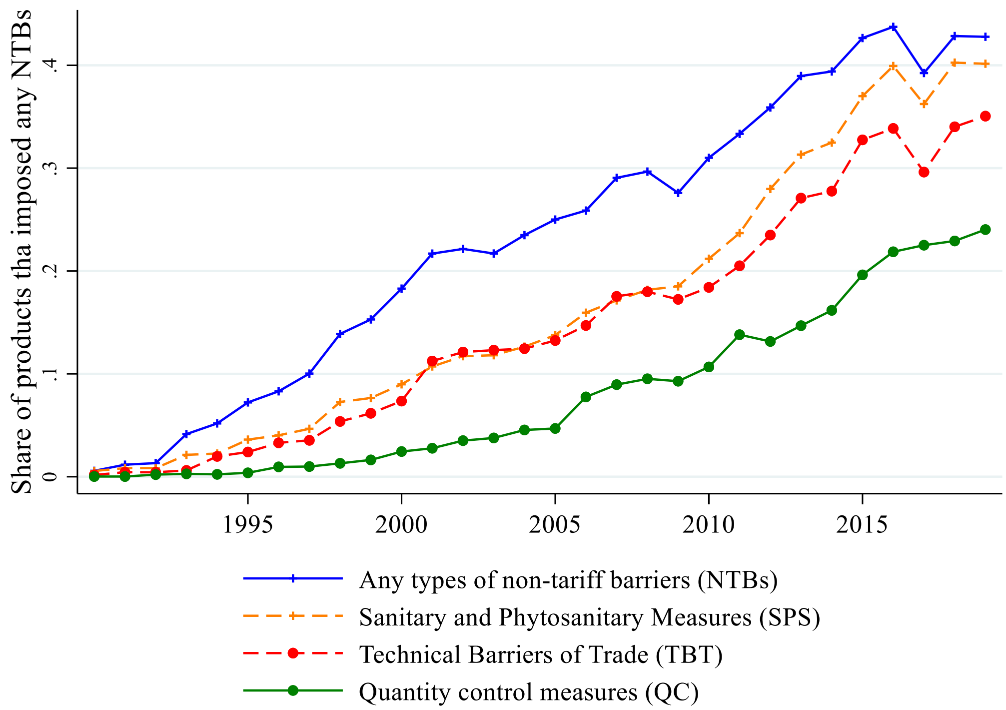

Figure 4. Share of products that have been imposed any NTBs from 1990 to 2019.

Note: This figure presents the share of different types of non-tariff barriers (NTBs) from 1990 to 2019.

4. Empirical Results

4.1 Impacts of tariffs and NTBs on import evasion

Table 3 presents the estimation results of equations (4.1) - (4.3) when the dependent variable is import evasion in terms of value. Columns (1)-(2) include importer, exporter, product, and year fixed effects. Columns (3)-(4) include country pair, product, and year fixed effects. Columns (5)-(6) include country pair by year, and product fixed effects. Note that the country-level control variables in specifications (5) and (6) cannot be estimated due to the inclusion of country pair by year fixed effects. Standard errors are two-way clustered at the country pair and year level.

There are three main findings in Table 3. First, higher tariffs increase import evasion while the existence of NTBs decreases import evasion. The magnitude of the impact of tariffs on import evasion decreases with specification generality and the magnitude of the impact of NTB on import evasion increases with specification generality. Quantitively, column (6) shows that a one percentage point increase in tariffs increases import value evasion by 5.1%, while the existence of any NTBs decreases import evasion by 6%. Both impacts are statistically significant at the 1% level. The finding that a one percentage point increase in tariffs leads to a 5.1% increase in import evasion implies that for any products whose tax rates exceed 20%, a one percentage point increase would lead to more than one percentage point reduction in reported imports. The average tax rate on imports is 15.3% (in Table 2), which indicates that an increase in the tax rate would still increase tax revenue at the average rate. The second finding is that importers with better property rights protection have lower import evasion, which aligns with previous studies that better institutions lead to lower import evasion (Dutt and Traca, 2010; Fishman and Wei, 2009). Finally, there is a novel finding that higher temperature in destination countries leads to higher import evasion, which could be caused by many factors. For example, higher temperature leads to less agricultural output and, therefore, greater import demand. Another potential explanation is that higher temperature could affect workers' attention in the customs, which would make import evasion easier. Exploring mechanisms of temperature on import evasion would be an interesting future research topic.

	(1)	(2)	(3)	(4)	(5)	(6)
Trade policies						
Tariffs	0.059***	0.059***	0.052***	0.052***	0.051***	0.051***
	(0.012)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Non-tariff barries (NTBs)		-0.036***		-0.037***		-0.060***
		(0.011)		(0.011)		(0.012)
Importer characteristics						
Corruption (0-1)	-0.032	-0.041	-0.001	-0.011		

	(0.071)	(0.071)	(0.070)	(0.069)		
Property rights protection (0-1)	-0.387***	-0.384***	-0.407***	-0.405***		
	(0.072)	(0.072)	(0.074)	(0.074)		
WTO member (Binary)	0.013	0.023	0.020	0.029		
	(0.042)	(0.042)	(0.040)	(0.039)		
Rain (mm)	-0.000	-0.000	0.000	0.000		
	(0.000)	(0.000)	(0.000)	(0.000)		
Temperature (Celsius)	0.020***	0.019***	0.019***	0.018**		
	(0.006)	(0.006)	(0.007)	(0.007)		
Exporter characteristics						
Corruption (0-1)	-0.038	-0.040	-0.047	-0.049		
	(0.059)	(0.060)	(0.062)	(0.062)		
Property rights protection (0-1)	-0.043	-0.045	-0.092	-0.093		
	(0.068)	(0.068)	(0.072)	(0.072)		
WTO member (Binary)	0.052	0.056	-0.001	0.003		
	(0.045)	(0.044)	(0.035)	(0.035)		
Rain (mm)	-0.000	-0.000	-0.000	-0.000		
	(0.000)	(0.000)	(0.000)	(0.000)		
Temperature (Celsius)	0.005	0.005	0.005	0.005		
	(0.007)	(0.007)	(0.008)	(0.008)		
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country pair fixed effects	No	Yes	No	No	Yes	No
Country pair by year fixed	No	No	Yes	No	No	Yes
R-square	0.051	0.051	0.079	0.079	0.116	0.116
Observations	2,427,823	2,427,823	2,427,210	2,427,210	2,407,331	2,407,331

Table 3. Impacts of tariff and non-tariff barriers on import evasion in terms of value.

Note: This table presents estimation results of equations (4.1) – (4.3), in which I regress import evasion in terms of value on tariff and non-tariff barriers and a set of country-level control variables and fixed effects. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. Note that the coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. Note that the number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Table 4 presents the estimation results of equations (4.1) – (4.3) when the outcome is import evasion in terms of quantity. While the findings are mostly in line with the findings in Table 3, there are several differences. First, the negative impacts of NTBs on import evasion become insignificant. With the finding in Table 3 that NTBs have significantly negative impacts on import evasion in terms of value, this finding indicates that NTBs could increase price underreporting. Table 4 also shows that more corrupted importers see higher import evasion in terms of quantity, although property rights protection and the temperature have no significant impacts on import evasion in terms of quantity.

	(1)	(2)	(3)	(4)	(5)	(6)
Trade policies						
Tariffs	0.060***	0.060***	0.060***	0.060***	0.065***	0.066***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Non-tariff barries (NTBs)		0.002		0.007		-0.033
		(0.046)		(0.047)		(0.028)
Importer characteristics						
Corruption (0-1)	0.520**	0.521**	0.555**	0.557**		
	(0.200)	(0.200)	(0.205)	(0.204)		
Property rights protection (0-1)	0.304	0.304	0.337	0.337		
	(0.501)	(0.502)	(0.498)	(0.499)		
WTO member (Binary)	0.299	0.299	0.301	0.300		
	(0.237)	(0.239)	(0.233)	(0.235)		
Rain (mm)	0.000	0.000	0.000	0.000		
	(0.001)	(0.001)	(0.001)	(0.001)		
Temperature (Celsius)	-0.117	-0.117	-0.118	-0.118		
	(0.089)	(0.089)	(0.089)	(0.089)		
Exporter characteristics						
Corruption (0-1)	-0.227	-0.226	-0.230	-0.230		
	(0.331)	(0.331)	(0.339)	(0.339)		
Property rights protection (0-1)	-0.517	-0.517	-0.591	-0.590		
	(0.423)	(0.424)	(0.428)	(0.428)		
WTO member (Binary)	-0.132	-0.133	-0.186	-0.187		
	(0.202)	(0.201)	(0.203)	(0.202)		
Rain (mm)	-0.002	-0.002	-0.002	-0.002		
	(0.001)	(0.001)	(0.001)	(0.001)		
Temperature (Celsius)	0.018	0.018	0.017	0.017		
	(0.038)	(0.038)	(0.038)	(0.038)		
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Country-pair by year fixed	No	No	Yes	No	No	Yes
R-square	0.074	0.074	0.090	0.090	0.260	0.260
Observations	2,427,823	2,427,823	2,427,210	2,427,210	2,407,331	2,407,331

Table 4. Impacts of tariff and non-tariff barriers on import evasion in terms of quantity.

Note: This table presents estimation results of regressing import evasion in terms of quantity on tariff and non-tariff measures and a set of country-level control variables and fixed effects. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. Note that the coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. Note that the number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Panels A and B in Table 5 present the estimation results of the impact of tariffs and NTBs on import evasion in terms of value and quantity when observations of extreme smuggling are included. Panel C presents the estimation results when the outcome is the binary variable denoting extreme smuggling. For simplicity, I only report the coefficients of tariffs and NTBs in table 5. The main findings that higher tariffs lead to significantly higher import evasion both in terms of value and quantity while NTB leads to lower import evasion in terms of value but not quantity remain robust. There is also evidence that higher tariffs lead to a higher probability of extreme smuggling.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Import evasion (Value)						
Tariff	0.188***	0.188***	0.193***	0.193***	0.190***	0.190***
	(0.021)	(0.021)	(0.022)	(0.022)	(0.020)	(0.020)
Non-tariff barriers		-0.292**		-0.299**		-0.072*
		(0.125)		(0.125)		(0.039)
R-square	0.383	0.383	0.409	0.409	0.547	0.547
Panel B: Import evasion (Quantity)						
Tariff	0.153***	0.153***	0.162***	0.161***	0.161***	0.161***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)
Non-tariff barriers		-0.243*		-0.242*		-0.046
		(0.122)		(0.122)		(0.039)
R-square	0.361	0.361	0.387	0.387	0.533	0.533
Panel C: Possibility of extreme smuggling						
Tariff	0.018***	0.018***	0.019***	0.019***	0.018***	0.018***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Non-tariff barriers		-0.021*		-0.022*		-0.003
		(0.011)		(0.011)		(0.003)

R-square	0.374	0.374	0.403	0.403	0.546	0.546
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Country-pair by year fixed effects	No	No	Yes	No	No	Yes
Observations	4,373,094	4,373,094	4,372,072	4,372,072	4,338,401	4,338,401

Table 5. Impacts of tariff and non-tariff barriers on the possibility of extreme smuggling.

Note: This table presents estimation results of regressing import evasion (or extreme smuggling) on tariff and non-tariff measures and a set of country-level control variables and fixed effects. Standard errors are in the parenthesis and are two-way clustered at the country pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Overall, the analysis of the impacts of trade barriers on import evasion shows robust evidence that higher tariffs lead to more import evasion, while NTBs reduce import evasion in terms of value but not quantity. In addition, importing countries with higher corruption have higher import evasion and with higher property protection index have lower import evasion. Finally, high temperature leads to more import evasion.

It’s worthwhile to compare the estimated evasion elasticity with evasion elasticities from other studies. In particular, Fishman and Wei (2004) estimated a 3% evasion elasticity based on China’s 1998 data. Mishra et al. (2008) found a relatively smaller impact of tariffs on import evasion in the context of the trade reform in India of the 1990s using data from 1988 to 2003. Specifically, Mishra et al. (2008) found that a one percentage point increase in tariffs increases evasion by about 0.1% and they found that the higher import evasion elasticity estimates in Fishman and Wei (2004) largely reflect that the product sample in Fishman and Wei (2004) is biased in favor of more differentiated goods. Javorcik and Narciso (2008) found that a one-percentage-point increase in tariff rate is associated with a 0.6% increase in the trade gap in the case of homogenous products and a 2.1% increase in the case of differentiated products. Therefore, the estimated import evasion elasticity of 5.1% here for agricultural products is slightly larger than the estimates in current literature, which indicates that the import evasion elasticity for agricultural products is larger in magnitude for non-agricultural products.

To have an idea of the overall impact of tariffs and NTBs on import evasion from 1990 to 2019. I use the estimates in the core specification (6) in Table 3 to calculate tariffs and NTBs explain how much the change in import evasion from 1990 to 2019. Table 2 shows that, from 1990 to 2019, tariffs decreased by 2.2% from 16.7% to 14.5% and the possibility of NTBs increased by 37.2% from 0.4% to 37.6%. Therefore, changes in tariffs decreased import evasion by 0.11% (2.2%*0.051), and the changes in NTBs decreased import evasion in terms of value by 2.2% (37.2%*0.06). Overall, the back-of-envelope analysis shows that changes in tariffs and NTBs decrease import evasion by 2.32% from 1990 to 2019.

4.2 Excluding freight and insurance rate from CIF

Given that only 27.8% of mirror trade statistics report CIF/FOB ratio greater than one (As shown in Figure 1), I conduct two analyses using the adjusted import value constructed from equation (3) to calculate import evasion. Table A1 presents the estimation results of equation (3). The impact of distance on the CIF/FOB ratio gradually declined from 1990 to 2010 and slightly increased from 2010 to 2019. This could be caused by the significant improvement of transportation technologies in the 1990s (Feyrer, 2019; He, 2021). Figure A3 presents the predicted CIF/FOB ratios. Using the predicted CIF/FOB ratio, I estimate the insurance and freight rate and then subtract it from the import value before constructing adjusted import evasion measurements.

Columns (1) – (6) in Table 6 present the estimation results of the impacts of tariffs and NTBs on import evasion only for observations with a CIF/FOB ratio greater than 1. Columns (1)-(3) use the adjusted import evasion while columns (4)-(6) use the unadjusted import evasion. Comparisons indicate that the estimates of the impact of tariffs and NTBs on import evasion are not significantly affected. I also present the estimation results using adjusted import evasion for all observations in columns (7)-(9). The results are not significantly different from the results in Table 3. These findings support previous studies that use unadjusted import data to measure import evasion.

	CIF/FOB>1						All observations		
	Adjusted import evasion			Unadjusted import evasion			Adjusted import evasion		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff	-0.015***	-0.018***	-0.017***	-0.013**	-0.018***	-0.017***	0.061***	0.064***	0.052***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)	(0.017)	(0.017)	(0.014)
Non-tariff barries (NTBs)	-0.006	-0.009	-0.019**	-0.005	-0.008	-0.019**	-0.107***	-0.101***	-0.058***
	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.030)	(0.029)	(0.013)
Exporter fixed effects	Yes	No	No	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No	No	Yes	No
Country-pair by year fixed effects	No	No	Yes	No	No	Yes	No	No	Yes
R-square	0.102	0.132	0.179	0.098	0.133	0.180	0.075	0.096	0.149
Observations	1,208,658	1,207,985	1,187,129	1,208,658	1,207,985	1,187,129	2,427,823	2,427,210	2,407,331

Table 6. Estimation impacts of tariffs and non-tariff barriers on import evasion adjusted by freight and insurance rate.

Note: This table presents the estimation results of the impact of tariffs and non-tariff barriers on import evasion that is adjusted with estimated insurance and freight rate. I use equation (3) to estimate the insurance and freight rate. The estimation results are presented in Table A1 in the appendix. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. Note that the coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. Note that the number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

4.3 Mechanism: price underreporting and product misclassification

Table 7 presents the estimation results of the impacts of tariffs and NTBs on the unit value gap constructed from equation (3). The results are presented with an increasing level of generality as moving from column (1) to (3). Column (3) shows that both tariffs and NTBs have no significant impact on the unit price gap. As for the impact of control variables, importing countries who are WTO members show statistically significantly lower import evasion, while countries that import goods from countries with higher property protection levels show a higher unit price gap. Overall, there is no significant evidence that tariffs or NTBs cause price underreporting.

	(1)	(2)	(3)
Trade policies			
Tariffs	0.011	0.004	0.001
	(0.007)	(0.007)	(0.007)
Non-tariff barries (NTBs)	0.018	0.017	-0.008
	(0.011)	(0.012)	(0.009)
Importer characteristics			
Corruption (0-1)	-0.068	-0.056	
	(0.128)	(0.130)	
Property rights protection (0-1)	-0.129	-0.145	
	(0.144)	(0.145)	
WTO member (Binary)	-0.150**	-0.144**	
	(0.057)	(0.057)	
Rain (mm)	-0.000	-0.000	
	(0.000)	(0.000)	
Temperature (Celsius)	-0.007	-0.006	
	(0.014)	(0.014)	
Exporter characteristics			
Corruption (0-1)	0.058	0.045	
	(0.115)	(0.110)	
Property rights protection (0-1)	0.596**	0.615**	
	(0.276)	(0.280)	
WTO member (Binary)	0.022	0.019	
	(0.049)	(0.049)	
Rain (mm)	0.001	0.001	
	(0.001)	(0.001)	
Temperature (Celsius)	0.013	0.013	
	(0.031)	(0.031)	
Exporter fixed effects	Yes	No	No
Importer fixed effects	Yes	No	No
Year fixed effects	Yes	Yes	No

Six-digit HS product fixed effects	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No
Country-pair by year fixed effects	No	No	Yes
R-square	0.125	0.145	0.373
Observations	2,366,179	2,365,550	2,345,776

Table 7. Estimated impacts of tariff and non-tariff barriers on unit value gap.

Note: This table presents estimation results of the impact of tariff and non-tariff barriers on the gap between unit export and import value. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Table 8 presents the estimation results of equation (7), in which I add the average tariffs of other products within the same HS4 digit to test the mechanism of product misclassification. The coefficients of Oth_Tar_{ijot} are significantly negative across all specifications, indicating that products whose similar products have lower tariffs have higher import evasion. Therefore, there is significant evidence of product misclassification.

However, it should be noted that the impacts in Tables 7-8 are average impacts for the full sample and might mask great heterogeneity across products and countries. The following section explores the heterogeneity of the impacts.

	Import evasion in terms of value			Import evasion in terms of quantity		
	(1)	(2)	(3)	(4)	(5)	(6)
Trade policies						
Tariffs	0.313***	0.311***	0.367***	0.264***	0.264***	0.310***
	(0.039)	(0.037)	(0.039)	(0.034)	(0.033)	(0.035)
Non-tariff barries (NTBs)	-0.292**	-0.299**	-0.072*	-0.243*	-0.243*	-0.045
	(0.125)	(0.125)	(0.039)	(0.122)	(0.122)	(0.039)
Tariffs on other similar	-0.160***	-0.151***	-0.229***	-0.141***	-0.131***	-0.193***
	(0.036)	(0.034)	(0.040)	(0.033)	(0.031)	(0.037)
Importer characteristics						
Corruption (0-1)	-0.193	-0.062		0.168	0.318	
	(0.584)	(0.575)		(0.577)	(0.565)	
Property rights protection (0-1)	1.162	1.294		1.416*	1.535*	
	(0.850)	(0.859)		(0.810)	(0.820)	
WTO member (Binary)	-0.115	-0.158		-0.123	-0.172	
	(0.178)	(0.176)		(0.195)	(0.191)	

Rain (mm)	0.001	0.001		0.001	0.001	
	(0.002)	(0.002)		(0.002)	(0.002)	
Temperature (Celsius)	0.006	0.008		-0.081	-0.079	
	(0.094)	(0.093)		(0.115)	(0.113)	
Exporter characteristics						
Corruption (0-1)	0.117	0.191		-0.121	-0.069	
	(0.353)	(0.351)		(0.384)	(0.384)	
Property rights protection (0-1)	-0.313	-0.543		-0.744	-0.981*	
	(0.418)	(0.428)		(0.512)	(0.532)	
WTO member (Binary)	-0.677***	-0.744***		-0.776***	-0.855***	
	(0.212)	(0.210)		(0.274)	(0.270)	
Rain (mm)	-0.001	-0.001		-0.002	-0.002	
	(0.001)	(0.001)		(0.001)	(0.001)	
Temperature (Celsius)	0.044	0.040		0.035	0.032	
	(0.029)	(0.033)		(0.037)	(0.040)	
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Country-pair by year fixed	No	No	Yes	No	No	Yes
R-square	0.383	0.409	0.547	0.361	0.387	0.533
Observations	4,373,094	4,372,072	4,338,401	4,373,094	4,372,072	4,338,401

Table 8. Estimated impacts of tariff and non-tariff barriers on import evasion: product misclassification.

Note: This table presents estimation results of equation (7), which tests the mechanism of product misclassification. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

4.4 Heterogeneity analysis

Lots of studies find that import evasion is easier for differentiated than for non-differentiated products. I test the impacts of tariff and NTBs on bulk and non-bulk products and expect to find stronger impacts of tariffs on import evasion for non-bulk products. I also test the impact of WTO membership on import evasion. Javorcik and Narciso (2017) find a significant negative impact of WTO membership on the impact of tariffs on underreporting of prices, as the WTO

Customs Valuation Agreement (CVA) limits the discretion of customs officials when it comes to assessing the price of imports.

Table 9 shows the results of the heterogeneity analysis. In panel A, while I still find a significantly positive impact of tariffs on import evasion (in both value and quantity) and find negative impacts of NTBs on import evasion in terms of value, I also find that import evasion is smaller for bulk products than for non-bulk products. Although the impact becomes statistically insignificant in the specification where the country pair-by-year fixed effects are included. The impacts of NTBs are not statistically significant for bulk and non-bulk products across all specifications. In panel B, there is evidence that importing countries who are WTO members are less likely to evade import tariffs. However, the impact is only significant when import evasion is measured in value but not in quantity.

	Import evasion (Value)			Import evasion (Quantity)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Heterogeneity across bulk and non-bulk products						
Tariff	0.062***	0.054***	0.053***	0.064***	0.063***	0.068***
	(0.013)	(0.012)	(0.012)	(0.018)	(0.018)	(0.018)
Non-tariff barriers (NTBs)	-0.035***	-0.035***	-0.058***	0.004	0.010	-0.028
	(0.010)	(0.011)	(0.012)	(0.047)	(0.048)	(0.029)
Tariff*Bulk	-0.104***	-0.066*	-0.063	-0.145***	-0.084**	-0.047
	(0.035)	(0.036)	(0.038)	(0.037)	(0.038)	(0.045)
Non-tariff barriers*Bulk	-0.013	-0.019	-0.021	-0.022	-0.037	-0.058
	(0.023)	(0.024)	(0.025)	(0.035)	(0.036)	(0.036)
R-square	0.051	0.079	0.116	0.074	0.090	0.260
Panel B: Heterogeneity across WTO and non-WTO reporters						
Tariff	0.264**	0.261**	0.449***	0.367	0.362	0.600*
	(0.098)	(0.099)	(0.149)	(0.282)	(0.287)	(0.330)
Non-tariff barriers (NTBs)	-0.069**	-0.065**	-0.083**	0.062	0.066	-0.048
	(0.026)	(0.026)	(0.036)	(0.089)	(0.091)	(0.047)
Tariff*reporter is a WTO member	-0.210**	-0.214**	-0.406**	-0.315	-0.309	-0.545
	(0.100)	(0.100)	(0.150)	(0.283)	(0.288)	(0.330)
Non-tariff barriers* reporter is a WTO member	0.035	0.031	0.026	-0.066	-0.065	0.015
	(0.029)	(0.028)	(0.039)	(0.093)	(0.094)	(0.053)

Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Country-pair by year fixed effects	No	No	Yes	No	No	Yes
R-square	0.052	0.079	0.116	0.074	0.091	0.261
Observations	2,427,823	2,427,210	2,407,331	2,427,823	2,427,210	2,407,331

Table 9. Heterogeneous impacts of tariff and non-tariff barriers on import evasion.

Note: This table presents estimation results of the heterogeneity impacts of tariffs and non-tariff barriers on import evasion across bulk and non-bulk products, and WTO and non-WTO countries. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

I then test whether the impacts of trade barriers on misclassification are different across WTO and non-WTO countries. Table 10 shows that the misclassification mechanism is much weaker in WTO than in non-WTO member countries, which indicates that the multilateral WTO is effective in curbing import evasion via product misclassification. In particular, higher tariffs lead to a higher unit price gap for non-WTO countries but have no significant impact on WTO countries, which aligns with Javorcik and Narciso's (2017) finding that the WTO Customs Valuation Agreement (CVA) limits the discretion of customs officials when it comes to assessing the price of imports. In addition, columns (1) – (6) indicate that the channel of product misclassification is much stronger for WTO countries, which indicates that WTO countries use misclassification as the main mechanism of import evasion.

Table 10. Heterogenous impacts of tariffs and non-tariff barriers on product misclassification.

	Import evasion (Value)			Import evasion (Quantity)			Unit price gap		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff	1.136***	1.126***	1.169***	1.217***	1.197**	1.245***	0.150***	0.147***	0.142***
	(0.358)	(0.354)	(0.367)	(0.439)	(0.439)	(0.446)	(0.034)	(0.033)	(0.029)
Non-tariff barriers (NTBs)	-0.069**	-0.065**	-0.083**	0.062	0.066	-0.047	-0.015	-0.012	0.000
	(0.026)	(0.026)	(0.036)	(0.090)	(0.091)	(0.047)	(0.022)	(0.022)	(0.020)
Tariff*reporter WTO	-1.098***	-1.081***	-1.125***	-1.149**	-1.125**	-1.178**	-0.142***	-0.147***	-0.145***
	(0.358)	(0.353)	(0.367)	(0.436)	(0.436)	(0.445)	(0.035)	(0.034)	(0.030)
Non-tariff barriers* reporter is a WTO member	0.036	0.031	0.025	-0.066	-0.065	0.015	0.035	0.032	-0.010
	(0.029)	(0.028)	(0.039)	(0.093)	(0.094)	(0.053)	(0.026)	(0.026)	(0.020)
Tariffs on other similar products	-0.912***	-0.906***	-0.769***	-0.890***	-0.875***	-0.689**			
	(0.297)	(0.293)	(0.262)	(0.299)	(0.299)	(0.274)			
Tariffs on other similar products* reporter is a WTO member	0.930***	0.908***	0.767***	0.871***	0.855***	0.675**			
	(0.296)	(0.291)	(0.260)	(0.296)	(0.296)	(0.276)			
Exporter fixed effects	Yes	No	No	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No	No	Yes	No
Country-pair by year fixed	No	No	Yes	No	No	Yes	No	No	Yes
R-square	0.052	0.079	0.116	0.074	0.091	0.261	0.125	0.145	0.373
Observations	2,427,823	2,427,210	2,407,331	2,427,823	2,427,210	2,407,331	2,366,179	2,365,550	2,345,776

Note: This table presents estimation results of the impacts of trade barriers on misclassification across WTO and non-WTO countries. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

5. Robustness Checks and Extensions

I conduct two robustness checks. The first checks the non-linearity of the impacts of tariffs on import evasion. The second tests whether results are robust to the exclusion of small trade flows.

5.1 Non-linearity of tariff evasion

I test the non-linear impact of tariffs on import evasion by including tariffs in different magnitudes as independent variables. I classify tariffs into five categories: <5%, 5-10%, 10-15%, 15-20%, and greater than 20%. Figure 5 presents the distribution of tariffs after excluding tariffs greater than 100%.[16] The estimation results presented in Table A2 in the appendix show strong evidence of non-linearity in the sense that smaller tariffs are likely to decrease import evasion, while tariffs higher than 20% are driving the positive impacts of tariffs on import evasion. This non-linearity holds for both import evasion measured in terms of value and quantity and holds whether the extreme smuggling with only exports is included in the analysis.

Table A3 in the Appendix presents the estimation results of the non-linear impacts of tariffs on extreme smuggling. It shows strong evidence that lower tariffs reduce the possibility of extreme smuggling, and higher tariffs increase the possibility of extreme smuggling. These non-linearity patterns align with Fisman and Wei (2004), which suggests sunk costs in import evasion.[17]

[16] The share of tariffs greater than 100% is less than 1%.
[17] In contrast, Mishra et al. (2008) find weak evidence for non-linear effects of tariffs on evasion and evasion elasticity does not appear to depend robustly on the level of tariffs.

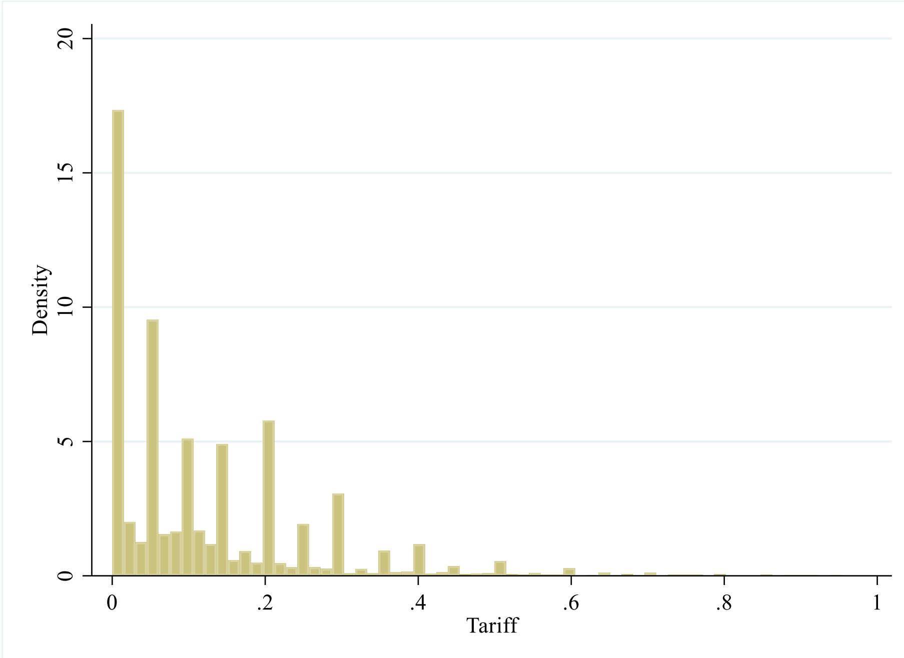

Figure 5. Distribution of tariffs smaller than 100%.

Note: This table presents the distribution of tariffs levels. I exclude tariffs greater than 100% (less than 1% of the entire sample) from the analysis for scaling purposes.

5.2 Excluding small trade flows

In the main analysis, I exclude exports smaller than $5,000. I relaxed the threshold to $10,000 as a robustness check. The results reported in Table A4 in the appendix show that the main finding that higher tariffs lead to more import evasion while NTBs reduce import evasion in terms of value but not of quantity remains robust. In addition, the findings that importing countries with higher corruption have higher import evasion and with higher property protection index have lower import evasion, and high temperature leads to more import evasion are also robust.

6. Conclusions and Discussion

Import evasion in the agricultural and food sector is widespread and could have adverse impacts on the ecosystem, public health, and welfare of agricultural producers in developing countries. However, studies on import evasion in the agricultural sector are quite limited. This article fills this gap in current literature by documenting the magnitude of import evasion in the agricultural and food sectors and quantifying the impacts of tariffs and NTBs on import evasion in the agricultural sector using a dataset covering broad countries and commodities for three decades. Empirical analysis shows that a one percentage point increase in tariffs increases import evasion by 5.1%, and the imposition of any NTBs decreases import evasion by 6%. Back-of-envelope analysis shows that changes in tariffs and NTBs decrease import evasion by 2.32% from 1990 to 2019.

While most studies find that both tariff and NTBs could reduce trade flows, few studies account for these trade policies' second-order import evasion impacts. The finding that a one percentage point increase in tariffs leads to a 5.1% increase in import evasion implies that for any products whose tax rates exceed 20%, a one percentage point increase would lead to more than one-percentage point reduction in reported imports. The main finding that tariff increases import evasion while NTBs decrease import evasion also has important policy implications. In particular, given that a decreasing trend for tariffs has largely been compensated by the growing NTBs in the agricultural sector, this finding indicates that it's important to account for the differentiated impacts of tariffs and NTBs on both trade flows and import evasion when discussing policies on substitution between NTBs and equivalent or lower tariffs.

This study has several caveats and can be extended in several ways. First, import evasion of agricultural and food products could affect food consumption and agricultural production. It would be important to analyze the impacts of import evasions of specific agricultural commodities, such as sugar, frozen meat, on local or global production and consumption. Second, an important limitation of this study is that I do not explicitly consider import evasion mechanisms other than price underreporting and product misclassification, such as transshipping.

Transshipping refers to the process of moving traded goods through a third country en route from its production point to its destination for consumption. While transshipping could be legitimate when moving goods through third countries of shipping hubs for logistical reasons, it becomes illegal when used to change or obscure a product's actual region of origin (Ferrier, 2021). A potential way of detecting the impacts of trade barriers on transshipping is via time-linked trade inflows and outflows of agricultural products through third countries. This method would ideally require a good understanding of the major trading countries of specific commodities and could provide insights that are hard to detect in this study. Finally, while import evasion is primarily driven by a disparity between the price of a good at its origin and its destination or other restrictive trade policies (Pitt, 1981), whether it is welfare-enhancing or welfare-decreasing depends on lots of factors, such as the market structure of the smuggling market and the quality of the smuggled products (Bhagwati and Hansen, 1973; Lovely and Nelson, 1995). It would be important to develop a framework that can analyze the welfare impacts of import evasion in the agricultural markets.

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Online Appendix for

"**Trade Barriers and Import Evasion in Agricultural Markets**"

Appendix A: Data Sources and Management

I compile data on bilateral trade, tariffs, non-tariff barriers, and country-level control variables from various sources. The details of the data sources and the data cleaning process are described below.

Data sources

i. Bilateral trade

Bilateral trade data come from the United Nation's Commodity Trade Statistics (UNComtrade) Database, which provides detailed annual bilateral mirror trade statistics (i.e., and importer's imports from an exporter and an exporter's exports to an importer) and accounts for more than 95% of the world trade. The dataset can be accessed from https://comtrade.un.org/data/.

Another commonly used trade data source, BACI, provides one reconciled trade flow between countries by first estimating and removing the CIF costs from import values to compute FOB import values and then evaluating the reliability of each country as a reporter of trade data. A reporter who tends to provide very different data from the ones reported by its partners will be assigned a lower weight to determine the reconciled trade flow value (Gaulier and Zignago, 2010). Specifically, Gaulier and Zignago (2010) regressed the CIF/FOB ratio on a set of gravity-type geographical variables, including the distance between two countries, whether the importer/exporter is landlocked, and a set of year and product fixed effects.

This study uses bilateral trade data at the 6-digit HS code level and estimates the predicted CIF/FOB value to get the predicted CIF rates and then distract it from the CIF values before calculating import evasion.

ii. Tariffs and non-tariff barriers

I collect tariff data from the United Nations Conference on Trade and Development's (UNCTAD) Trade Analysis Information System (TRAINS) (UNCTAD, 2021).

Non-tariff measures classified into technical measures, non-technical measures, and export-related measures also come from the UNCTAD global database on Non-tariff Measures (UNCTAD, 2021).

iii. Country-level control variables

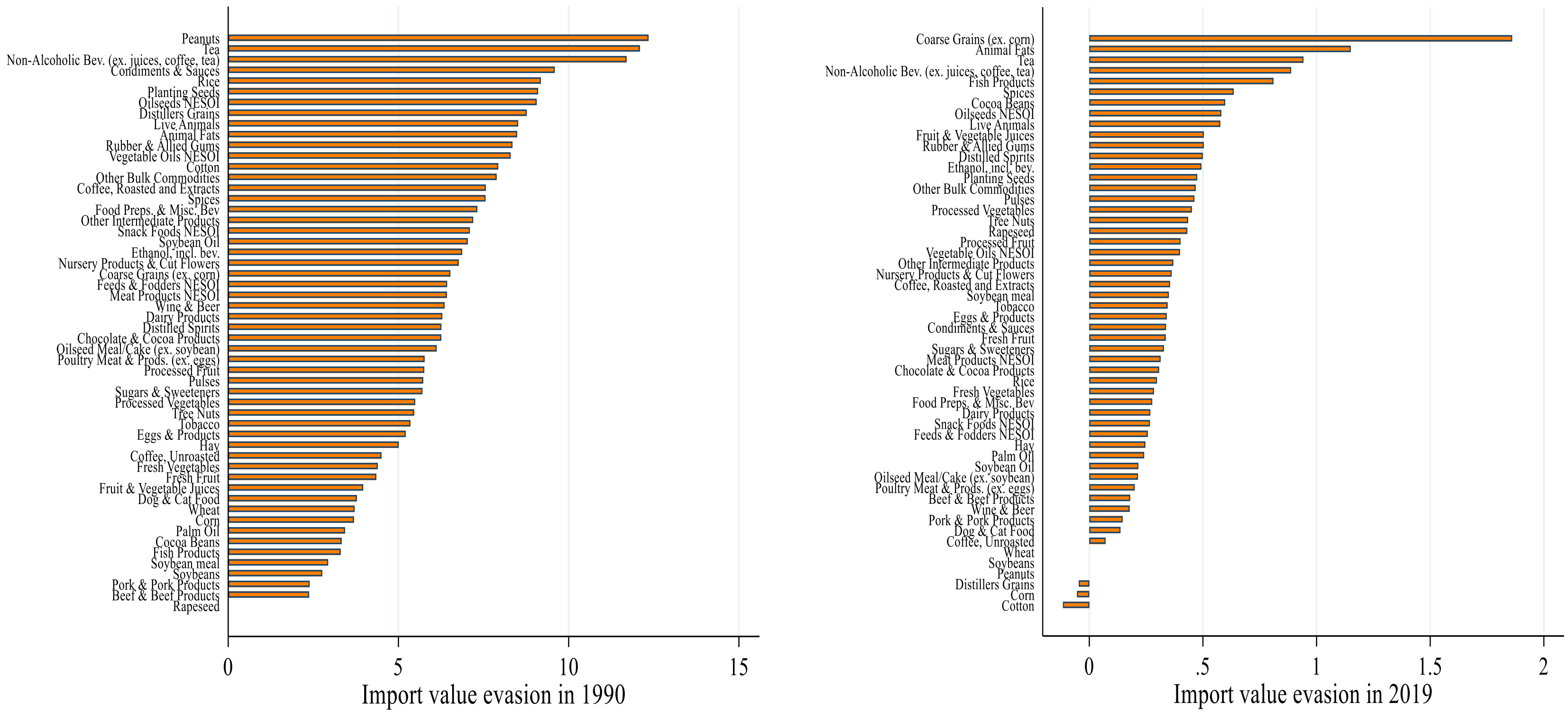
Other than tariff and non-tariff policies, I collect property rights protection and corruption levels from the V-Dem project by Coppedge et al. (2020) and weather variables, including rainfall and precipitation, from NOAA National Centers for Environmental Information (NOAA NCEI, 2020).

Data management

After matching trade data with trade policies and country-level control variables, there is a total number of 11,333,803 observations that cover 246 importing countries, 166 exporting countries, 696 commodities at the six-digit HS code level over thirty years from 1990 to 2019. To exclude observations with potential quality problems, I drop observations with less than 5,000$ in export values and observations within the upper 1% and lower 1% distribution of import evasion from the analysis. The final sample in the analysis is an unbalanced panel dataset of 8,075,938 observations covering 246 importing countries, 165 exporting countries, and 696 products at the six-digit HS code level from 1990 to 2019.

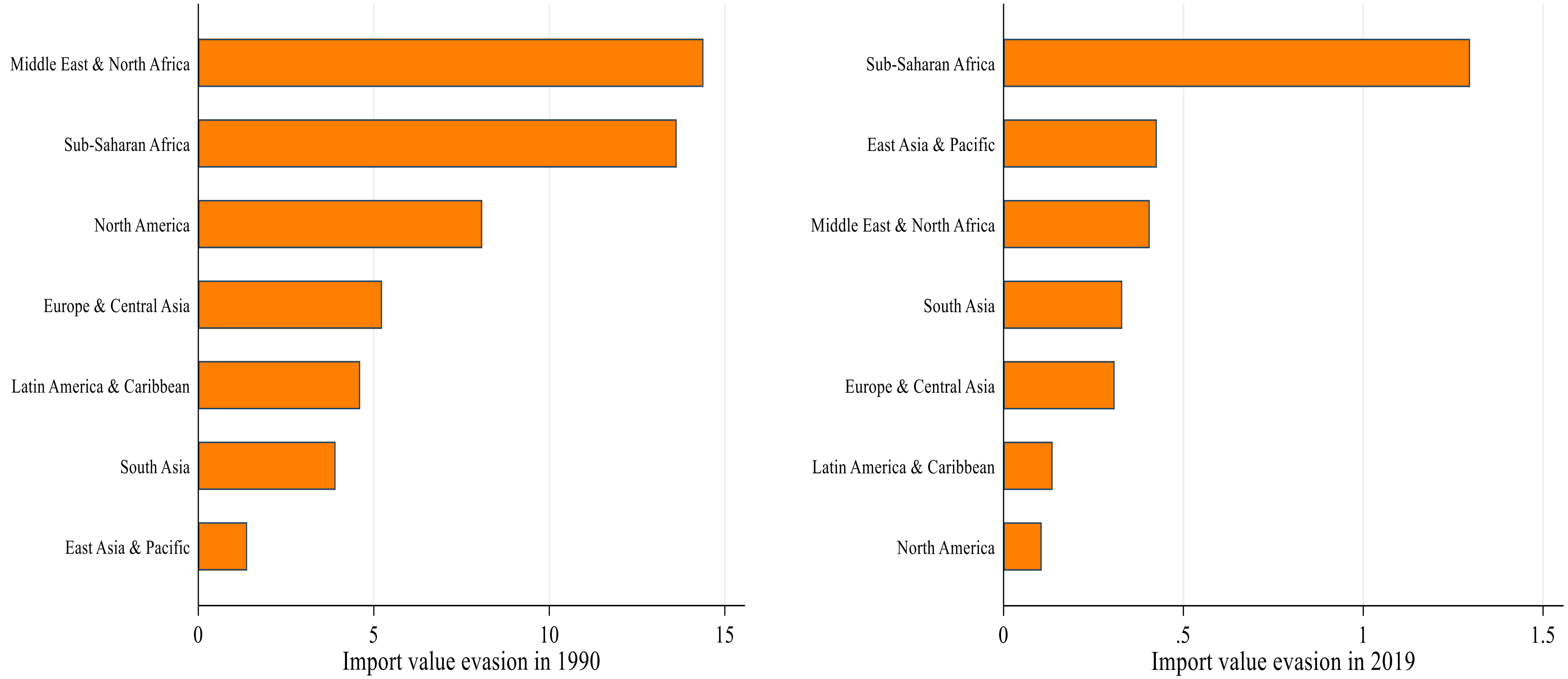
Appendix B: Additional figures

Figure A1. Import evasion across commodities.



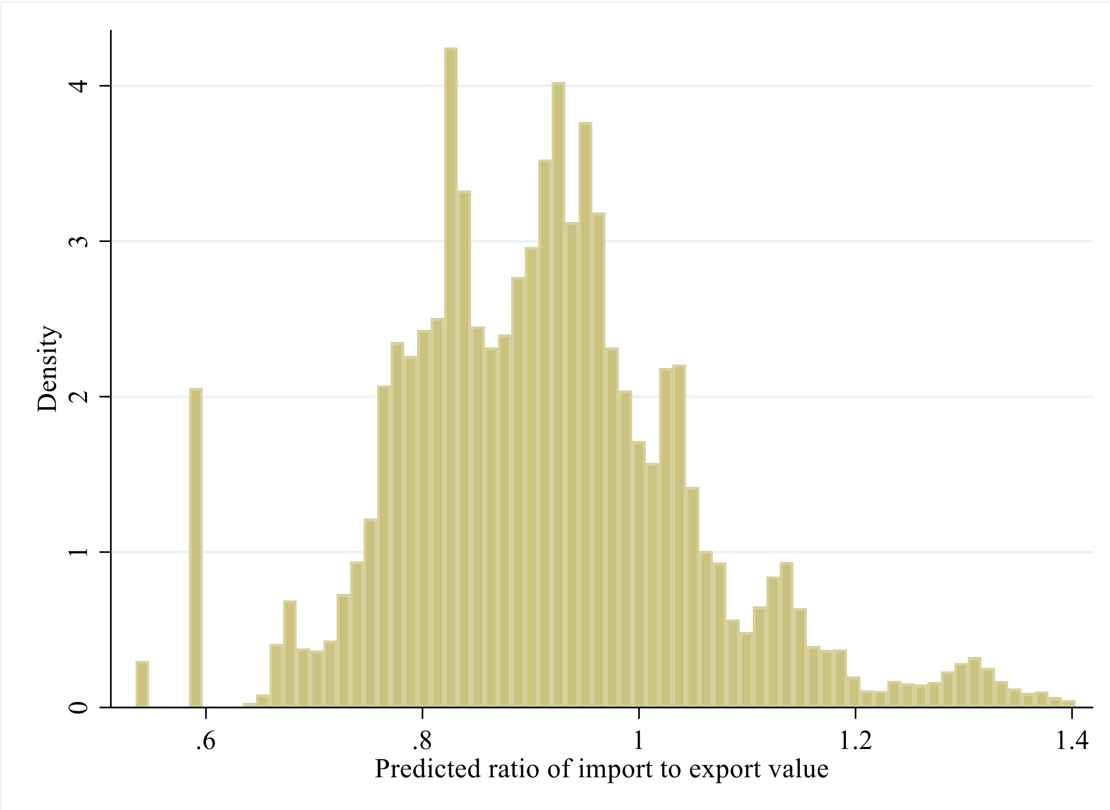
Note: The two figures show the average import evasion (defined as log (1+export value)-log (1+import value)) at the country-pair by HS6 level in 1990 and 2019 for agricultural commodities. Observations where exports have no corresponding imports are excluded.

Figure A2. Import value evasion across regions.



Note: The two figures show the average import evasion (defined as log (1+export value)-log (1+import value)) at the country-pair by HS6 level in 1990 and 2019 for seven regions. Observations where exports have no corresponding imports are excluded**.**

Figure A3. The predicted ratio of import to export value.



Note: This figure presents the distribution of the predicted ratio of import to export value from equation (3). The estimation results are presented in Table A1 in the appendix.

Appendix C: Additional figures.

Table A1. Estimation results of impacts of distance and contiguity on the ratio of import to export value.

	The ratio of import to export value
Distance between country pair	
Dummy for 1990-1994	0.087***
	(0.019)
Dummy for 1995-1999	0.071***
	(0.010)
Dummy for 2000-2004	0.048***
	(0.009)
Dummy for 2005-2009	0.037***
	(0.009)
Dummy for 2010-2014	0.052***
	(0.008)
Dummy for 2015-2019	0.061***
	(0.010)
The two countries are contiguous	-0.103***
	(0.031)
Importer fixed effects	Yes
Exporter fixed effects	Yes
Commodity fixed effects	Yes
Year fixed effects	Yes
R-square	0.029
Observations	5,380,696

Note: This table presents the estimation results of equation (3), in which I test the impacts of distance and contiguous on the ratio of import to export value.

Table A2. Non-linear impacts of tariffs on import evasion.

	Import evasion (Value)			Import evasion (Quantity)		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Excluding extreme import evasion						
Tariff (<=5%)	-1.224***	-0.991***	-1.035***	-0.477	-0.215	-0.099
	(0.249)	(0.246)	(0.258)	(0.380)	(0.385)	(0.323)
Tariff (>5% and <=10%)	-0.085	-0.020	-0.142	-0.073	0.088	-0.070
	(0.124)	(0.121)	(0.124)	(0.212)	(0.222)	(0.161)
Tariff (>10% and <=15%)	0.030	0.045	-0.019	-0.107	-0.023	0.090
	(0.089)	(0.089)	(0.087)	(0.186)	(0.187)	(0.137)
Tariff (>15% and <=20%)	0.280***	0.272***	0.200***	0.195	0.232	0.136
	(0.070)	(0.069)	(0.071)	(0.153)	(0.152)	(0.102)
Tariff (>=20%)	0.056***	0.050***	0.049***	0.046**	0.048***	0.057***
	(0.012)	(0.011)	(0.011)	(0.017)	(0.017)	(0.017)
Non-tariff barriers (NTBs)	-0.029**	-0.024*	-0.054***	-0.026	-0.015	-0.036
	(0.013)	(0.012)	(0.012)	(0.042)	(0.043)	(0.029)
R-square	0.039	0.064	0.096	0.073	0.089	0.234
Observations	4,156,572	4,155,773	4,132,076	4,156,572	4,155,773	4,132,076
Panel A: Including extreme import evasion						
Tariff (<=5%)	-7.419***	-7.628***	-3.086***	-6.283***	-6.583***	-1.859***
	(2.156)	(2.096)	(0.639)	(2.025)	(1.993)	(0.579)
Tariff (>5% and <=10%)	-3.493***	-3.377***	-1.487***	-3.161***	-3.036***	-1.085***
	(0.693)	(0.687)	(0.360)	(0.677)	(0.671)	(0.345)
Tariff (>10% and <=15%)	-2.332***	-2.163***	-0.446**	-2.042***	-1.874***	-0.027
	(0.432)	(0.425)	(0.196)	(0.466)	(0.457)	(0.193)
Tariff (>15% and <=20%)	-1.700***	-1.567***	-0.206	-1.524***	-1.373***	-0.010
	(0.371)	(0.360)	(0.149)	(0.364)	(0.348)	(0.139)
Tariff (>=20%)	0.113***	0.117***	0.156***	0.085***	0.093***	0.134***
	(0.022)	(0.020)	(0.017)	(0.022)	(0.020)	(0.017)
Non-tariff barrier	-0.283	-0.288	-0.037	-0.259	-0.257	-0.021
	(0.176)	(0.172)	(0.037)	(0.164)	(0.160)	(0.036)
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country pair fixed effects	No	Yes	No	No	Yes	No
Country pair by year fixed	No	No	Yes	No	No	Yes
R-square	0.405	0.433	0.553	0.385	0.412	0.541
Observations	7,218,301	7,216,883	7,176,791	7,218,301	7,216,883	7,176,791

Note: This table presents the estimation results of the impact of tariffs in the different intervals on import evasion in terms of value and quantity. Country-level control variables are included, but their coefficients are not reported for the sake of simplicity. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Table A3. Non-linear impacts of tariffs on the possibility of extreme smuggling.

	A binary variable of extreme smuggling		
	(1)	(2)	(3)
Tariff (<=5%)	-0.832***	-0.847***	-0.412***
	(0.191)	(0.185)	(0.055)
Tariff (>5% and <=10%)	-0.437***	-0.421***	-0.231***
	(0.061)	(0.060)	(0.027)
Tariff (>10% and <=15%)	-0.277***	-0.257***	-0.082***
	(0.042)	(0.041)	(0.017)
Tariff (>15% and <=20%)	-0.204***	-0.186***	-0.050***
	(0.034)	(0.033)	(0.012)
Tariff (>=20%)	0.009***	0.010***	0.013***
	(0.002)	(0.002)	(0.001)
Non-tariff barrier	-0.024	-0.025	0.000
	(0.016)	(0.015)	(0.003)
Exporter fixed effects	Yes	No	No
Importer fixed effects	Yes	No	No
Year fixed effects	Yes	Yes	No
Six-digit HS fixed effects	Yes	Yes	Yes
Country pair fixed effects	No	Yes	No
Country pair by year fixed effects	No	No	Yes
R-square	0.403	0.433	0.557
Observations	7,218,301	7,216,883	7,176,791

Note: This table presents the estimation results of the impact of tariffs in different intervals on the possibility of extreme smuggling. Country-level control variables are included, but their coefficients are not reported for the sake of simplicity. Standard errors are in the parenthesis and are two-way clustered at the country pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. The coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. The number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.

Table A4. Impact of tariffs on import evasion: keep exports greater than $10,000.

	Import evasion (Value)			Import evasion (Quantity)		
	(1)	(2)	(3)	(4)	(5)	(6)
Trade policies						
Tariff	0.062***	0.055***	0.054***	0.065***	0.066***	0.070***
	(0.013)	(0.012)	(0.012)	(0.018)	(0.018)	(0.018)
Non-tariff barriers	-0.040***	-0.040***	-0.064***	0.000	0.006	-0.035
	(0.011)	(0.011)	(0.013)	(0.048)	(0.049)	(0.029)
Importer characteristics						
Corruption	-0.050	-0.020		0.532**	0.565**	
	(0.072)	(0.071)		(0.205)	(0.210)	
Property rights protection	-0.419***	-0.434***		0.277	0.313	
	(0.072)	(0.076)		(0.523)	(0.521)	
WTO member	0.020	0.026		0.300	0.303	
	(0.044)	(0.042)		(0.249)	(0.245)	
Annual rain	0.000	0.000		0.000	0.000	
	(0.000)	(0.000)		(0.001)	(0.001)	
Annual average temperature	0.019***	0.018**		-0.126	-0.127	
	(0.006)	(0.007)		(0.094)	(0.094)	
Exporter characteristics						
Corruption	-0.053	-0.063		-0.239	-0.245	
	(0.061)	(0.063)		(0.350)	(0.357)	
Property rights protection	-0.053	-0.103		-0.537	-0.616	
	(0.069)	(0.074)		(0.439)	(0.444)	
WTO member	0.054	0.001		-0.127	-0.180	
	(0.043)	(0.034)		(0.206)	(0.207)	
Annual rain	-0.000	-0.000		-0.002	-0.002	
	(0.000)	(0.000)		(0.001)	(0.001)	
Annual average temperature	0.003	0.003		0.018	0.017	
	(0.007)	(0.008)		(0.040)	(0.039)	
Exporter fixed effects	Yes	No	No	Yes	No	No
Importer fixed effects	Yes	No	No	Yes	No	No
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Six-digit HS product fixed	Yes	Yes	Yes	Yes	Yes	Yes
Country-pair fixed effects	No	Yes	No	No	Yes	No
Country-pair by year fixed	No	No	Yes	No	No	Yes
R-square	0.057	0.086	0.124	0.078	0.095	0.271
Observations	2,232,022	2,231,392	2,211,058	2,232,022	2,231,392	2,211,058

Note: This table presents estimation results of regressing import evasion in terms of value and quantity on tariff and non-tariff measures and a set of country-level control variables and fixed effects. Standard errors are in the parenthesis and are two-way clustered at the country-pair and year level. *, **, and *** denote significant level at 10%, 5%, and 1%, respectively. Note that the coefficients of country-level control variables cannot be estimated due to the inclusion of country pair-by-year fixed effects. Note that the number of observations is smaller than the number of observations in the summary statistics in Table 2 because some observations are dropped due to collinearity caused by the inclusion of fixed effects.