No 2018-24 – December

Working Paper

CEPII

Institutions and Customs Duty Evasion

Sébastien Jean, Cristina Mitaritonna & Antoine Vatan

Highlights

- This paper studies theoretically and empirically the relation between institutional quality and customs evasion.
- We develop a model interacting customs officers and importing firms behavior. We consider different cases such as collusion versus corruption and endogenous versus exogenous inspection effort.
- Emprically, in line with the general framework, we find a positive, and marginally decreasing, tariff elasticity.
- The tariff elasticity becomes negative above a given threshold. It is consistent with either a non-collusive framework or a collusive one where the custom officer knows that the probability of control is higher for hig-tariff products.
- Institutional quality, e.g. transparency, reduces the evasion elasticity while the ease of enforcement (differentiated products) matters only if customs officer does not collude with importing firms.

RESEARCH AND EXPERTISE
ON THE WORLD ECONOMY

Abstract

Tariff receipts are important for many countries but their collection is often problematic. To analyze why and to what extent this occurs we first model customs duty evasion as an interaction between customs officers considered to be corruptible law enforcers, and importing firms. In this context, higher tariffs generally lead to greater customs duty evasion but their marginal impact is decreasing, and may turn negative above a given threshold if customs officers adapt their inspection effort endogenously. While transparency (the probability of effective control) always limits evasion, we show that ease of enforcement (e.g. ease of establishing the shipment`s true value) matters only if customs officers do not collude with importers. Our empirical analysis spans 55 importing countries over the period 2001-2010 and confirms our predictions. This lends support to the assumptions of endogenous inspection effort and widespread collusion. World Trade Organization membership is found also to limit the extent of duty evasion.

Keywords

Tax Evasion, Customs Duty, Institutions, International Trade.

JEL

F13, H26, K42.

Working Paper

CEPII

CEPII (Centre d'Etudes Prospectives et d'Informations Internationales) is a French institute dedicated to producing independent, policy-oriented economic research helpful to understand the international economic environment and challenges in the areas of trade policy, competitiveness, macroeconomics, international finance and growth.

CEPII Working Paper
Contributing to research in international economics

Editorial Director:
Sébastien Jean

Production:
Laure Boivin

No ISSN: 1293-2574

CEPII
20, avenue de Ségur
TSA 10726
75334 Paris Cedex 07
+33 1 53 68 55 00
www.cepii.fr
Press contact: presse@cepii.fr

RESEARCH AND EXPERTISE ON THE WORLD ECONOMY

Institutions and customs duty evasion

Sébastien Jean* Cristina Mitaritonna† Antoine Vatan‡

1. Introduction

Customs duty evasion is a serious concern in many developing countries where tariff receipts are often important but their collection is problematic. Although tariff receipts are generally considered to benefit from lower collection costs compared to most other taxes, there is abundant anecdotal evidence of fraudulent importers evading this tax. Since tariff evasion is an unlawful practice it is not directly observable. However, Bhagwati (1964, 1967) hints at the possibility of indirect investigation of this phenomenon using trade statistics and exploitingthe fact that both the importing and the exporting countries generally declare trade flows. Evasion more often involves the importer understating the import value at customs clearance, *i.e.*, rather than an exporter making a fake declaration in its own country.

While there are several factors that might give rise to a gap between the values recorded by the importer and the exporter, evasion is the only issue that shows a positive relationship between the tariff and the magnitude of this gap. Fisman and Wei (2004) study Chinese imports from Hong Kong and show that identifying a relationship between trade value and the tariff is an indirect way to demonstrate tariff evasion. They find that this relationship is not negligible, and that a 1 percentage point higher duty rate is associated to a 3% larger tariff duty evasion –a relative increase, in this case equal to 3, which in what follows, we describe as evasion elasticity. Applying their approach to trade between Germany and 10 Eastern European countries in 1992-2003, Javorcik and Narciso (2008) found that higher product-level tariffs provoke higher levels of tariff evasion with weaker estimated evasion elasticities than those estimated in the Chinese case. Javorcik and Narciso (2008) show also that the responsiveness of trade gaps to tariff levels is greater for differentiated than homogeneous goods, which they explain as due to the greater ease of concealing the real value of differentiated goods. The results in Mishra et al. (2008) for the case of India during the 1990s are similar. These authors find a significant and robust impact of tariffs on evasion although they estimate a much lower evasion elasticity of around 0.1. They agree that this elasticity of evasion is greater for differentiated products, and show also that it varies by mode of entry; goods entering by air transport exhibit a lower evasion elasticity compared to those that enter via a seaport which is consistent with the less advanced state of

*INRA & CEPII, 20, avenue de Ségur 75007 Paris (sebastien.jean@cepii.fr)
†CEPII, 20, avenue de Ségur 75007 Paris (cristina.mitaritonna@cepii.fr)
‡CEPII, 20, avenue de Ségur 75007 Paris (antoine.vatan@cepii.fr)

computerization at seaports in India. Bouët and Roy (2012) use a comparable framework for the cases of Nigeria, Kenya and Mauritius, and find a positive and significant evasion elasticity for all three countries which they link to their institutions. They highlight that the tariff evasion is higher in countries with comparatively weak institutions which applies to Nigeria, and to a lesser extent Kenya, vis-à-vis Mauritius. Javorcik and Narciso (2017) analyzed the influence of World Trade Organization (WTO) accession, and in particular, adoption of the WTO Custom Valuation Agreement which limits the discretion of customs officials in assessing the price of imports. Based on 15 importing countries which joined the WTO between 1996 and 2008, they show that removing this discretion limits misrepresentation of import prices. Howevery, they found that some importers seem to switch to other evasion methods: underreporting of quantities and product misclassifications increased after WTO accession. However, overall levels of evasion remain unchanged.

Overall, the literature suggests that tax evasion is widespread, that there are many ways to evade customs duties,[1] and that evasion is affected by several aspects including level and distribution of tariffs, quality of law enforcement, and policies aimed at improving customs administration. The present work takes a broader perspective and tries to identify both the determinants and the mechanisms at play.
To do this, we propose a theoretical framework where customs duty evasion results from interactions between the customs officer and the importing firm. Importers may try to hide the true value or nature of their shipments in order to minimize their tax payments. Customs officers are supposed to enforce the law and sanction mis-declarations (motivated perhaps, by a reward for the cases identified) but they may be willing to accept a bribe to overlook misdeclarations which in turn might risk sanction from an external control. We consider two cases: collusion where customs officer and importer agree ex-ante about the declared value of the shipment which is not necessarily its true value; and non-collusive corruption where the importer declares a value before submitting the shipment to the customs officer's inspection. We alternatively consider or ignore the possibility that customs officers endogenously adapt the intensity of their inspection effort to the characteristics of the shipment. We show that evasion increases with tariffs but is marginally decreasing, at least up to a given level. When the customs officer adapts the inspection effort endogenously, and in this case only, this relation is reversed above a certain tariff level. In all cases, the probability of a customs officer's fraud being sanctioned (which we describe as transparency) is proved to decrease both evasion and its elasticity to tariff duties. In contrast, the model suggests that ease of enforcement (linked e.g. to ease of establishing the shipment's true value) matters only in a context of non-collusive corruption.

To assess the empirical relevance of this model, we measure tariff evasion as the misrepresentation of import values at the 6-digit Harmonized System (HS) product level over the period 2001-2010, using the exporting country's declared value as the reference. To increase reliability,

[1] Ranging from fallacious declarations of value based on misrepresentation of prices or underreporting of quantities, to misclassifications of high tariff products as lower tariff goods, to bribery and smuggling, all of which result in in lower collection of duty.

following Javorcik and Narciso (2017), we retain only data from exporters in the top quartile of the World Bank's ranking of the least corrupt exporters. After accounting for some consistency and reliability requirements, we obtain a sample of 55 importing countries. We use a strong fixed effects structure, i.e. both product-year and country pair-year, and test all plausible propositions.

We find strong support for the model's main predication of a significantly positive evasion elasticity with regard to tariffs which is reduced greatly by transparency, measured either as control of corruption or WTO accession. Our finding that ease of enforcement is not significant in the most complete specifications lends support also to the hypothesis that on average, collusion prevails which is in line with the recent findings in Chalendard et al. (2018). In addition, we show that customs duty evasion tends to decline for very high tariff levels which is consistent with the assumption that customs officers adapt their inspection effort endogenously.

The theoretical framework which includes different scenarios and propositions is presented in Section 2. Section 3 describes the empirical approach, the data, and the descriptive statistics. Sections 4 and 5 discuss the econometric results, and section 6 concludes.

2. Theoretical Framework

We develop a simple model of the determinants of customs duty evasion. Adapting the analysis in Mookherjee and Png (1995) of corruptible law enforcers, we model the interaction between customs officers and importers explicitly. We assume by default that there is no collusion between importer and customs officer before customs inspection. We consider the collusion case in a second step.

2.1. Non-collusive corruption under exogenous inspection effort

We consider a firm importing a fixed amount M facing an *ad valorem* tariff duty t.[2] The importer can choose to conceal the true value of the shipment and to declare an import value of only $(1-\gamma)M$ with $0 \leq \gamma \leq 1$. The main ways to evade custom duties are discussed in the next section. Upon customs clearance, the customs officer might disclose the true value of the shipment with probability $d(\gamma, \epsilon) = e\epsilon\gamma^2$, where e is the effort devoted by the customs officer to inspecting the shipment and $\epsilon \in [0;1]$ (which in what follows we describe as ease of enforcement is an index measuring external factors influencing this probability, such as the ease of evaluating the shipment's true value.[3] As emphasized by Javorcik and Narciso (2008) and Mishra et al. (2008), product differentiation is an important factor because the true value

[2] M is assumed to be exogenous as in *e.g.* Mishra et al. (2008); however, assuming otherwise does not change the subsequent results.

[3] In this simple specification, ϵ is the probability of complete smuggling being discovered (*i.e.*, the probability that $\gamma = 1$). However, using $f(\epsilon)$ instead of ϵ where f is any function such that $f > 0, f' > 0$ does not change the results, meaning that this interpretation should not be considered essential.

of a shipment is more difficult to assess for differentiated than for homogenous products. We assume an increasing and convex function in the share of import smuggled to reflect the fact that concealing the true value of a shipment is increasingly difficult in both average and marginal terms, as the share smuggled increases.

If the customs officer discovers the true value of the shipment, assuming it has been understated by the importer (*i.e.*, $\gamma > 0$), he should sanction the importer by imposing a penalty S^F. In this case, we assume the customs officer will be rewarded with a bonus proportional to the tariff revenue recovered, $B = \beta^0 t\gamma M$ where $0 \leq \beta^0 \leq 1$ as in Anson et al. (2006). However, the customs officer may be open to a bribe b from the importer to overlook the understatement. In this case, the customs officer is exposed to an administrative control. The probability that this control is applied, reveals the bribery and gives rise to a sanction depends on a variety of factors including the effort expended by government on these controls and on measures aimed specifically at improving the customs administration, and the credibility of sanctions.[4] For simplicity, we represent this probability by an index measure τ which in what follows we refer to as transparency. If the bribery is discovered, the customs officer is sanctioned with a penalty S^0 and the importer receives a penalty S^F. The sequence of events is summarized in figure 1 which is adapted from Mookherjee and Png (1995). Of course, the decision to engage or not in bribery involves more than only an economic dimension. As suggested by Allingham and Sandmo (1972), non-pecuniary factors need to be considered in the agent's utility function. However, here we ignore this dimension and focus exclusively on purely economic incentives, assuming agents to be risk neutral.

In this framework, the probability $d(\gamma, \epsilon)$ of the shipment's true value being disclosed by the customs officer depends *inter alia* on the level of effort the officer devotes to the inspection. First, we consider the case where this effort is exogenous (and for simplicity is equal to 1). Later, we examine the case where the customs officer can adapt the inspection effort to maximize the officer's utility, and show how this changes the results.

We solve the model backward by assessing first under which conditions bribery might take place. In the event of the true shipment value being discovered, the importer expects to gain $-b + (1-\tau)S^F$ from bribing the customs officer whose expected benefit from accepting the bribe is $b - \tau S^0 - B$. Bribery will take place if and only if it benefits both agents, *i.e.*

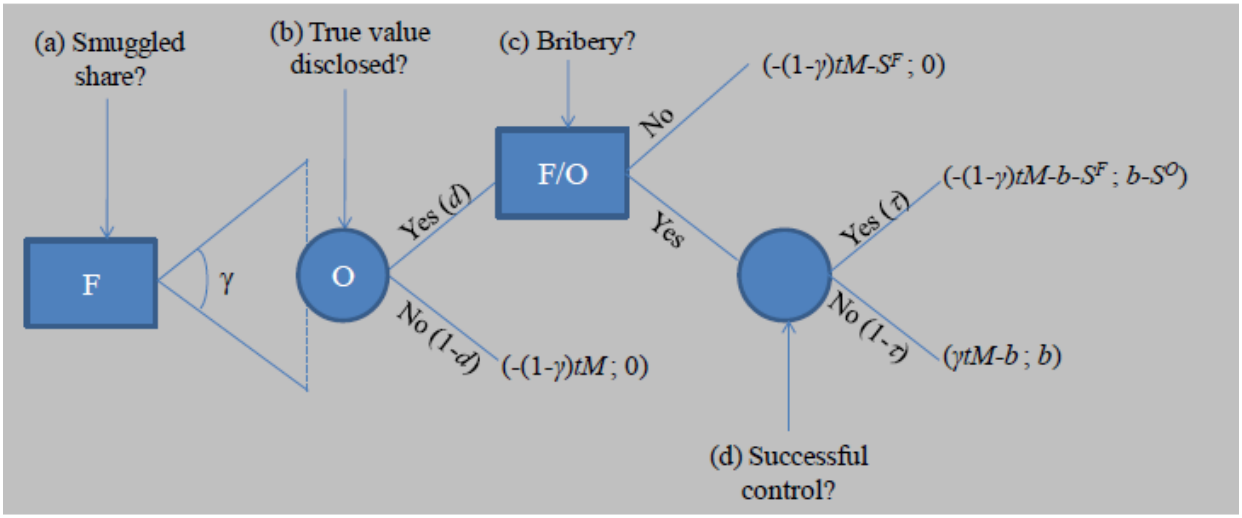
$$(1-\tau)S^F - \tau S^0 - B \geq 0 \tag{1}$$

If bribery occurs, for simplicity we assume that the bribe is set as a Nash bargaining solution between importer and customs officer, and assume equal bargaining power.[5] The benefits they

[4] For simplicity, we assume that this probability does not depend on the share smuggled, *e.g.* because the control technology is the same for the customs officer and the administrative controller.

[5] This assumption is made also by Mookherjee and Png (1995) and simplifies the exposition but does not condition our conclusions.

Figure 1 – Sequence of decisions and events in the non-collusive case



Note: F is the importer, O us the custom officer. The importer and customs officer payoffs are in parentheses. The figure depicts cases where the importer does understate the shipment value (i.e. $\gamma > 0$). If $\gamma = 0$, the payoffs are (-tM;0).

obtain from bribery equalize, with a bribe defined as

$$b = \left(\tau S^0 + (1-\tau)S^F + B\right)/2 \tag{2}$$

Assuming that the parameters are such that bribery is profitable, the importer's expected payoff can be written as

$$\Pi^F(\gamma) = -(1-\gamma)Mt - C(M, \gamma, \tau, \epsilon, t) \tag{3}$$

where $C(M, \gamma, \tau, \epsilon, t) = d\left(\tau S^0 + (1+\tau)S^F + B\right)/2$ is the expected cost to the importer of smuggling a share γ of its shipment. This expression makes clear the parallels with the models proposed by Slemrod (2001) and Mishra et al. (2008). However, in our case the cost of duty avoidance is derived explicitly from the description of the interaction between the importer and the customs officer.

As emphasized in Yitzhaki (1974) for instance, in the case of income tax avoidance, the form of the penalty to which the agents are exposed is important. In most cases it depends on the value of the tax understatement; a simple form that encompasses them is $S^i = (s_1^i + s_2^i t)\gamma M$, $i = O, F$, where s_1^i and s_2^i are positive parameters. As discussed in Anson et al. (2006), the two components are unlikely to be simultaneously non-zero but this general form allows discussion of various different cases in a unified framework. In what follows, it is useful to note that whatever these parameters, $C_\gamma \geq 0, C_t \geq 0, C_{\gamma t} \geq 0, C_{\gamma\gamma} \geq 0$ and $tC_{\gamma t} \leq C_\gamma$. These properties are logical consequences of the fact that here the cost of evasion is the product of the probability of non-disclosure which is increasing and convex in the share smuggled, and a combination of the penalties which are increasing functions of the share smuggled and the tariffs. The last property

reflects the fact that sanctions are at maximum, proportional to the tariffs.[6]
The importer sets the smuggled share γ so as to maximize its payoff. The first-order condition is

$$\Pi_{\gamma}^{F} = Mt - C_{\gamma} = 0 \tag{4}$$

Provided the institutional variables ϵ and τ are large enough to ensure that C_{γ} is negative for γ equal to 1, this condition characterizes an interior solution γ^{*} for γ. This solution can be written as

$$\gamma^{*} = \sqrt{\frac{4t}{3\eta\epsilon}}, \qquad \text{with } \eta = \tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + t\beta^0 \tag{5}$$

Deriving this condition with respect to t implies that

$$\sigma = \frac{\partial\gamma^{*}}{\partial t} = \frac{C_{\gamma} - tC_{\gamma t}}{tC_{\gamma\gamma}} \geq 0 \tag{6}$$

where $\sigma$is the "evasion elasticity" as in Mishra et al. (2008), defined as the partial derivative of the smuggled share with respect to the tariff. Also, ignoring the third order terms (*i.e.* and assuming $C_{\gamma t}$ and $C_{\gamma\gamma}$ is constant), then the second derivative is negative $\frac{\partial\sigma}{\partial t} \leq 0$. This leads to the following proposition:

Proposition 1 *The evasion elasticity (i.e. the partial derivative of the smuggled share with respect to the tariff) is positive and is a decreasing function of the tariff duty.*

Equation (5) implies also, that the derivative of γ^{*} with respect to the ease of enforcement, ϵ, is negative, hence

Proposition 2 *Greater ease of enforcement decreases the evasion elasticity.*

Turning to the effects of transparency, τ, we can check easily that

$$\frac{\partial\gamma^{*}}{\partial\tau} < 0 \qquad \text{and} \qquad \frac{\partial\sigma}{\partial\tau} < 0 \tag{7}$$

Hence

Proposition 3 *The share smuggled and its elasticity with respect to tariff decrease with transparency.*

[6]This property parallels the additional assumption in Mishra et al. (2008) case IV which is the only case where t is one of the determinants of the cost of evasion according to which the marginal cost of evasion with respect to the tariff is declining. We are unaware of any case - either theoretical or real - where the penalties are more than proportional to the tariffs.

In addition, it can be checked easily that

$$\frac{\partial^2 \gamma^*}{\partial \tau \partial \epsilon} \geq 0 \qquad \text{and} \qquad \frac{\partial^2 \sigma}{\partial \tau \partial \epsilon} \geq 0 \tag{8}$$

The sign of these two cross-derivatives may be enclosed in the following proposition:

Proposition 4 *The benefits of greater transparency are larger when enforcement is more difficult.*

Penalties may include a constant component, for instance if the risk to the customs officer is firing or some other disciplinary sanction if convicted of corruption. Appendix 1.B shows that the conclusions are the same in this case.

2.2. Non-collusive corruption under endogenous inspection effort

Since evasion is more likely for high-tariff products, the customs officer may choose to devote more effort to their control. To consider this possibility, let us assume that the customs officer adapts the inspection effort endogenously, product by product. If e denote this effort, then $d = e\epsilon\gamma^2$ is the probability that the customs officer will discover the true value of the shipment. As in Anson et al. (2006), let $c(e) = Me^2/2$ be the cost to the customs officer of this inspection effort. The bribe offered if the true value is not disclosed is the same as in the case of an exogenous inspection effort, as is the bonus offered to the officer in the case the officer identifies and denounces the fraud. The condition for bribery to take place remains the same.
The net benefit expected by the customs officer from accepting a bribe is

$$\Pi^c(e) = \frac{\left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right) Me\epsilon\gamma^3 - Me^2}{2} \tag{9}$$

While the benefit expected by the importer is

$$\Pi^F(\gamma) = -(1-\gamma)Mt - \frac{\left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + \beta^0 t\right) Me\epsilon\gamma^3}{2} \tag{10}$$

Since τ is the probability of successful control of the customs officer's work, it is necessarily lower than 1. Both profits are maximized for

$$\gamma^* = \left(\frac{4t}{3\epsilon^2 \left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right)\left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + \beta^0 t\right)} \right)^{\frac{1}{5}} \tag{11}$$

Despite the apparent complexity of the formula, it is clear that the smuggled share is decreasing with ϵ. In contrast, the sign of the derivative with respect to τ depends upon the levels of $s_1^i, s_2^i, i = F, O$, and thus remains an empirical question in this context.

In relation to the influence of the tariff level on the smuggled share, we show in appendix 1.A.3 that it remains positive up to a certain threshold and then turns negative it. This non-monotonicity of evasion with regard to the tariff is distinctive of the endogenous effort case due to the fact that very high-tariff products are inspected so closely as expected benefit of the officer is increasing in tariff. This in turns implies that it may not be profitable to attempt to cheat about their value. It can be shown also, that the signs of all cross derivatives (derivatives of σ with respect to τ and ϵ) change above this level of t (see formal proof in appendix 1.A.3).

Proposition 5 *When the customs officer's inspection effort is endogenous, the results in propositions 1 to 3 (positive evasion elasticity, decreasing with ease of enforcement and transparency) remain valid up to a threshold level of t. Above this threshold, the evasion elasticity becomes negative, and the signs of cross derivatives found with exogenous effort are reversed, meaning that the evasion elasticity becomes a positive function of transparency and the ease of enforcement.*

2.3. Collusion

An alternative hypothesis which is in line with the recent empirical findings in Chalendard et al. (2018), is that the importer and the customs officer collude to set a declared shipment value. In this case, the importer offers the customs officer a bribe in advance, and importer and customs officer decides jointly what value to declare. Then the share smuggled is set to maximize their joint profit.

In this context, the customs officer's ability to reveal the true value of the shipment is irrelevant because there it would not benefit the customs officer to disclose the real value. However, the probability of successful control must still be considered. We assume this probability to be linked to the share smuggled, and write it as $\tau\gamma^2$. Assuming penalties take the same form as previously, the joint benefit to the customs officer and the importer of smuggling a share γ of the shipment becomes

$$\Pi(\gamma) = -(1-\gamma)tM - \tau\gamma^2(S^0 + S^F) = -(1-\gamma)tM - \tau\gamma^3 M(s_1 + s_2 t) \tag{12}$$

where for convenience $s_n = s_n^0 + s_n^F$, $n = 1, 2$. The benefit is calculated compared to the case where the import value is declared up front. Note that in this case a possible bonus would have no effect. The FOC of maximization gives (and corresponds to the equation 5 in the "corruption" case)

$$\gamma^* = \left(\frac{t}{3\tau(s_1 + s_2 t)}\right)^{\frac{1}{2}} \tag{13}$$

It is easy to see that $\sigma \geq 0$, $\partial\sigma/\partial t \leq 0$, $\partial\gamma^*/\partial\tau \leq 0$ and $\partial\sigma/\partial\tau \leq 0$ but the ease of enforcement ϵ no longer has an effect. Therefore, propositions 1 and 3 remain valid but propositions 2 and 4 do not. Thus, the nature of corruption is an important feature. It is not directly observable in the data but given these theoretical outcomes the data can be used to deduce which type of corruption is at play.

3. Empirical approach

Since evasion cannot be measured directly, the first empirical step is to define the form of the dependent variable. We discuss the methodology used to analyze evasion along with the data sources and treatments.

3.1. Measurement and methodology

Before describing the setting, we need to define our key variable, evasion. Throughout the paper, we report the results for trade gaps in values, defined as the difference between the logarithms of the values declared by the trading partners:

$$Trade\ gap_{ijkt} = ln\ X_{ijkt} - ln\ M_{ijkt} \tag{14}$$

where X and M respectively refer to the exporter and importer values of product k at time t reported by the exporter i and the importer j. The gap is calculated at the HS-6 product level for each exporter-importer combination and each year during the period 2001-2010. Statistical records are used for data on free-on-board (FOB) exports, and import values include cost-insurance and freight (CIF). In other words, the observed export values do not refer to the value X at customs clearance (CIF) but rather to the value X^*, measured FOB. This difference can drive a systematic wedge between reported exports and imports which is unrelated to tax-induced evasion. To remove this source of difference is not straightforward since it is difficult to assess the magnitude of the margin(see e.g. Hummels and Lugovskyy (2006) or Gaulier et al. (2008), and the references therein). A useful first-order approximation can be achieved by separating the CIF-FOB margin into a product-specific margin and a margin specific to each country-pair: $lnX^*_{ijk} = lnX_{ijk} + \lambda_k + \mu_{ij} + v_{ijk}$, where X^*_{ijk} refers to the CIF value of exports, and λ_k and μ_{ij} are constants. Since these constants are unknown, it would be impossible to disentangle differences in CIF and FOB margins from misstatements. However, if properly controlled for, these margins do not prevent our studying evasion elasticity. This applies particularly if as we assume in what follows, the residual term v has zero mean and is independent of the corresponding tariff duty t. We focus on the determinants of evasion elasticity by studying the link between trade gaps in value and tariff duties, based on the following generic model:

$$Trade\ gap_{ijkt} = \sigma * t_{ijkt} + \alpha_{kt} + \beta_{ijt} + \epsilon_{ijkt} \tag{15}$$

The coefficient of interest is the evasion elasticity of σ, interpreting a positive semi-elasticity of the value gap with respect to the tariff ($\sigma > 0$) as evidence of tariff evasion. The model includes product-time, importer-exporter-time fixed effects. Since the above theoretical model predicts

that evasion elasticity depends on the ease of enforcement and on transparency, σ should be variable across products and importers. However, identification based on this specification is problematic given the very large number of products and countries over time. Therefore, we impose restrictions on the pattern of evasion elasticities, assuming σ to be constant within two categories of products, homogeneous and non-homogeneous, and to vary across countries as a linear function of the countrywide variables, Z_{it}^n (n=1,...N, where N is the total number of variables taken into account at time t). We base this on the premise that the ease of enforcement should be greater for homogeneous products whose value is easier to assess, and that countrywide variables should be determinants of what we refer to as transparency in the above model. Thus, the specification to be estimated is:

$$Trade\ gap_{ijkt} = \sigma t_{ijkt} + \sigma_h Homog_k \times t_{ijkt} + \sum_n \sigma_n Z_{it}^n \times t_{ijkt} + \sum_n Z_{it}^n + \alpha_{kt} + \beta_{ijt} + \epsilon_{ijkt} \quad (16)$$

where $Homog_k$ is a dummy variable equal to 1 if product k is classified as homogeneous. Some products may be intrinsically more prone to misstatement than others *e.g.* because of their smaller volume (diamonds are an extreme case) which may be the source of a specific form of heteroskedasticity. We account for this using standard errors clustered at the product level. Finally, all regressions are weighted by the inverse of the number of observations by importer-year divided by the mean, so that the total weight attached to each reporter is 1.

3.2. Data and descriptive statistics

The method described so far relies on analysis of the gaps between the trading partners' declarations to infer information about customs duty evasion. Bilateral trade data at the HS-6 level are sourced from the UN Comtrade database which uses countries' original declarations. The discrepancies between pairs of declarations have been emphasized frequently, and illustrated on a large scale in Hummels and Lugovskyy (2006). We expect some parts of these discrepancies to reflect evasion, and we acknowledge the need to control for the CIF-FOB margin. However, measurement errors in trade statistics can be due to many other reasons including unintentional incorrect importer and exporter identifications; unintentional product misclassifications; currency conversions; time lag and yearly classifications; confidentiality in the case of a very small number of firms; reporting errors; and different custom valuation practices (see De Wulf (1981) and Yeats (1995)). As a result, our dependent variable is estimated with potentially large measurement errors. We argue that this does not prevent our using these data to infer information about evasion because there is no real reason why measurement errors should be correlated to tax evasion. If the measurement error in the dependent variable is unrelated to the error term, it will render the estimation less efficient but will not be a source of bias. This is why we chose to use the most detailed data available for all countries where reliable data exist despite the burdensome treatment entailed. We rely on a large sample to enable us to

identify the variables of interest accurately despite the noise linked to measurement errors. It could be argued also that some variables that influence trade gaps are omitted from our model e.g. export taxes or subsidies if applied, which might influence declared export values. However, to the extent that they are not correlated to tariff duties these omitted variables should not bias the coefficient of interest: in what follows identification of the variables of interest does not rely on trade gaps but only on the way they are related to tariffs.

Limiting measurement errors is important to improve estimation efficiency. Thus, we cross-check and filter the data in several ways. First, we focus on importers and exporters originally declaring in the same product nomenclature, year by year, keeping only complete and homogenous mirror declarations for countries declaring at least seven times during the period 2001-2010. We disregard values of less than USD10,000 which is the value used by several countries as the minimum threshold below which they do not declare trade flows. To ensure the homogeneity of reporting practices, we retain data only from countries following UN recommendations on the following key points (unless otherwise specified the answer should be yes): Is the statistical value of imported goods a CIF-type value? (Question 53);[7] Is the statistical value of exported goods an FOB-type value? (Question 54); Do you use customs declarations as a source? (Question 106). This filter resulted in significant reduction to the sample size but is likely to improve data quality substantially (see Gaulier et al. (2008)).

Countries maintaining multiple exchange regimes according to the IMF (2016) are also excluded from the sample since such configuration gives rise to specific incentives to fake import declarations (see Bhagwati (1964)). Also excluded from the sample are intra-EU trade flows whose measurement rests on specific methods and more fundamentaly becasue of zero tariff. Re-exports can also cause problems since frequently they are subject to ambiguous or misleading declarations. We deal with this concern by relying only on specific trade declarations which excludes warehoused and re-exported goods, and we exclude those re-exporters most heavily involved in such trade. Discarded countries and the reasons why they are excluded are presented in appendix B. Additional concerns may arise in relation to specific products. We exclude from the analysis HS chapters 43 (fur skins and furs), 84 (nuclear reactors), 88 (aircraft), 89 (ships), 93 (arms and ammunition) and 97 (arts and antiques), and the HS heading 96 (worked ivory), since trade in these sectors is frequently restricted or kept confidential (on the smuggling of art, see Fisman and Wei (2009)). Chapters 22 (beverages) and 24 (tobacco) are also disregarded, because we cannot control adequately for the widespread excise duties levied in these sectors which often are collected at customs clearance points.[8] Finally, we exclude trade in ores and oil (Chapters 26 and 27), for which shipping origin and destination are frequently unknown. As a robustness check, in our empirical analysis we check how the results change if we include all goods and re-exporter countries.

[7] Question number refers to UN National compilation or reporting practices (see https://unstats.un.org/unsd/tradereport/question.asp).

[8] Without relevant information on these excise duties, our estimates would suffer from omission of this variable which potentially is important for explaining fraud in these sectors.

For exporters we follow Javorcik and Narciso (2017)[9] and focus only on relatively uncorrupt countries to avoid confounding the effects of corruption in the exporting and in the importing country. According to the World Bank control of corruption index 13 countries are in the top quartile of the least corrupt countries at the beginning of the period considered, and are also major global exporters: Australia, Canada, Finland, France, Germany, Iceland, Ireland, Japan, New Zealand, Norway, Spain, Sweden and Switzerland. As a result of this successive data filtering there are 55 importers in our main sample (see table A1 in appendix C).

Our second variable of interest is the tariff applied. The main source of data on tariffs is MacMap-HS6 [10] developed jointly by the ITC (UNCTAD-WTO) and CEPII. It provides disaggregated (HS6 product level), exhaustive and bilateral date on tariff duties, taking account of regional agreements and trade preferences at the world level. The data were published every three years between 2001 to 2010; we complete the panel using other sources of information - both provided by the World Bank. The first one is the World Integrated Trade Solutions (WITS) database which contains preferential tariffs at the same level of detail as MacMap-HS6, for product and country pairs.[11] The second is the Global Preferential Trade Agreements Database (GPTAD) [12] which offers a comprehensive mapping of international trade agreements including information on country membership and date of entry into force of the agreement. In most cases, information on importers in our sample was taken from MacMap-HS6 and GPTAD. In a few cases, it was augmented by data from WITS (see appendix E). In the case of missing years if no new trade agreement came into force we assume that tariffs are equal to those applied in the previous year, and to those applied in the following year otherwise. Summary statistics for the tariffs in our sample are displayed in tables A5 and A6 in appendix E.

We also construct variables for institutional measures relying on the World Bank Worldwide Governance Indicators (WGI) [13] for regard measures for Control of Corruption, Rule of Law and Government Effectiveness which are relevant for our investigation. The WGI which are available for more than 200 countries over the period 1996-2016, rank countries from -2.5 to 2.5, with higher values corresponding to better outcomes. We also use WTO membership as another measure of the institutional environment,[14] in line with Javorcik and Narciso (2017). The list of countries with WTO status during the period 2001-2010, and level of Control of Corruption, is presented in table A2 in appendix C.

Finally, using Rauch (1999), products are classified into three groups: homogeneous goods (their

[9]Authors consider only three major exporters countries (Germany, USA and France), relatively less corrupt according to the Transparency International Corruption Index. We used this index also to classify the least corrupt countries as an alternative to the World Bank control of corruption index; our selected countries remained the same.
[10]See http://www.cepii.fr/anglaisgraph/bdd/macmap.htm
[11]See https://wits.worldbank.org/
[12]See https://wits.worldbank.org/gptad/trade_database.html
[13]See http://info.worldbank.org/governance/wgi/#home
[14]See https://www.wto.org

price is set in organized exchanges), differentiated goods (no quoted price, thus treated as differentiated) and an in-between category (non-treated in an organized exchange but with some quoted reference price e.g. industry publications). To resolve possible ambiguities when classifying products into these three categories, we propose the categories of liberal and conservative where, such that conservative minimizes the number of commodities classified as homogeneous. We employ the conservative definition (see table A1 in appendix C) but our results are robust also to the liberal definition.

Comparing partner-country trade data, we would expect the value reported by the importer to exceed the exporter's mirror declaration due to the CIF-FOB margin. Also, it is generally assumed that imports are monitored more closely than exports. According to Bhagwati (1964), a flow where the reported imports are inferior to the value reported by the exporter can be considered as exhibiting a discrepancy in the "perverse direction", which may be interpreted as prima facie evidence of under-invoicing of imports.[15]

The general pattern in Table 1 is consistent with these priors: reported imports exceed reported exports by more than 4% for half of the time (the median ratio of exports over imports equals 0.96, see row 1, column 1[16]). For the whole set of importing countries, this median discrepancy increases with the level of tariffs, reaching 1 for tariffs between 25% and 40% (row 1, column 4). Interestingly, it declines for tariffs over 40% which is consistent with the hypothesis of endogenous inspection effort. Also, grouping importing countries by level of corruption shows that within a given range of tariffs, the median discrepancy increases with the level of corruption.

4. Estimation results

Based on equation 16 and the above-described data, we can now analyze the determinants of customs duty evasion (Table 2). First, to test **proposition 1**, we check and can confirm that the trade gap is positively and significantly related to the preferential tariff duty applied (column 1), and that this relationship is non-linear with a declining marginal impact, as reflected by the negative coefficient of the squared tariff (column 2). Also, the corresponding coefficients are statistically significant.

We next test **proposition 2** and examine the effect of ease of enforcement on tariff evasion by introducing an interaction term between the tariff and a dummy for homogeneous products, using either the conservative (column 3) or the liberal (column 4) definition. The negative sign

[15] Over-reporting of exports is not excluded, especially if there is a form of subsidy attached to exporting, or if currency conversion is not free. This second case is ruled out by the exclusion from our sample of countries with currency problems. We also exclude some products with heavy restrictions on their export in the source country which would give traders a strong incentive to under-report their exports (i.e. art items in Fisman and Wei (2009)). Finally, as already mentioned, export misstatements do not bias our econometric estimates as long as they are not correlated to tariffs.

[16] Medians are preferred here because they are less sensitive to extreme values which are not uncommon given that the statistic studied is a ratio.

Table 1 – Value reported by the exporter as a share of value reported by the importer, median ratio. By group of countries and by level of applied tariff rates, 2001-2010

	Tariff level				
	All products	t<10	10<=t<25	25<=t<40	t>=40
	(1)	(2)	(3)	(4)	(5)
All importers	0.96	0.96	0.98	1.00	0.95
By corruption level					
Low	0.96	0.96	0.92	0.97	0.92
Lower-middle	0.97	0.97	0.96	0.98	0.94
Upper-middle	0.95	0.95	0.96	1.00	0.98
High	0.96	0.93	1.00	1.00	0.98

Scope: Countries and products included in the main estimation sample (see text). Note: Groupings by corruption level built from splitting the country sample ranked by the World Bank level of corruption index, in four quarters. Ratios are computed by country and year. These figures are unweighted.

Table 2 – Trade gaps and Control of corruptions, 2001-2010.

	Dep. variable: log X over M					
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	0.0862***	0.175***	0.217***	0.226***	0.166***	0.158***
	(2.66)	(4.72)	(4.47)	(4.46)	(3.71)	(3.65)
Squared tariff		-0.0231***	-0.0251***	-0.0257***	-0.0313***	-0.0378***
		(-4.18)	(-4.81)	(-4.85)	(-4.74)	(-4.72)
Tariff*Homog			-0.0751**		0.0449	0.0415
			(-1.98)		(0.85)	(0.75)
Tariff*Homog. (liberal dummy)				-0.0856**		
				(-2.16)		
Tariff*Ctrl. of Corrup.					-0.0796***	-0.118***
					(-3.54)	(-3.32)
Tariff*Ctrl. of Corrup.*Homog						0.0795
						(1.63)
Ctrl. of Corrup.*Homog						-0.0149*
						(-1.89)
Adjusted R^2	0.105	0.106	0.106	0.106	0.106	0.106
Observations	1676369	1676369	1676369	1676369	1665169	1665169
Importer*Exporter*Year FE	yes	yes	yes	yes	yes	yes
Product HS6*Year FE	yes	yes	yes	yes	yes	yes

Note: All regressions are weighted by the inverse of the number of observations by importer year divided by the mean, so that the total weight attached to each importer? Exporter? is 1. To ease interpretation, the importer Control of Corruption index is de-meaned. t statistics based on standard errors clustered at the six digit product level are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

of this interaction suggests that easier enforcement (as in the case of homogeneous products) is reflected in a smaller impact of tariff level on tariff evasion which is in line with previous studies (see Mishra et al. (2008); Javorcik and Narciso (2008); Bouët and Roy (2012)). Testing the other model propositions requires introducing a measure of transparency, defined as the probability of effective control and sanction. We first consider the World Bank "Control of Corruption" variable [17] and find that tighter corruption control is associated to with a weaker link between tariffs and trade gaps shown by the negative and significant estimated coefficient of the interaction term **proposition 3**. Interestingly, the differentiated effect on homogeneous products disappears in this case, in line with the theoretical analysis of collusion (column 5). Considering an interaction term between tariff and transparency also does not alter these results significantly, and the added variables exhibit limited statistical significance (column 6).

4.1. Other institutional variables

Using a control of corruption index to assess the extent of tariff evasion might seem redundant to the extent that the latter depends directly on the level of corruption among customs officers. Therefore, evaluating how much institutional quality might condition the spread of corruption requires use of alternative measures for what we refer to as transparency in our theoretical analysis. We rely on two measures drawn from the World Bank Worldwide Governance Indicators (WGI). The first is the rule of law index, defined as 'measuring perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the policy and the courts, as well as the the likelihood of crime and violence'. Rule of law is important for determining to what extent potential penalties are credible threats in the case of unlawful practices. The second dimension is government effectiveness, 'measuring perceptions of the quality of public services, the quality of civil services and the degree of independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies'. Government effectiveness could influence the thoroughness and chance of success of customs controls as well as the reality that customs officers are likely to face. Given the well-known strong collinearity between such institutional variables (see table A3 in appendix D), we test each of them separately. In both cases, the results are very similar to those obtained using the "control of corruption" variable: better institutions are reflected in a lower evasion elasticity, and the specificity of homogeneous products is no longer significant when we account for this relationship (table 3). The results are less significant when using the government effectiveness index which suggests that this institutional aspect may not be the most relevant here.

We assess also, whether WTO membership makes a difference. Among the 55 countries in our sample, over the whole period 2001-2010 only 4 are not WTO members (Azerbaijan, Bosnia

[17] This variable is defined as control over 'The extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as elite capture of the state'. A higher score reflects lower corruption.

and Herzegovina, Ethiopia and Russia), and another 3 joined during the period (Saudi Arabia, Vietnam and Macedonia, see table A3 in appendix C). The direct impact of WTO membership on trade gaps cannot be assessed, since a WTO dummy would be perfectly collinear to our fixed effects. However, we can estimate the interaction between WTO membership and the applied tariff duty. This shows that WTO membership is associated to a significantly lower evasion elasticity (table 4). This result holds when accounting for institutional quality using any of the three above-mentioned variables which suggests that WTO membership is associated to better enforcement by customs offers. The findings are robust to the inclusion of all goods and re-exporters in the sample (see table A7 in appendix F).

Table 3 – Trade gaps and other institutional variables, 2001-2010.

	Dep. variable: log X over M			
	(1)	(2)	(3)	(4)
Tariff	0.177***	0.177***	0.184***	0.199***
	(3.88)	(3.84)	(4.20)	(4.66)
Squared tariff	-0.0364***	-0.0393***	-0.0325***	-0.0329***
	(-4.69)	(-4.15)	(-4.22)	(-3.35)
Tariff*Homog	0.0424	0.0397	0.0127	-0.00798
	(0.82)	(0.75)	(0.23)	(-0.13)
Tariff*Rule of law	-0.0802***	-0.0929***		
	(-3.50)	(-2.74)		
Tariff*Rule of law*Homog		0.0313		
		(0.56)		
Rule of law*Homog		-0.00540		
		(-0.67)		
Tariff*Gov. Eff.			-0.0617**	-0.0578
			(-2.17)	(-1.34)
Tariff*Gov. Eff.*Homog				0.00276
				(0.04)
Gov. Eff.*Homog				-0.0109
				(-1.02)
Observations	1665169	1665169	1665169	1665169
Adjusted R^2	0.106	0.106	0.106	0.106
Importer*Exporter*Year FE	yes	yes	yes	yes
Product HS6*Year FE	yes	yes	yes	yes

Note: All regressions are weighted by the inverse of the number of observations by importer year divided by the mean, so that the total weight attached to each importer is 1. To facilitate interpretation, importer's Rule of Law and Government Effectiveness indexes are de-meaned. t statistics based on standard errors clustered at six digit products are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 – Trade gaps and WTO membership, 2001-2010.

	Dep. variable: log X over M			
	(1)	(2)	(3)	(4)
Tariff	0.620***	0.527***	0.535***	0.566***
	(4.20)	(3.60)	(3.66)	(3.90)
Squared tariff	-0.0208***	-0.0264***	-0.0305***	-0.0263***
	(-4.08)	(-4.16)	(-4.13)	(-3.50)
Tariff*Homog	-0.0521	0.0412	0.0405	0.00777
	(-1.36)	(0.78)	(0.78)	(0.14)
Tariff*WTO	-0.446***	-0.388***	-0.388***	-0.411***
	(-3.07)	(-2.64)	(-2.64)	(-2.80)
Tariff*Ctrl. of Corrup.		-0.0636***		
		(-2.93)		
Tariff*Rule of law			-0.0650***	
			(-2.97)	
Tariff*Gov. Eff.				-0.0430
				(-1.56)
Observations	1676369	1665169	1665169	1665169
Adjusted R^2	0.106	0.106	0.106	0.106
Importer*Exporter*Year FE	yes	yes	yes	yes
Product HS6*Year FE	yes	yes	yes	yes

Note: All regressions are weighted by the inverse of the number of observations by importer year divided by the mean, so that the total weight attached to each reporter is one. To ease interpretation, importer's Control of Corruption,Rule of Law and Government Effectiveness indexes are demeaned. t statistics, based on standard errors clustered at six digit products, reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2. Is evasion lower for very-high tariff products?

The above theoretical analysis shows that if customs officers endogenously adapt their inspection effort depending upon the tariff level applicable, then the evasion elasticity will turn negative above a given tariff level. To test this prediction (and **proposition 5**), we define five bins based on the duty level applicable, with cutoffs at 1.5% (the median over the whole sample), 10%, 25% and 90%. In order to model the relationship between trade gaps and tariff levels as a spline,

we define the following five variables:

$$\beta_i = \begin{cases} 0, & if\, t <= t_i \\ t - t_i, & if\, t_i < t < t_{i+1} \\ t_{i+1} - t_i, & if\, t >= t_{i+1} \end{cases} \tag{17}$$

where $i = 1$ to 5; t is the tariff with $t_1 = 0$, $t_2 = 1.5\%$, $t_3 = 10\%$, $t_4 = 25\%$ and $t_5 = 90\%$. The sum of these five variables is included in the estimation equation in place of the applied tariff and its squared level. In this specification, β_i is the evasion elasticity within bin i. The estimation is carried out controlling for institutional quality using either the control of corruption or rule of law index.

These estimates are consistent with the previous ones regarding the coefficients of institutional quality and product homogeneity, and show that evasion elasticity does not differ significantly from zero in the first bin where tariffs are very low (Table 5). Above that level, they exhibit a clear pattern of continuously declining elasticity with the level of tariff: significantly positive in the case of the second and third bins although lower in the latter case, and close to zero and insignificant in the case of the fourth bin, *i.e.* for tariffs between 25% and 90%. In the last bin, *i.e.* for tariffs higher than 90%, the elasticity is negative meaning that tariff evasion is comparatively lower. This finding is consistent with our theoretical analysis and our assumption that customs officers' inspection efforts are endogenous in a non-collusive framework. It is straightforward to check that it is consistent also with a collusion framework as soon as the customs officer knows that the probability of control is higher for high-tariff products.

Table 5 – Evasion elasticity by tariff level.

	Dep. variable: log X over M	
	(1)	(2)
β_1 ([0;1.5%])	-1.144	-1.131
	(-0.95)	(-0.94)
β_2 ([1.5%;10%])	0.416**	0.420**
	(2.16)	(2.17)
β_3 ([10%;25%])	0.273**	0.280**
	(2.09)	(2.15)
β_4 ([25%;90%])	0.0350	0.0512
	(0.40)	(0.61)
β_5 (>90%)	-0.0850**	-0.101**
	(-1.98)	(-2.12)
Tariff*Homog	0.0676	0.0668
	(1.22)	(1.23)
Tariff*Ctrl. of Corrup.	-0.0447**	
	(-2.34)	
Tariff*Rule of law		-0.0426**
		(-2.34)
Observations	1665169	1665169
Adjusted R^2	0.106	0.106
Importer*Exporter*Year FE	yes	yes
Product HS6*Year FE	yes	yes

Note: All regressions are weighted by the inverse of the number of observations by importer year, divided by the mean, so that the total weight attached to each reporter is one. To ease interpretation, importer's Control of Corruption and Rule of Law indexes are demeaned. t statistics, based on standard errors clustered at six digit products, reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion

This paper examined customs duty evasion from both a theoretical and an empirical perspective. Based on a framework where importers interact with customs officers, considered as a corruptible law enforcers, out theoretical analysis highlights why evasion is likely to increase with the level of applied duties. We showed also that the marginal effect of tariff level on evasion declines with the level of tariff and that these effects are dampened with greater transparency (*i.e.*, better institutional quality), and greater ease of enforcement (e.g. because the product is homogenous). However, when customs officer adapt their inspection efforts endogenously, acknowledging that tariff evasion attempts are more likely for high-tariff products, the extent of tariff evasion should decline beyond a certain level of tariff. Finally, we show that ease of enforcement is irrelevant if importers collude with customs officers.

Our empirical analysis which covered 55 countries during the period 2001-2010, confirms that customs duty evasion is widespread. Its extent increases with tariff levels in a non-linear fashion, and is lower in an environment of poor institutional quality, measured with alternative indicators provided by the World Bank and WTO membership as well. When this relationship is taken into account, product homogeneity matters significantly, suggesting that collusion between importers and customs officers may be extensive. In addition, we found that tariff evasion declines in relative terms for very high tariff levels which supports the assumption that inspection efforts are endogenous. These results shed light on the extent and nature of tariff evasion and should contribute to the formulation of policy solutions.

References

Allingham, M. G. and Sandmo, A. (1972). Income tax evasion: A theoretical analysis. *Journal of public economics*, 1(3-4):323–338.

Anson, J., Cadot, O., and Olarreaga, M. (2006). Tariff evasion and customs corruption: Does pre-shipment inspection help? *The BE Journal of Economic Analysis & Policy*, 5(1).

Bhagwati, J. (1964). On the underinvoicing of imports. *Oxford Bulletin of Economics and Statistics*, 27(4):389–397.

Bhagwati, J. (1967). Fiscal policies, the faking of foreign trade declarations, and the balance of payments. *Oxford Bulletin of Economics and Statistics*, 29(1):61–77.

Bouët, A. and Roy, D. (2012). Trade protection and tax evasion: Evidence from kenya, mauritius, and nigeria. *The Journal of International Trade & Economic Development*, 21(2):287–320.

Chalendard, C., Fernandes, A. M., Mattoo, A., Raballand, G., and Rijkers, B. (2018). Collusion in Customs: Evidence from Madagascar.

De Wulf, L. (1981). Statistical analysis of under- and overinvoicing of imports. *Journal of Development Economics*, 8(3):303–323.

Fisman, R. and Wei, S.-J. (2004). Tax rates and tax evasion: evidence from 'missing imports' in China. *Journal of political Economy*, 112(2):471–496.

Fisman, R. and Wei, S.-J. (2009). The smuggling of art, and the art of smuggling: Uncovering the illicit trade in cultural property and antiques. *American Economic Journal: Applied Economics*, 1(3):82–96.

Gaulier, G., Mirza, D., Turban, S., and Zignago, S. (2008). International transportation costs around the world: A new cif-fob rates database, cepii. Cepii.

Hummels, D. and Lugovskyy, V. (2006). Are matched partner trade statistics a usable measure of transportation costs? *Review of International Economics*, 14(1):69–86.

IMF (2016). Annual report on exchange arrangements and exchange restrictions. Technical report, IMF.

Javorcik, B. S. and Narciso, G. (2008). Differentiated products and evasion of import tariffs. *Journal of International Economics*, 76(2):208–222.

Javorcik, B. S. and Narciso, G. (2017). Wto accession and tariff evasion. *Journal of Development Economics*, 125:59–71.

Mishra, P., Subramanian, A., and Topalova, P. (2008). Tariffs, enforcement, and customs evasion: Evidence from india. *Journal of public Economics*, 92(10):1907–1925.

Mookherjee, D. and Png, I. P.-L. (1995). Corruptible law enforcers: how should they be compensated? *The Economic Journal*, pages 145–159.

Rauch, J. (1999). Networks versus markets in international trade. *Journal of International Economics*, 48(1):7–35.

Slemrod, J. (2001). A general model of the behavioral response to taxation. *International Tax and Public Finance*, 8(2):119–128.

Yeats, A. (1995). Are partner-country statistics useful for estimatiing "missing" trade data? *The World Bank, Policy research working paper series 1501*.

Yitzhaki, S. (1974). Income tax evasion: A theoretical analysis. *Journal of public economics*, 3(2):201–202.

Appendix

A Theoretical Analysis - Additional Details

A.1. Corruption, exogenous inspection effort (base case, developed in the main text)

Knowing γ^* from equation 5 and the cost of evasion $C(M, \gamma, \tau, \epsilon, t) = d\left(\tau S^0 + (1+\tau)S^F + B\right)/2$ with $S^i = (s_1^i + s_2^i t)\gamma M, i = 0, F$ and $B = \beta^0 t\gamma M$ then

$$\sigma = \frac{\partial \gamma^*}{\partial t} = \frac{C_\gamma - tC_{\gamma t}}{tC_{\gamma\gamma}} = \left[\frac{\tau s_1^0 + (1+\tau)s_1^F}{\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + t\beta^0}\right]\frac{\gamma^*}{2t} \tag{18}$$

This expression shows that $\sigma \geq 0$ and $\frac{\partial \sigma}{\partial t} \leq 0$. Derivating with respect to ϵ

$$\frac{\partial \sigma}{\partial \epsilon} = \left[\frac{\tau s_1^0 + (1+\tau)s_1^F}{\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^t) + t\beta^0}\right]\frac{1}{2t}\frac{\partial \gamma^*}{\partial \epsilon} \leq 0 \tag{19}$$

Similar computations can be done for transparency. Derivating the FOC with respect to τ

$$C_{\gamma\tau} + C_{\gamma\gamma}\frac{\partial \gamma^*}{\partial \tau} = 0 \tag{20}$$

Since $C_{\gamma\tau}$ is unambiguously positive, this proves the $\frac{\partial \gamma^*}{\partial \tau} \leq 0$. Derivating equation18 with respect to τ

$$\begin{aligned}\frac{\partial \tau}{\partial \epsilon} = &\left[\frac{\tau s_1^0 + (1+\tau)s_1^F}{\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^t) + t\beta^0}\right]\frac{1}{2t}\frac{\partial \gamma^*}{\partial \tau} \\ &+ \frac{s_1^0 s_2^F - s_1^F s_2^0 + \beta^0(s_1^0 + s_1^F)}{[\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + t\beta^0]^2}\frac{\gamma^*}{2}\end{aligned}$$

Replacing the partial derivative $\frac{\partial \gamma^*}{\partial \tau}$ by its expression

$$\frac{\partial \sigma}{\partial \tau} = -\frac{(\tau s_1^0 + (1+\tau)s_1^F)(s_1^0 + s_2^0 + s_1^F + s_2^F) + 2t(s_1^F s_2^0 - s_1^0 s_2^F + \beta^0(s_1^0 + s_1^F))}{(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + t\beta^0)^2}\frac{\gamma^*}{4t} \tag{21}$$

THe sign of this expression cannot be established unconditionnaly, but it can only be positive if

$$2ts_1^0 s_2^F \geq (\tau s_1^0 + (1+\tau)s_1^F)(s_1^0 + s_2^0 + s_1^F + s_2^F) + 2t(s_1^F s_2^0 + \beta^0(s_1^0 + s_1^F)) \tag{22}$$

Irrespective of the value of t and τ, a sufficient condition for the sign to be negative is thus $s_1^F s_2^0 \geq s_1^0 s_2^F$, i.e. that the customs officer's penalty is more depedent in the tariff than the importer's penalty.[18] This is in particular the case if the base for computing the panely (value

[18] If the importer's penalty is far more dependent on the tariff rate than the customs offcier's penalty, then an increased transparency makes the cost of evasion less sensitive to tariffs, which may offset the dissuasive effect of enhanced transparency.

understatement of tax understatement) is the same for the importer and the customs officer. To study the interaction between efficiency and transparency, let us rewrite

$$\frac{\partial \gamma^*}{\partial \epsilon} = -\frac{C_{\gamma\epsilon}}{C_{\gamma\gamma}} = \frac{\gamma^*}{2\epsilon} \tag{23}$$

therefore

$$\frac{\partial^2 \gamma^*}{\partial \tau \partial \epsilon} = -\frac{1}{2\epsilon}\frac{\partial \gamma^*}{\partial \tau} \geq 0 \tag{24}$$

Derivating the equation 21 with respect to t then shows in addition that $\frac{\partial^2 \sigma}{\partial \epsilon \partial \tau} \geq 0$.

A.2. Corruption, exogenous inspection effort, penalty with a fixed component

let $S^i = s_2^i t\gamma M + s_3^i, i = 0, F$ be the penalties to which the importer and the customs officer are exposed. s_3^i is the fixed component of the penalty, and we will note $s_3 = s_3^0 + s_3^F$. The cost of evasion writes $C = 1/2[\tau(s_2^0 t\gamma M + s_3^0) + (1+\tau)(s_2^F t\gamma M + s_3^F) + \beta^0 t\gamma M]\epsilon\gamma^2$, so that the evasion elasticity can be rewritten

$$\sigma = \frac{\partial \gamma^*}{\partial t} = \frac{C_\gamma - tC_{\gamma t}}{tC_{\gamma\gamma}} = \left[\frac{\tau s_3^0 + (1+\tau)s_3^F}{\tau(3s_3^0 t\gamma M + s_3^0) + (1+\tau)(3s_2^F t\gamma M + s_2^F) + 3t\beta^0\gamma M}\right]\frac{\gamma^*}{t} \tag{25}$$

This proves that $\sigma \geq 0$ (and $\partial\sigma/\partial t \leq 0$) and $\partial\gamma^*/\partial\epsilon \leq 0$ is still valid. As in case I, derivating σ with respect to ϵ shows in addition that $\partial\sigma/\partial\epsilon \leq 0$.
As in case I, $\frac{\partial\gamma^*}{\partial\tau} \leq 0$ but an additional parameter restriction is needed in order to conclude about the sign of the second derivative with regards to t and τ. As in case I, assuming that penalties are proportional for the two agent categories (i.e. $s_3^0 s_2^F - s_3^F s_2^0 = 0$) is enough to conclude that $\partial\sigma/\partial\tau \leq 0$.

A.3. Endogenous Effort

We have

$$\Pi^c(e) = \frac{\left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right) Me\epsilon\gamma^3 - Me^2}{2} \tag{26}$$

then

$$\frac{\partial \Pi^c(e)}{\partial e} = 0 \Leftrightarrow e = \frac{\left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t)) + \beta^0 t\right)\epsilon\gamma^3}{2} \tag{27}$$

For a given value of e, importers set γ^* so as to maximize their payoff

$$\Pi^F(\gamma) = -(1-\gamma)Mt - \frac{\left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t)) + \beta^0 t\right) Me\epsilon\gamma^3}{2} \tag{28}$$

$$\frac{\partial \Pi^F(\gamma)}{\partial \gamma} = 0 \Leftrightarrow \gamma = \left(\frac{2t}{3e\epsilon\left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t)) + \beta^0 t\right)}\right)^{\frac{1}{2}} \tag{29}$$

Combining equations 27 and 29 gives

$$\gamma^* = \left(\frac{4t}{3\epsilon^2 \left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right)\left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + \beta^0 t\right)} \right)^{\frac{1}{5}} \tag{30}$$

Let's posit $f(t) = \left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right)\left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + \beta^0 t\right)$

$$\frac{\partial \gamma^*}{\partial t} < 0 \Leftrightarrow f(t) - tf'(t) < 0 \tag{31}$$

In addition, let's define $f(t) = u(t)v(t)$ with

$$u(t) = \left(\tau(s_1^0 + s_2^0 t) + (1-\tau)(s_1^F + s_2^F t) + \beta^0 t\right) \tag{32}$$
$$v(t) = \left(\tau(s_1^0 + s_2^0 t) + (1+\tau)(s_1^F + s_2^F t) + \beta^0 t\right) \tag{33}$$

We have

$$f(t) - tf'(t) < 0 \Leftrightarrow t\left(\frac{u'}{u} + \frac{v'}{v}\right) > 1 \tag{34}$$

Yet

$$t\frac{u'}{u} = \frac{\tau s_2^0 + (1-\tau)s_2^F + \beta^0}{\tau s_2^0 + (1-\tau)s_2^F + \beta^0 + \frac{\tau s_1^0 + (1-\tau)s_1^F}{t}} \tag{35}$$
$$t\frac{v'}{v} = \frac{\tau s_2^0 + (1+\tau)s_2^F + \beta^0}{\tau s_2^0 + (1+\tau)s_2^F + \beta^0 + \frac{\tau s_1^0 + (1+\tau)s_1^F}{t}} \tag{36}$$

Therefore, with $0 \leq \tau \leq 1$

$$t\left(\frac{u'}{u} + \frac{v'}{v}\right) \underset{t\to 0}{\longrightarrow} 0 \quad ; \quad t\left(\frac{u'}{u} + \frac{v'}{v}\right) \underset{t\to \infty}{\longrightarrow} 2 \quad \text{and} \quad \frac{\partial\left(t\left(\frac{u'}{u} + \frac{v'}{v}\right)\right)}{\partial t} > 0, \forall t > 0 \tag{37}$$

So, with endogenous effort, there exists a unique $t > 0$ above which the evasion elasticity is negative.

B. Cross-checking and filtering data

- Countries excluded because declaring less than 7 times during the period 2001-2010 in the same product nomenclature as reporter countries; in parentheses the number of times the

country appears in the database: Angola (2), Bermuda (3), Buthan (6), Botswana (6), Belize (4), Brunei (1), Burkina (Faso (6), Myanmar (2), Burundi (2), Cameroon (3), Cape Verde (4), Central Africa Rep. (3), Cook Islands (5), Cuba (5), Benin (2), Dominica (4), Dominican Rep (6), Djibuti (1), Gabon (4), Georgia (5), Palestine (4), Ghana (4), Kiribati (2), Grenada (1), Guinea (4), Indonesia (2), Iran (5), Kazakistan (6), Kuwait (2), Laos (1), Mauritania (1), Mongolai (6), Moldova (6), Montenegro (4), Montserrat (3), Morocco (5), Mozambique (6), Nepal (3), Neth. Antilles (2), Nigerioa (4), Papau New Guioea (4), Philippines (1), East Temor (2), Qatar (3), Rwanda (5), St. Kitts and Nevis (3), Santa Lucia (1), Saint Vincent (3), Sao Tome and Principe (1), Serbia (6), Seychelles (2), Sudan (5), Suriname (1), Swaziland (1), Syrian (6), Togo (6), Turks and Caicos (3), Ukraine (1), Egypt (3), Tanzania (6), Venezuela (2), Samoa (3), Yemen (3), Serbia and Montenegro (1).

- Countries excluded as importers because trade flows are not declared at C.I.F. value (Question 53): Angola, Bermuda, Brazil, Canada, Cambodia, Dominican Rep., Georgia, Guinea, Israel, Paraguay, SACU, South Africa, Ukraine, USA. We also discarded countries for which the answer to the question is not available: Algeria, Laos, Mali, Samoa, Tajikistan, Turkmenistan.
- Countries excluded as exporters because trade flows are not declared at F.O.B. value (Question 54): Georgia, Mariana Isl., Ukraine and USA. We also discarded countries for which the answer to the question is not available: Algeria, Laos, Samoa, Tajikistan, Turkmenistan.
- Countries excluded because they do not use custom declarations as a source (Question 106): Austria, Belgium, Czech Rep., Denmark, Latvia, Luxembourg, Malta, Poland, Portugal, Slovenia, Sweden, UK.
- Countries excluded as importers because dual of multiple exchange rate regimes: Argentina, Armenia, Belarus, Maldives, Uganda and Uruguay.
- Countries excluded because high re-exporter countries: Bahamas, Honk Kong, Netherlands, Panama and Singapore.

C. Importing countries in the sample

Table A1 – Importing countries in the sample and the number of observations by product group, 2001-2010

Country	ISO	Diff.	Hom.	n.c.	nb years	Country	ISO	Diff.	Hom.	n.c.	nb years
Azerbaijan	AZE	3956	1024	347	8	Latvia	LVA	10537	3376	736	10
Australia	AUS	60356	23472	5155	10	Lithuania	LTU	11177	4012	712	10
Bolivia	BOL	4156	1098	301	10	Madagascar	MDG	6423	1937	502	10
Bosnia and H.	BIH	8771	3256	618	7	Malawi	MWI	459	70	33	8
Bulgaria	BGR	8902	3668	599	10	Malaysia	MYS	27726	17054	2758	8
Sri lanka	LKA	7941	3655	844	9	Mauritius	MUS	8245	3227	673	9
Chile	CHL	29027	11225	2584	10	Mexico	MEX	40973	19570	3833	9
China	CHN	65542	39602	6397	10	Oman	OMN	5208	1608	386	7
Colombia	COL	19867	10402	1683	10	New Zeal.	NZL	38953	15819	3166	10
Costa rica	CRI	8159	2927	574	9	Norway	NOR	61859	25132	5455	10
Croatia	HRV	27628	11817	2159	10	Peru	PER	13628	6369	1231	9
Cyprus	CYP	19727	5930	1095	10	Romania	ROM	12011	5121	983	10
Ecuador	ECU	9755	4053	751	9	Russian fed.	RUS	56810	24035	4352	10
Ethiopia	ETH	2925	697	280	9	Saudi Arab.	SAU	27156	9630	2202	10
Estonia	EST	10915	3868	784	10	Senegal	SEN	7842	3254	693	8
Finland	FIN	15257	4569	1140	10	India	IND	25652	16606	2826	7
France	FRA	30829	14395	2543	10	Slovakia	SVK	11682	4869	981	10
Germany	DEU	41217	21432	3603	10	Vietnam	VNM	14660	8757	1573	7
Hungary	HUN	19648	8431	1585	10	Zimbabwe	ZWE	1045	237	80	7
Iceland	ISL	19600	5382	1470	10	Spain	ESP	19274	8104	1577	10
Ireland	IRL	7596	2924	644	10	Switzer.	CHE	67738	37536	5868	10
Israel	ISR	39015	17940	3151	10	Thailand	THA	35059	20800	3512	10
Italy	ITA	28074	12284	2271	10	Trinidad and Tob.	TTO	3847	1618	377	8
Côte d'Iv.	CIV	7689	3755	716	8	Tunisia	TUN	24527	11519	1959	9
Jamaica	JAM	2388	876	287	7	Turkey	TUR	48461	25035	4395	10
Japan	JPN	55955	25319	4471	10	Macedonia	MKD	7959	3368	529	10
Jordan	JOR	11865	4549	803	10	Zambia	ZMB	1146	206	125	9
Kenya	KEN	6133	2343	538	9						
Total								1162950	529762	98910	

Note: n.c. refers to products not classified as homogeneous or differentiated, and as such disregarded in estimations where dummy for homogeneous products is included. The number of observations refers to imports by the reporting country from all the 13 exporters. The number of years indicates how many times the importer declares in the same product nomenclature than the exporters.

Table A2 – Importing countries in the sample, by control of corruption and WTO membership 2001-2010

	Control of corruption index				Wto		Control of corruption index				Wto
ISO	Mean	Std. Dev.	Min	Max	Entry date	ISO	Mean	Std. Dev.	Min	Max	Entry date
AZE	-1.15	0.07	-1.3	-1.04		LVA	0.12	0.16	-0.07	0.38	1999
AUS	1.98	0.07	1.81	2.05	1995	LTU	0.30	0.09	0.13	0.43	2001
BOL	0.62	0.16	-0.09	-0.4	1995	MDG	-0.25	0.12	-0.45	-0.07	1995
BIH	-0.32	0.05	-0.38	-0.24		MWI	-0.56	0.16	-0.77	-0.27	1995
BGR	-0.13	0.07	-0.25	-0.03	1996	MYS	0.21	0.13	-0.06	0.34	1995
LKA	-0.27	0.1	-0.42	-0.15	1995	MUS	0.41	0.11	0.25	0.56	1995
CHL	1.44	0.09	1.3	1.6	1995	MEX	-0.26	0.06	-0.36	-0.17	1995
CHN	-0.51	0.11	-0.61	-0.22	2001	OMN	0.56	0.22	0.35	0.93	2000
COL	-0.24	0.1	-0.4	-0.13	1995	NZL	2.30	0.06	2.20	2.39	1995
CRI	0.61	0.14	0.42	0.87	1995	NOR	2.03	0.08	1.9	2.19	1995
HRV	0.11	0.12	-0.07	0.29	2000	PER	-0.27	0.08	-0.39	-0.08	1995
CYP	1.04	0.13	0.89	1.23	1995	ROM	-0.38	0.11	-0.49	-0.14	1995
ECU	-0.77	0.07	-0.89	-0.69	1996	RUS	-0.95	0.13	-1.13	-0.76	
ETH	-0.69	0.09	-0.77	-0.45		SAU	-0.1	0.14	-0.29	0.20	2005
EST	0.88	0.1	0.74	1.03	1999	SEN	-0.26	0.23	-0.64	-0.05	1995
FIN	2.35	0.09	2.16	2.44	1995	IND	-0.41	0.05	-0.47	-0.35	1995
FRA	1.38	0.07	1.23	1.47	1995	SVK	0.24	0.15	-0.01	0.49	1995
DEU	1.84	0.07	1.74	1.94	1995	VNM	-0.66	0.07	-0.73	-0.54	2007
HUN	0.65	0.11	0.37	0.79	1995	ZWE	-1.26	0.15	-1.37	-0.98	1995
ISL	2.22	0.12	1.94	2.34	1995	ESP	1.26	0.13	1.06	1.4	1995
IRL	1.57	0.16	1.29	1.76	1995	CHE	2.08	0.05	2.01	2.15	1995
ISR	0.93	1.47	0.76	1.23	1995	THA	-0.26	0.09	-0.41	-0.17	1995
ITA	0.39	0.16	0.13	0.73	1995	TTO	-0.02	0.1	-0.17	0.24	1995
CIV	-1.09	0.17	-1.24	-0.68	1995	TUN	-0.11	0.23	-0.3	0.37	1995
JAM	-0.26	0.11	-0.35	0.03	1995	TUR	-0.07	0.18	-0.52	0.11	1995
JPN	1.26	0.14	0.97	1.56	1995	MKD					2003
JOR	0.19	0.12	-0.05	0.36	2000	ZMB	1.48	-0.54	0.1	-0.73	1995
KEN	-0.98	0.07	-1.06	-0.86	1995						

Note: The control of corruption index by the World Bank ranges from -2.5 to +2.5, with higher values corresponding to better outcomes.

D. Correlation between institutional variables, 2001-2010

Table A3 – Correlation matrix, 2001-2010

	Control Corr	Rule of Law	Gov Eff
Control Corr	1		
Rule of law	0.9687	1	
Gov Eff	0.9442	0.9520	1

Note: All the institutional variables by the World Bank range from -2.5 to +2.5, with higher values corresponding to better outcomes.

E. Tariff information

Table A4 – Countries with incomplete information on applied tariff, 2001-2010

Country	MacMap-HS6	WITS
Bosnia and H.	2001, 2004, 2007, 2010	2007-2010
Cyprus	2001, 2004, 2007, 2010	2001-2002 , 20004-2010
Ethiopia	2001, 2004, 2007, 2010	2008-2009
Jordan	2001, 2004, 2007, 2010	2005-2010
Kenya	2001, 2004, 2007, 2010	2005-2010
Slovakia	2001, 2004, 2007, 2010	2004-2010
Trinidad and T.	2001, 2004, 2007, 2010	2006-2008
Tunisia	2001, 2004, 2007, 2010	2005-2006
Zambia	2001, 2004, 2007, 2010	2007
Zimbabwe	2001, 2004, 2007, 2010	2003, 2005, 2008, 2009

Table A5 – Summary statisitcs for tariffs, 2001-2010

	Mean	Median	Min	Max	Nb. Observations
Tariffs	6.3%	1.5%	0%	1000%	1676369

Table A6 – Frequency of tariffs by ranges, 2001-2010

Tariffs range	t==0	0<t<=1.5	1.5<t<=10	10<t<=25	25<t<=40	40<t<=90	t>90
Nb of Observations	766326	88324	416779	357396	41887	17322	4660

F. Robustness checks

Table A7 – Trade gaps and Insitutional variables, 2001-2010. Robusteness checks

	Dep. variable: log X over M					
	All goods			All goods and Re-exporters		
	(1)	(2)	(3)	(4)	(5)	(6)
Tariff	0.492***	0.494***	0.526***	0.587***	0.596***	0.613***
	(3.85)	(3.83)	(4.12)	(4.93)	(5.00)	(5.16)
Squared tariff	-0.0237***	-0.0260***	-0.0230***	-0.0244***	-0.0252***	-0.0238***
	(-4.40)	(-4.23)	(-3.88)	(-5.12)	(-4.87)	(-4.57)
Tariff*Homog	-0.0286	-0.0252	-0.0522	-0.0259	-0.0293	-0.0421
	(-0.57)	(-0.51)	(-1.00)	(-0.62)	(-0.70)	(-0.97)
Tariff*WTO	-0.326**	-0.325**	-0.348***	-0.424***	-0.428***	-0.440***
	(-2.49)	(-2.46)	(-2.65)	(-3.45)	(-3.48)	(-3.58)
Tariff*Ctrl. of Corrup.	-0.0353*			-0.0206		
	(-1.84)			(-1.32)		
Tariff*Rule of law		-0.0382**			-0.0176	
		(-2.00)			(-1.12)	
Tariff*Gov. Eff.			-0.0161			-0.00632
			(-0.68)			(-0.33)
Observations	2065533	2065533	2065533	2830462	2830462	2830462
Adjusted R^2	0.101	0.101	0.101	0.121	0.121	0.121
Importer*Exporter*Year FE	yes	yes	yes	yes	yes	yes
Product HS6*Year FE	yes	yes	yes	yes	yes	yes

Note: All regressions are weighted by the inverse of the number of observations by importer year, divided by the mean, so that the total weight attached to each reporter is one. To ease interpretation, importer's Control of Corruption,Rule of Law and Government Effectiveness indexes are demeaned. t statistics, based on standard errors clustered at six digit products, reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$