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Abstract

Global imports subject to pre-shipment inspections (PSI) – a practice under which imports need to undergo a third party review process before shipment – shrank from 700 bn USD in 2010 to 87 bn in 2018. However, only little is known about the trade impact of such procedures, which on the one hand involve administrative costs, but on the other hand provide information. This paper – the first PSI analysis consistent with a structural gravity framework – shows that PSI requirements reduce bilateral trade and are most harmful for trade in differentiated manufacturing products. In contrast, PSI facilitate trade in food products. Trade in products subject to sanitary and phytosanitary measures even doubles when these measures are combined with PSI. Overall, counterfactual analysis suggests that the removal of PSI requirements between 2010 and 2018 implied a 2.6% increase in total imports across the 32 developing countries covered by our data.

JEL-Codes: F130, F140, F170.

Keywords: pre-shipment inspections, structural gravity, trade facilitation.

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1 Introduction

As part of the Trade Facilitation Agreement (TFA) that entered into force in 2017, members of the World Trade Organization (WTO) agreed that mandatory[1] pre-shipment inspections (PSI) – a trade policy practice under which imports need to undergo a third party review process before shipment – should no longer be used for the purpose of tariff classification and customs valuation. WTO members should also refrain from the imposition of new PSI requirements.[2] A substantial decline in the worldwide usage of PSI already in anticipation of the TFA could be observed after negotiations were concluded in 2013: while imports subject to PSI accounted for 700 bn USD in 2010, this figure collapsed to 87 bn USD in 2018.

With a PSI procedure, inspections in the country of origin are carried out either on-site at production facility or at the port by third parties – often private companies (Rege, 2001). The cost of such activities depends on the quantity to be shipped. After a quantity verification, a quality check is performed on a random selection of products according to an internationally recognized statistical sampling procedure. Conformity verification includes proof of product dimensions, material and construction, weight, color, making, and labelling. Finally, a functioning and safety test is performed. PSI results are documented in an inspection report, which for some importing countries serves as customs declaration.

Reasons other than information dissemination have historically led to the imposition of PSI, notably the objective to prevent the *over-invoicing* of imports to circumvent capital controls. After the suspension of capital controls in most parts of the world, governments used PSI for the purpose of curbing import tariff evasion due to *under-invoicing* (Anson et al., 2006). *Prima facie*, this may provide an explanation why PSI have predominantly been used by low-income countries whose fiscal budgets typically contain a large share of tariff revenues.[3] By this logic, the recent drop in PSI usage might suggest that the primary purposes of PSI for most governments was indeed related to tariff classification and customs purposes, as surmised e.g. by Low (1995) and Rege (2001).[4]

While costly and potentially trade-inhibiting, PSI also provide valuable product information

[1] We disregard PSI performed on a voluntary basis whereby business parties (buyer, seller, trade financier) agree on the conduct of a PSI. For example, trade financiers sometimes demand the sending of the inspection report for executing payment orders.

[2] Cf. Article 10.5 of the *Trade Facilitation Agreement*.

[3] Drummond et al. (2012), e.g., show that for Sub-Saharan African countries trade related taxes make up large shares (up to 50 percent) of the fiscal budget.

[4] The Uruguay Round (1986-1994) also concluded with an Agreement on PSI, based on the principles of the General Agreement on Tariffs and Trade (GATT). Agreed PSI principles include, among others, non-discrimination, transparency, protection of confidential business information, avoidance of unreasonable delay, the use of specific guidelines for conducting price verification and the avoidance of conflicts of interest by the PSI agencies. For a brief historical overview of PSI under GATT/WTO legislation, cf. *Fifth Review of the Agreement on Preshipment Inspection*.

to the parties involved, thereby reducing sourcing risks for cross-border transactions and, hence, potentially facilitating international trade.[5] Risk reduction appears particularly important in sectors in which the government attaches strong importance to the fulfillment of relevant regulations before admitting the merchandise into its jurisdiction, for instance for reasons of public health or safety, and/or where verification of these requirements can be carried out more easily or with a higher level of confidence at the place of origin.

The research question of this paper is therefore also embedded in the broader discussion about non-tariff measures (NTMs) as trade "catalysts" versus trade "barriers".[6] However, in contrast to the large body of literature on the trade effects of tariff and non-tariff measures in general, only little attention has been paid to PSI specifically, and there is no empirical evidence of the causal impact of PSI on trade, be it positive or negative. Santeramo et al. (2019), analyzing the effects of PSI in the context of international trade of wine, find a positive link between PSI and imports.[7] The effectiveness of PSI requirements in reducing tariff evasion has also been questioned. Anson et al. (2006) obtain mixed results for three countries examined (Argentina, Indonesia and the Philippines). In a sample of approximately 100 countries, Yang (2008b) finds that countries implementing PSI experience large increases in import duty collections, due to declines in falsification of import documentation and in under-valuation and mis-reporting of goods classifications. However, in a careful case study (Yang, 2008a), the same author finds that increased enforcement of PSI in the Philippines did not lead to any change in total duty avoidance, due to substantial displacement to an alternative duty-avoidance method (shipping via duty-exempt export processing zones).

Against this background, *the aim of this paper is to structurally estimate the trade effects of PSI requirements*. To the best of our knowledge, we are the first to do so. Our empirical approach is grounded on a theoretical framework that predicts ambiguous PSI effects depending on compliance cost and product-specific quality signals. We bring this theoretical prediction to the data, using NTM data disseminated through the World Integrated Trade Solution (WITS), which provides information on product-specific PSI requirements for the years 2010-2018. Combining this information with bilateral import flows from UN Comtrade, we end up with a database of

[5] Siror et al. (2010) discuss whether technological advancements are suited to lower the administrative cost associated with PSI. They focus on tracking technologies like GPS and Radio Frequency Identification. It is neither clear whether these technologies have been implemented for the facilitation of PSI, nor if countries requiring PSI accept such procedures.

[6] Our paper also contributes to the literature addressing the impact of specific requirements in the TFA on international trade, as the elimination of PSI for certain purposes constitutes a key obligation under the TFA. Hillberry and Zurita (2021) point out that PSI is the second most frequently committed area of action by WTO members.

[7] In fact, for the case of wine, essential characteristics of the final product strongly depend on the production process which is unobservable for the importer. Hence, reducing uncertainty and assuring product conformity may foster wine trade.

PSI enforced by 32 importing countries at the granularity of 1,124 4-digit HS-heading. From our theoretical framework we derive a structural gravity equation incorporating PSI as both a *demand shifter* (signaling effect) and a *variable cost of exporting*. Controlling for a battery of fixed effects, we explain bilateral trade at the HS 4-digit level in a given year by the presence of PSI. Namely, we exploit the variation in the presence of PSI requirements for given importer-product combinations at different points in time. Endogeneity concerns are addressed using instrumental variable (IV) and propensity score matching (PSM) approaches. Hence, we are confident having identified causal trade effects related to PSI.

We show that, *on average*, the net effect of PSI is to reduce trade by 4.9%. This effect is entirely driven by differentiated industrial products. This effect is consistent across different estimation methods, i.e. by employing standard Poisson Pseudo Maximum Likelihood (PPML), IV, and PSM estimators. In contrast, for agricultural products, there is no statistically significant effect of PSI on exports, indicating that the positive trade effect of disseminating information to importers on the compliance with relevant product standards compensates for the negative effect on trade due to the additional costs of inspection. We find positive effects of PSI on trade in food products (+13.8% net effect) and in the presence of certain sanitary and phytosanitary (SPS) requirements, i.e. SPS conformity assessment documentation requirement. In the latter case, trade more than doubles. Finally, we perform a counterfactual analysis and provide a quantification of the trade impact of the removal of PSI requirements: the removal of PSI requirements between 2010 and 2018 implied a 2.6% increase in total imports across the 32 developing countries covered by our data.

The remainder of this paper is structured as follows. The data used in the empirical analysis are presented in Section 2, which also provides stylized facts on the dissemination of PSI. Section 3 lays out a theory-consistent empirical strategy that allows to establish a causal relationship between PSI and bilateral trade. Section 4 presents our baseline results and provides a slate of robustness checks. Section 5 discusses possible channels that cause heterogeneous trade effects of PSI depending on essential product characteristics. Section 6 quantifies the trade and welfare effect of PSI. Section 7 investigates whether the presence of PSI requirements is associated with more accurate and complete trade statistics. Section 8 summarizes our core findings and concludes.

2 Data and stylized facts

The lack of evidence on the trade impact of PSI in the previous literature may be associated with limited data availability.[8] To measure the adoption of PSI by importing countries, we rely on UNCTAD data accessed via the TRAINS NTM database.[9] The data is organized as panel from 2010 to 2018. Information on PSI requirements is available for all importers with NTM data at the HS 4-digit product level.[10] Figure 1 highlights the 32 countries that have made use of pre-shipment inspection requirements during the period of investigation. The vast majority of importers requiring PSI are in Africa (13) and Asia/ Oceania (13), among the latter being even four G20 economies (China, India, Indonesia, and Saudi Arabia). In Latin and Central America 6 importers require PSI, whereas no PSI requirements exist in North American or European countries.

Table A-1 in the Appendix shows, for each year, how many of the 1,124 HS 4-digit product codes are subject to PSI requirements.[11] These vary greatly within years: in 2010, Burkina Faso, Mali, and Niger required PSI for 87% or more of imported product lines, an indication that PSI could serve as a measure for tariff classification and customs valuation. New Zealand and Bahrain had PSI measures in place for only 1 or 2 product lines, respectively, supposedly to address SPS conformity issues. Large variation is present also over time: in 2010, a total of 5,618 importer-product-specific PSI requirements were recorded. This figure fell by 90% in 2018, when only 7 importers requiring PSI were left. This give an indication of the effectiveness of the TFA concluded in 2013 and becoming effective in February 2017.[12]

Against this overall trend of reductions in the number of PSI requirements, there are some exceptions: Panama and Uruguay did not require inspection until 2017, when they introduced this measure for a very limited number of products. Other importers, who introduced PSI during the period of observation later removed the measure again. This is the case for Liberia, Nigeria, Uganda, and Zimbabwe. Thus, our estimated effects are not just identified on the removal of PSI measures but also on their introduction.

Annual bilateral trade data at the 6-digit product level are taken from the UN Comtrade database. We take the perspective of the importing country and rely on CIF (Cost, Insurance

[8]The descriptive evidence provided by Gourdon (2014) shows that high income countries rarely use PSI and that PSI requirements vary greatly across sectors, affecting predominantly agricultural products, wooden products, textiles and footwear.

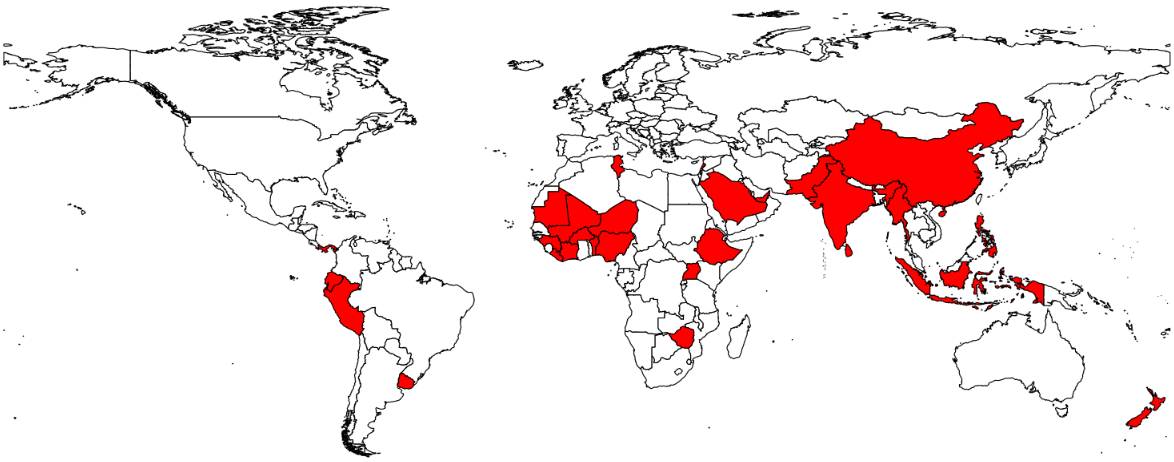
[9]The database can be accessed here.

[10]For this reason, note that our analysis is conducted at the HS 4-digit level and that the terms "products" and "goods" relate to them.

[11]HS Chapters 25, 26, 27, 71, 93, 97, and 98 are removed from the sample.

[12]In fact, 85% of WTO members implemented the TFA provision on PSI, i.e. its elimination for tariff classification and customs valuation purposes, by 2018.

Figure 1: Countries imposing PSI requirements, 2010-201



Source: TRAINS, 2021.
Notes: The figure marks those 32 countries that made use of PSI requirements over the period 2010-2018. Our sample of importers is reduced to those countries. Table A-1 provides detailed information on the number of products for which PSI requirements exists per year and importer.

and Freight) import values. When not available we use mirror export FOB (Free On Board) values, converted to CIF by adding the median CIF-FOB differential of the respective year. UN Comtrade data in the classification of 2007 cover the entire set of countries for which we have information on PSI adoption in the years 2010-2018. Since PSI information comes at the 4-digit level, we aggregate trade data accordingly. We differentiate between agricultural, food, and manufacturing trade based on the HS Industry Classification.[13] After merging PSI with bilateral import data, the final sample is reduced to only those importers and 2-digit HS Chapters with variation in PSI. We end up with a sample of 1,613,047 observations.

PSI and trade data are supplemented with several other data sources for control variables. Non-tariff SPS measures are from TRAINS, the same source as the PSI data. This data has information on different types of SPS measures, the most relevant for our study being the measure "SPS Conformity Assessment Requirements".[14] The type of product, homogeneous versus differentiated, is based on the Rauch (1999) classification.[15] Tariff data are accessed via UNCTAD TRAINS. The measures for tariff variation within HS 4-digit product groups are based on 6-digit tariff lines. Product code concordance tables are accessed via UN Trade Statistics.[16] In-sample descriptive statistics are reported in Table 1.

Figure 2 shows Kernel density plots for log trade values, separated by the PSI policy they are

[13] Cf. *HS 2002 Classification by Section*. Products of Section I-III are considered as agricultural goods, Section IV are defined as food products, Section VI-XXI except Section XIV (Pearls and Precious Stones), and XIX (Ammunition) are considered as industrial goods.
[14] These measures are classified according to the UNCTAD NTM Classification in the Version of 2019. Cf. *UNCTAD NTM Classification*. The variables of interest are A8 (Chapter A is on SPS), as well as the whole Chapter C on pre-shipment inspections.
[15] This classification defines products at the 6-digit level. Our preferred measure for differentiated products is binary and considers only 4-digit level products with no within classification variation.
[16] Cf. *UN Conversion and Correlation Tables*.

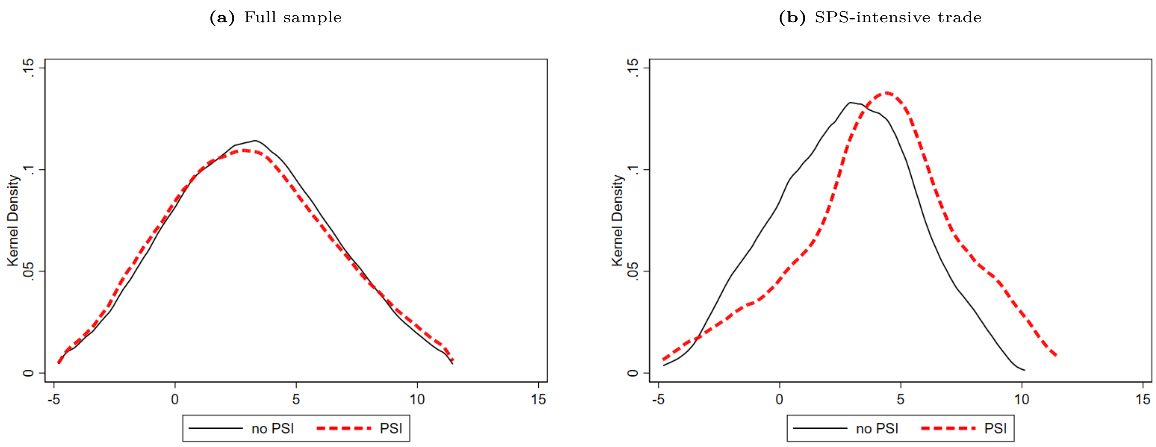
Table 1: In-sample descriptive statistics

	Mean	Median	Minimum	Maximum	Standard Dev.
Trade Value in 1,000 USD	7,615	20.3	0.00	97,475,408	254,542
Ln Trade Value	3.09	3.01	-26.71	18.40	3.58
PSI	0.35	0.00	0.00	1.00	0.48
SPS Conformity Assessment	0.00	0.00	0.00	1.00	0.06
Differentiated binary, including missings	0.79	1.00	0.00	1.00	0.41
$\ln(1+\tau)$	0.08	0.07	0.00	1.10	0.08
Tariff variation (sd)	1.55	0.00	0.00	106.07	2.90
Tariff variation (sd/mean)	0.19	0.00	0.00	3.74	0.35
Observations	1,613,047				

Source: UN COMTRADE, 2021; TRAINS, 2021; WITS, 2021; Rauch (1999).

subject to. For ease of visualization, statistical outliers are removed by cutting the distribution at the top and bottom 1%. The left panel on the full sample indicates that trade flows free of PSI are on average slightly lower than those subject to PSI requirements. The right-hand panel, by contrast, suggests that conditional on SPS requirements PSI is associated with larger trade flows. Understanding these differences in trade patterns in the context of PSI is at the very heart of this study.[17]

Figure 2: Kernel Density Plot: Ln Trade Value by PSI treatment



Source: TRAINS, 2021; UN COMTRADE, 2021; own calculations.
Notes: See Figure A-1 for Kernel density plots for the sector specific samples and for differentiated products.

The next section proposes a simple theoretical framework illustrating the two channels through which PSI can affect imports; this reasoning underpins the empirical strategy used thereafter to obtain consistent estimates on the direction and magnitude of the impact of PSI on trade, in the absence of reverse causality and omitted variable bias.

[17]Figure A-1 in the Appendix shows Kernel density plots reporting the patterns of trade flows subject to PSI by macro sector and type of products.

3 Identification strategy

The dual nature of the PSI discussed above suggests a simple theoretical framework.[18] Assume that the time (and cost) of inspection undertaken by a third party in the exporter country is proportional to the quantity to be shipped, such that the introduction of a PSI requirement by importer country j constitutes an increase in the variable (iceberg) trade costs for all shipments directed to country j. The natural way of thinking of PSI requirements is therefore to model it as an increase s_j to the bilateral iceberg trade cost d_{ij} in a standard monopolistic competition model of trade. In this case, the imposition of a PSI requirement is expected to reduce the bilateral import demand with an elasticity of $1-\sigma$ (where σ is the elasticity of substitution across varieties produced in different exporting countries).

However, as discussed above, the pre-shipment inspection certifies the conformity of the product to the importer's regulations and standards. This represents a *signal* of compliance with standards and other regulations among consumers at destination, and as such, increases the demand for imports. The signaling effect of PSI can be modeled as a demand shifter, $a\left(c\right)_j$, attached to any imported variety that complies with j's regulations *via* a pre-shipment inspection. Since compliance with the importer's regulations is particularly relevant for health-sensitive and complex products (for which otherwise conformity can hardly be recognized at destination), the preference parameter $a\left(c\right)_j$ is an increasing function of product complexity (or sanitary risk)[19] c.[20]

Under the usual assumptions of a monopolistic competition model of trade, it is straightforward to obtain the quantity q_{ij} demanded in country j for goods produced in i as:

$$q_{ij} = a\left(c\right)_j^{\sigma-1} p_{ij}^{-\sigma} E_j P_j^{\sigma-1} \tag{1}$$

with $P_j^{1-\sigma} = \sum_{i\in S} a\left(c\right)_j^{1-\sigma} p_{ij}^{1-\sigma}$ and E_j being the total expenditure of the importing country j. The import price p_{ij} can be defined as the mill price in the exporter country p_i augmented by: (i) the iceberg trade cost d_{ij}, (ii) the mandatory PSI inspection cost s_j fully passed on the consumer, and (iii) the tariff τ_{ij} at destination for goods shipped by exporter country i.[21] The

[18]Given the separability property of a CES demand function, our theoretical setting applies to any specific product. We therefore save notation and remove the product subscript. This will be explicitly introduced in the empirical model.
[19]Jaud et al. (2013) show how sanitary risk of agri-food products affect the EU import pattern.
[20]$a\left(c\right)_j$ is such that $a\left(0\right)_j = 1$ and $a'\left(c\right)_j > 0$. For vary basic and elementary products, $c = 0$, and the effect of the signal channel vanishes.
[21]The tariff is charged on the CIF price.

ij-specific price can therefore be expressed as follows:

$$p_{ij} = p_i(1 + s_j)(1 + d_{ij})(1 + \tau_{ij}) \tag{2}$$

By multiplying import quantity in Eq. (1) by the price p_{ij} in Eq. (2) we obtain the demand function – in value – x_{ij}:

$$x_{ij} = \left(\frac{1 + s_j}{a\left(c\right)_j}\right)^{1-\sigma} (1 + d_{ij})^{1-\sigma} (1 + \tau_{ij})^{1-\sigma} p_i^{1-\sigma} E_j P_j^{\sigma-1} \tag{3}$$

As discussed above, the imposition of a PSI is expected to decrease the demand of imports *via* an increase in the inspection costs s_i with elasticity $1 - \sigma$. At the same time, going through pre-shipment inspections signals the compliance of the product and increases the demand for imports *via* the preference parameter $a\left(c\right)_j$. Since the preference parameter is expected to be more effective with increasing degree of product complexity c, the net effect of the imposition of PSI on bilateral imports depends on the relative magnitude of the elasticity to inspection costs and the preference parameter channel. For purely non-complex products or products with no sanitary risk ($c = 0$), the preference parameter does not play any role and the effect of the imposition of PSI is expected to be unambiguously negative. For complex and health-sensitive products, whose conformity is effectively signaled at destination by fulfilling inspection procedures, the net effect of the imposition of PSI may even be positive.

Bringing this setting to the data, we introduce the product subscript k and time t, and our theory-consistent baseline estimation model takes the following exponential form:

$$x_{ijk,t} = exp[\beta_1 PSI_{jk,t} + \phi_{ik,t} + \xi_{jt} + \chi_{jk} + \psi_{ji}] \times \epsilon_{ijk,t} \tag{4}$$

where $x_{ijk,t}$ denotes bilateral imports (in value) from exporter i to importer j of product k at time t. $PSI_{jk,t}$ is a binary variable equal to one if pre-shipment inspection is required by importer j for product k in year t, and therefore varies along a the jkt-dimension. PSI, hence, captures the *net effect* of the pre-shipment inspection – additional inspection costs and demand shifter. β_1 is the coefficient of interest. The transport cost d_{ij} in Eq. (3) is captured by a dyadic fixed effect ψ_{ji}.[22] By doing so, we purge our PSI coefficient from any other transaction cost channel. In line with Eq. (3), we always control for jt fixed effects (ξ_{jt}) capturing the total expenditure (E_{jt}) and price index (P_{jt}) in Eq. (3).[23] Aligned with structural gravity (Anderson

[22]Directional country-pair fixed effects ψ_{ji} indeed also account for standard gravity variables (colonial ties, common border, common language, cultural proximity).

[23]Introducing the product subscript k in equation (3) implies controlling for product-specific expenditure and price index in importing country. While these terms would be perfectly captured by importer-product-year fixed effect, we are prevented to include such a set of fixed effects because collinear with our variable of interest. The

and Van Wincoop, 2003), we include multilateral resistance terms (MRT). Exporter-product-year fixed effects $\phi_{ik,t}$ capture the outward MRT and any export supply shock of country i in product k. As for the inward MRT, the importer-product fixed effects χ_{jk} cannot have a time dimension due to perfect correlation with our explanatory variable of interest. It accordingly controls for any time-invariant importer-product specific characteristics affecting the bilateral import demand (i.e. product specialization). Lastly, $\epsilon_{ijk,t}$ represents a random disturbance.

The identification of the net effect of PSI is performed in the importer-product-time dimension. Considering the structure of fixed effects in Eq. (4), and the nature of imports data varying along the $jikt$-dimension, in estimating coefficient β_1 we exploit the time variation in the imposition/removal of pre-shipment inspection requirement by a given importer on a specific product for a given exporter-product-year combination.

Eq. (4) is estimated using PPML, as suggested by Santos Silva and Tenreyro (2006), Santos Silva and Tenreyro (2011), Head and Mayer (2014), and Yotov et al. (2016). Standard errors are clustered at the importer-product-year level, the same dimension as the variable of interest.[24]

In our baseline estimations we do not explicitly control for applied tariffs $\tau_{ijk,t}$ because of the presence of many missing values (the estimation sample shrinks by 34%). However, we run several robustness checks controlling explicitly for bilateral applied tariffs, and despite the considerable reduction in the estimation sample our results hold. Moreover, bilateral product specific tariffs have very small time variation – see Fontagné et al. (2022) – and the inclusion of ijk fixed effects reported in a further set of robustness checks would control *de facto* for bilateral applied tariffs. Controlling for bilateral applied tariffs – directly or *de facto* by ijk fixed effects – captures any preferential market access relationship granted by the presence of a Preferential Trade Agreement (PTA).[25] A robustness check controlling for the presence of a PTA does not alter our results. Results are shown in Tables A-6 and A-7 in the Appendix.

3.1 Endogeneity

The large sets of fixed effects discussed above considerably reduce omitted variable concerns. Still, unobserved importer-product specific shocks (i.e. import demand shocks) may contemporaneously affect bilateral trade flows and the imposition/removal of PSI requirements, and thus

inclusion of importer-product fixed effects (χ_{jk}) controls for the average (time-invariant) expenditure and price index of country j in product k and considerably reduces any omitted variable problem.

[24]In our setting, potential PPML fixed effect biases described in Weidner and Zylkin (2021) cannot lead to inconsistent estimates of coefficients due a small time dimensions. Hence, any biases would apply only to standard errors. We address this by robustness proofs of our clustering approach.

[25]Any preferential market access relationship granted by the presence of a Preferential Trade Agreement (PTA) is captured here by using the bilateral *applied* tariffs. Moreover, we decided to exclude the PTA dummy from the set of controls because otherwise we would have had to drop tariffs from the regressions as suggested by Baier and Bergstrand (2007) and Anderson and Yotov (2016).

potentially imply biased PPML coefficients. We address this identification problem by using sequentially an instrumental variable (IV) and propensity score matching (PSM) approach.

Our instrumental variable is based on the idea that the presence of a PSI requirement of a given importer j on product k depends on: (i) how inclined a country is towards imposing PSI requirements (i.e. $\frac{1}{K'}\sum_{k'} PSI_{jk't}$), and (ii) how frequently a product (HS 4-digit) is subject to PSI (i.e. $\frac{1}{J'}\sum_{j'} PSI_{j'kt}$). Our IV takes the following form:

$$PSI_{jkt}^{IV} = \begin{cases} 1 & \text{if} \left(\frac{1}{J'}\sum_{j'} PSI_{j'kt} \times \frac{1}{K'}\sum_{k'} PSI_{jk't}\right) > 0 \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

The first component of PSI_{jkt}^{IV} is the average number of importers requiring PSI for product k – leaving out the jk-specific PSI occurrence. The second component of PSI_{jkt}^{IV} is the average number of PSI imposed by country j across products k – leaving out again the jk-specific PSI occurrence.[26] The exclusion restriction is based on the idea that PSI required for a given product k by third-countries j' interacted with the PSI requirement imposed by country j on other products k', and conditional on importer-year and sector-year fixed effects, is not directly correlated with $ijkt$-specific imports.[27] Note that the potential direct effect of third-countries' (average) PSI on jk-specific imports is captured by fixed effects. Also, the weak substitutability across HS 4-digit industries reassures the absence of a direct effect of third-countries' product PSI on jk-specific imports. To qualitatively test the exclusion restriction assumption, we follow van Kippersluis and Rietveld (2018) and estimate the direct effect of PSI_{jkt}^{IV} on bilateral imports on a sub-sample of country-pairs for which the IV does not predict the observed PSI measure.[28] In a sub-sample of countries for which the IV has zero-effect on the treatment (PSI dummy) the effect of the IV on bilateral imports should also be zero if the exclusion restriction holds. The null coefficient on PSI_{jkt}^{IV} in explaining $ijkt$-specific imports reassures us on the validity of our IV – see Table A-2.

[26] In practice, we calculate the total number of PSI requirements imposed by a given importer j at time t across product k; we then subtract from this sum the jkt-specific PSI requirement, if there is any. Thus, we obtain the total number of PSI requirements imposed by importer j at time t net of the jkt-specific PSI policy. Then, we divide this by the j- specific total number of HS 4-digit import products (minus one). Note that this measure is still jkt-specific because we subtract jkt-specific PSI occurrences from the total count. Finally, we collapse this measure along the jt-dimension to obtain a country-year specific PSI intensity measure. The product specific PSI intensity measure is calculated analogously.

[27] Considering the two sources of variation in defining the IV, standard errors in 2SLS are clustered at the importer-year and product-year level.

[28] As discussed in van Kippersluis and Rietveld (2018), a convenient way to test the exclusion restriction is using units of observations for which the IV does not predict the endogenous variables. Indeed, in a sub-sample for which the first stage shows null impact of the IV on the treatment variable, the reduced form (i.e. the effect of the IV on the outcome) should also be zero if the exclusion restriction holds. We therefore perform the first stage regression by macro-region (using World Bank classification), select regions for which the first stage produces non-significant coefficient on PSI_{jkt}^{IV} and test the direct effect of PSI_{jkt}^{IV} on imports for such a reduced sub-sample. The exclusion restriction here seems to be satisfied as we obtain zero effect of PSI_{jkt}^{IV} on bilateral imports.

An alternative way of addressing endogeneity is estimating Eq. (4) on a sub-sample of country-product combinations having different *observed* PSI requirements but similar *probability* of having PSI in force, i.e. propensity score matching approach (PSM) estimations. The intuition is that within a sub-sample of country-product cells having the same probability of having PSI in place, the difference in the *observed* presence of PSI can be considered random, and therefore exogenously assigned. To proceed, we estimate year-by-year the probability that a jk combination has a PSI measure in place (i.e. the *propensity score*).[29] Then we match an importer-product combination having a PSI measure in place with a PSI-free importer-product combination having a similar propensity score (we use one-to-one matches without replacement).[30] The resulting data set contains jk combinations with highly-similar probabilities of having PSI, but different *observed* PSI requirements in force. Estimating Eq. 4 on this sub-sample further reduces any endogeneity concerns.

4 Baseline results: average trade effects of PSI

This section provides baseline estimations on the effect of PSI on bilateral imports at the product level. We also address potential endogeneity concerns related to our identification strategy and argue that the results reflect a causal relationship. Therefore, we estimate PPML, IV and PSM. We also carry out a battery of robustness checks to further prove that our identification strategy does not suffer from omitted variable biases or reverse causality.

Table 2 shows results for our baseline specification as described in Eq. (4). The effect of PSI on imports is significantly negative and non-negligible in magnitude: over all sectors, requiring PSI reduces bilateral imports by 4.9 percent (Column 1).[31] This result is both qualitatively and quantitatively confirmed by controlling for applied tariffs in Column 2, and by IV and PSM estimations addressing endogeneity concerns. Columns (3)-(4) of Table 2 show results from our IV approach. While the PSI 2SLS point estimates are a bit larger (in absolute value) than the baseline PPML estimates, coefficients are not statistically different from each other.[32] The bottom part of Table 2 supports the relevance of our IV (significant first stage coefficient) and the absence of weak instrument problem (F-stat above 10). Columns (5)-(6) of Table 2 show

[29]The probability of having a PSI has been estimated using product-specific dummies, GDP, population, the average price of the importing country j and its political environment (i.e. regulation quality, government effectiveness and political stability indices from the World Bank WGI database).

[30]The PSM balancing descriptive statistics for years 2010 and 2018 are reported in Table A-3. With some exceptions in year 2010, the average value of covariates in the first stage PSM is the same for the treated (PSI) and untreated (PSI-free) sample of importer-product combinations.

[31]The regression coefficient on *PSI* can be interpreted as percentage change applying the following formula: $\Delta\% = (e^{\beta} - 1) \times 100\%$.

[32]It must be also noted that PPML and 2SLS coefficient cannot be directly compared, given the non-linear and linear estimators respectively (we use the log of export as dependent variable in the 2SLS approach).

results for our PSM approach. The number of observations declines because PSM only uses matched *jk*-couples; but our baseline results are confirmed in both sign and point estimates.

This first set of results overwhelmingly confirms the average negative impact of PSI on *ijkt*-specific imports. The PPML PSI point estimates remain statistically unaffected after addressing potential endogeneity biases *via* IV and PSM approaches.

Table 2: Effects of PSI on imports

	PPML		IV		PSM	
	(1)	(2)	(3)	(4)	(5)	(6)
PSI	-0.05**	-0.07***	-0.12**	-0.09*	-0.04**	-0.06***
	(0.02)	(0.02)	(0.06)	(0.05)	(0.02)	(0.02)
ln(1+τ)		-0.47**		-0.84***		-0.41*
		(0.21)		(0.18)		(0.21)
Exporter-Product-Time FE	✔	✔	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔	✔	✔
Importer-Product FE	✔	✔	✔	✔	✔	✔
Country-Pair FE	✔	✔	✔	✔	✔	✔
Observations	1,364,596	902,008	1,364,596	902,008	997,462	696,358
First stage IV coeff.			0.486***	0.531***		
First stage F-stat			51.03	59.48		

Source: TRAINS, 2021; COMTRADE, 2021.
Notes: PPML estimations, standard errors in parentheses are clustered at the importer-product-year level in columns 1, 2, 5 and 6. Standard errors are clustered at the importer-year and product-year level in columns 2 and 3. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.

4.1 Robustness Checks

This section discusses a battery of robustness checks reported in the Appendix and aimed to further reduce omitted variables and reverse causality concerns.

Reverse causality. In the context of our analysis, reverse causality implies that changes in *ijkt*-specific imports lead to a change in the importer's PSI policy. Given the structure of our data, we consider reverse causality a minor threat to our identification. Our dependent variable, being bilateral and thus *inter partes*, is unlikely to drive the imposition PSI requirements that are applied *erga omnes*. Moreover, the IV and PSM approaches discussed above further alleviate any reverse causality concerns. Here we follow a coarse but intuitive approach to further reduce potential reverse causality issues. We run a battery of robustness checks using sub-samples of data obtained by eliminating the most important exporters in terms of bilateral total trade volume.[33]

Table A-4 in the Appendix presents the results of successively eliminating the five top ex-

[33] A similar approach has been used by Boehm et al. (2020) in the context of tariff elasticity estimations to reduce reverse causality concerns.

porters for any given importer. Neither specification changes our results in terms of the direction of effects and their statistical significance. The magnitude of reported PSI effects even increases in absolute value although point estimates do not statistically differ across specifications. As an additional robustness check, regressions shown in Table A-5 exclude importers with high import concentration.[34] If certain bilateral trade flows were to affect a country's PSI policy, this would be particularly the case for countries whose imports are mainly concentrated in a few major trading partners. Our results prove that dropping the top 10, 20, and 30 percent of importers with the highest import concentration does not change the effect of PSI on trade as identified above. Throughout all specifications, the effect of PSI on imports is estimated at -4.9 to -3.9% while remaining statistically significant at the 5-percent-level. Hence, we conclude that our results are estimated consistently and do not suffer important reverse causation biases.

Lastly, we run regressions that remove, once at a time, all importers of the sample. In all 32 regressions, PSI coefficients are negative and 31 of them are statistically significant at 5-percent level. The coefficients vary from -0.03 to -0.09, with both median and mean close to -0.075. This shows that the negative effect caused by PSI does not depend on the inclusion into the estimation sample of single countries that endogenously impose PSI measures.

Omitted variables. For our baseline PPML regression, bilateral trade agreements (RTA) can potentially constitute confounding factors causing omitted variable biases. This is a minor concern, as PSI requirements are national trade policies applied on an MFN basis and are therefore hardly determined by bilateral trade agreements. Also, any preferential market access is captured in previous estimations by applied bilateral tariffs. Nevertheless, we present here some checks that confirm the robustness of our results when we control for the RTA dummy. First, in Column 1 of Table A-6 we control for any ijt preferential relation (i.e. also for the existence of an RTA) by including country-pair-time fixed effects. The coefficient of interest is slightly affected by the inclusion of ij, t fixed effects, suggesting PSI reducing bilateral imports by -7.7 percent. The slight change in magnitude comes as no surprise as including ij, t-fixed effects conditions the identification on cross-product variation only. In Column 2 of Table A-6 we explicitly control for the presence of a trade agreement by using updated RTA data from Egger and Larch (2008). The inclusion of the RTA dummy leaves the PSI coefficient unchanged both in terms of magnitude and statistical significance.

Another source of omitted variables can be related to unobserved ijk-specific patterns (or preferential relations) affecting imports in j for a specific variety ik. The inclusion of ijk fixed effects in Column (3) of Table A-6 addresses this concern and shows the robustness of our results.

[34] Import concentration is measured as the import share of the top five exporters in 2015.

PSI requirements, until the TFA, have often been used for tariff classification and customs valuation purposes. Therefore, variation in tariff lines across products within HS 4-digit product categories might provide a case for governments to require PSI. Adding the standard deviation of tariffs within 4-digit product (Column 4), hence, controls for this sort of endogenous determination of PSI requirements. The PSI coefficient is less negative at -3.9%. However, the number of observations decreases by 40 percent compared to the baseline because of the introduction of tariff-based covariates.

5 The effect of PSI by type of product

So far we established the causal relationship between PSI requirements and bilateral imports. We showed that, on average, the trade cost component of PSI outweighs the quality information signal. This result is robust to the inclusion of high dimensional fixed effects, sample stratification exercises, IV and PSM approaches. However, as discussed in the theoretical framework of Section 3, the net effect of PSI requirement depends on product characteristics. For complex and health-sensitive products the quality signaling effect of PSI ($a(c)_j$ term in Eq. 3) may offset the trade cost component (s_j). Accordingly, in this section we test the heterogeneous effects of PSI on several product characteristics. Namely, we interact the PSI dummy with: (i) an indicator for trade in agricultural and food products, (ii) a binary variable for differentiated products, and (iii) a binary variable indicating whether an SPS measure is imposed by importer j on product k. Baseline results are still based on PPML estimations. A propensity score matching approach is also used to reduce the endogeneity concern.[35]

Results are reported in Table 3. PSI is not found to impact agricultural trade differently than trade in manufacturing goods (both -4.9%, no significant coefficient for the interaction term with agricultural products). By contrast, the PSI effect on food products is significantly different: the net effect for these products is +13.8% indicating that PSI requirements substantially *increase* trade in the food sector. This result is confirmed by the PSM approach in column 4. The reported effects are in line with our theoretical intuition: for these types of products, quality characteristics (and safety in production in particular) are crucial and are more easily verifiable in the exporting country before shipment. Thus, the signaling channel, with importing governments seeking to ensure supplies of reliable quality and fulfillment of crucial safety requirements, is likely to offset the cost channel.[36]

[35] We cannot use the IV approach discussed above because using the same source of variation as an IV to instrument the treatment variable PSI and its interactions implies a weak IV problem.

[36] Recent anecdotal evidence based on notifications made to the WTO Committee on PSI as well as showcasing by prominent PSI agencies, such as Cotecna and SGS, show that these companies have increasingly branched out into the verification of compliance with safety standards on request of importing countries, particularly since

The latter can be tested even more directly: Columns 2 and 5 of Table 3 show that PSI more than doubles imports when applied to products for which SPS conformity assessment documentation is required. This suggests that PSI is used as a tool to avoid the import risk of non-compliance with SPS standards, such as food safety requirements.

Finally, relying on the Rauch (1999) product classification, Columns 3 and 6 in Table 3 show that the effect of PSI requirements is larger for differentiated products. This is in line with our theoretical framework. The quality of differentiated products is either observable or signaled, making PSI unnecessary. For these products, the trade costs involved in PSI cannot therefore be compensated by an information gain.[37]

All of these heterogeneous effects of PSI are confirmed by the robustness checks reported in Table A-7 controlling for applied bilateral tariffs.

Table 3: Effects of PSI, by sector and type of product

	PPML			PSM		
	(1)	(2)	(3)	(4)	(5)	(6)
PSI	-0.05**	-0.05***	0.03	-0.04**	-0.04**	0.02
	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)
PSI x Agri	-0.08			-0.04		
	(0.06)			(0.06)		
PSI x Food	0.18***			0.22***		
	(0.06)			(0.06)		
PSI x SPS Conformity Assessment		1.09***			0.94***	
		(0.30)			(0.32)	
PSI x Differentiated Product			-0.09**			-0.08**
			(0.04)			(0.04)
Exporter-Product-Time FE	✔	✔	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔	✔	✔
Importer-Product FE	✔	✔	✔	✔	✔	✔
Country-Pair FE	✔	✔	✔	✔	✔	✔
Observations	1,364,596	1,364,596	1,137,885	997,462	997,462	822,231

Source: TRAINS, 2021; COMTRADE, 2021.

Notes: PPML estimations, standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.

the prohibition of PSI for tariff classification and customs valuation purposes under Article 10.5 of the Trade Facilitation Agreement. Cf., for instance, *Presentation for cotton Interventions – Cotecna Inspection India Pvt. Ltd.*. Moreover, the safety of basic foodstuffs is commonly considered to be a particularly important public policy objective and related standards are often best verified at origin and certified by widely accredited PSI agencies, particularly in the case of weak domestic institutions. In fact, in the case of basic foodstuffs, the commonly applied Hazard Analysis Critical Control Point (HACCP) procedure requires in-depth controls during the production process. In international trade, the proper documentation of these controls is then certified by an internationally accredited agency. Cf. *U.S. FDA information on HACCP*.

[37] Conversely, Low (1995) emphasizes the importance of physical inspection for homogeneous products before shipment, as possible quality concerns may be hard to detect at destination.

6 Counterfactual scenarios

To give a sense of the trade impact of removing PSI, as largely required by the TFA, we need to take into account the sectoral import composition of countries enforcing PSI, as not all sectors are affected in the same way. This section performs a simple counterfactual analysis aiming to assess the overall impact of PSI removal on imports of developing countries.

Using the observed PSI distribution across country-sectors in 2018 as a baseline scenario, we calculate the expected change for a given country's imports from two counterfactual scenarios: (i) the case in which all countries re-introduce PSI they imposed in 2010 (*Scenario 1*), (ii) the case in which countries re-introduce the most restrictive PSI policy that they had in place between 2010 and 2018 (*Scenario 2*). By comparing the two counterfactual scenarios with the baseline situation, we can quantify the effect of the removal (or imposition) of PSI over the period 2010-2018. To that end, we retrieve estimated parameters from the specification reported in Column 1 of Table 3, and calculate the expected country-sector imports $\hat{X}_{ijk,t}$ for the baseline scenario as follows:

$$\hat{X}_{ijk,t} = exp[\hat{\beta}_1 PSI_{jk,t} + \hat{\phi}_{ik,t} + \hat{\xi}_{jt} + \hat{\chi}_{jk} + \hat{\psi}_{ji}] \tag{6}$$

where the $PSI_{jk,t}$ variable keeps the 2018 values (i.e. $PSI_{jk,2018}$), and $\hat{\beta}_k$ is the trade elasticity of PSI depending in the sector (i.e. agriculture, food and manufacturing). Then, we calculate the expected imports for the two scenarios by introducing the respective counterfactual values for $PSI_{jk,t}$ (i.e. $PSI_{jk,2010}$ and $max\,[PSI_{jk,2010}, ...PSI_{jk,2018}]$). The expected import changes are reported in columns 1-2 of Table 4.

Reverting to PSI imposed in 2010 (*Scenario 1*) implies a 2-7% reduction of imports for almost all countries. Exceptions are countries that did not change PSI policy between 2010 and 2018 (i.e. zero change in imports), those who actually imposed new PSI measures only after 2010 (e.g. Panama, Uruguay and Indonesia), and countries that had PSI measures concentrated in food products (where the PSI elasticity was found to be positive in Column 1 of Table 3). If importers re-introduced the most restrictive PSI policy that they had in place between 2010 and 2018 (*Scenario 2*), total imports (across countries) would fall by 3%. Interestingly, Liberia and Zimbabwe seem to lose from the removal of PSI measures in 2018. This is due to the fact that these countries imposed PSI measures after 2010 in food products only – see Table A-1.

Table 4: Counterfactual analysis: percentage variation in imports, with respect to the baseline (2018).

	Δ Imports	
	Scenario 1	Scenario 2
Barhain	-0.72	-4.48
Benin	-5.43	-5.77
Burkina Faso	-2.44	-2.67
China	-3.12	-3.41
Cote d'Ivoire	-1.45	-1.53
Dominica	-6.79	-7.41
Ecuador	0.00	0.00
Ethiopia	-3.5	-3.8
Grenada	-5.91	-6.12
Guinea	-2.13	-2.07
India	-3.03	-3.05
Indonesia	2.22	0.00
Lebanon	-1.49	-2.44
Liberia	0.00	9.38
Mali	-2.08	-2.29
Mauritania	0.00	-0.01
Mauritius	-3.47	-3.55
Myanmar	2.53	0.00
New Zealand	-0.21	-0.27
Niger	-2.78	-2.94
Nigeria	0.00	-3.46
Pakistan	-0.27	-0.28
Panama	4.6	0.00
Peru	5.39	0.00
Philippines	0.00	0.00
Saudi Arabia	-0.2	-2.53
Sri Lanka	0.00	-3.14
Tunisia	-6.58	-7.46
Uganda	0.00	-4.36
United Arab Emirates	-5.17	-7.46
Uruguay	7.33	0.00
Zimbabwe	0.00	15.46
Total	-2.58	-3.07

Source: TRAINS, 2021. COMTRADE, 2021.

7 Missing trade and trade mis-invoicing

Trade mis-invoicing or the occurrence of missing trade – orphan imports and lost exports – are a widely known phenomenon in international trade statistics. Historically, PSI requirements have been deployed to avoid trade mis-invoicing, i.e. that imports are over- or under-declared, either to circumvent capital controls or for the sake of tariff evasion, respectively. This section investigates whether PSI policy changes between 2010 and 2018 have had an effect on trade mis-invoicing or missing trade.

For those observations for which both exports and imports are reported, the discrepancy between import and export figures can be used as proxy for the degree of mis-invoicing. Namely, the degree of mis-invoicing can be calculated as $disc = |\frac{2(M-X)}{M+X}| \times 100\%$ (Braml and Felbermayr, 2021). This discrepancy measure is non-directed, meaning that it does not differentiate between over-declared or under-declared imports. If importers required PSI for providing accurate tariff classification and customs valuation, mis-reporting of imports should decrease with PSI requirements.[38] Column (1) of Table 5 shows, for a regression setting similar to our baseline estimation, the effect of PSI on the trade discrepancy. In line with expectations, PSI is statistically significant in reducing the observed discrepancy. Quantitatively, this effect is rather small: the estimated coefficient in column (1) implies that PSI reduces discrepancies by 1.7 percent of one standard deviation.[39]

With respect to the extensive margin of mis-invoicing, i.e.missing trade flows, we construct two different dependent variables: in Column (2) of Table 5, the dependent variable is a binary variable indicating whether for a given reported import flow a corresponding export flow is recorded or not. Hence, the sample is constrained to trade flows for which imports are reported. Imports without mirror exports are denoted as "orphan imports". According to a linear probability estimate, the presence of PSI has no effect on the presence of orphan imports. Since PSI is an importer-specific measure and the estimation is conditional on imports being reported, this comes as no surprise.

In Column (3) of Table 5, the dependent variable is a binary variable indicating whether for a given reported export flow a corresponding import flow is recorded or not. Exports without mirror imports are denoted as "lost exports". According to the same linear probability estimate as in column (2), the presence of PSI leads to a 0.9 percentage points lower probability of exports being "lost". Hence, the probability that for a given export the mirroring import is not reported decreases in the presence of PSI. This is in line with expectations, as PSI has disciplining effects in the importing country on the reporting of the corresponding flow. In practice, PSI makes it easier for customs officials and statistical institutions to collect and record the relevant data. However, as shown in column (4) of Table 5, this effect only materializes in the presence of efficient customs.[40] For countries having minimum level of custom efficiency (2.05 in our sample) the effect of PSI is not statistically different from zero. Interestingly, the more efficiently customs perform, the more PSI reduces the likelihood for exports going missing. Presumably, more efficient customs are better capable of processing the provided information, as the sending of an inspection report in isolation does not replace customs clearance and statistical recording.

[38] The TFA stipulates that PSI should no longer be used for tariff classification and customs valuation purposes.
[39] The standard deviation of the discrepancy variable is 66.
[40] The World Bank customs efficiency measure is used in interaction with PSI. It ranges between 1 (low) and 5 (high) indicating the institutional quality of customs authorities. We use importer-specific averages over time.

Table 5: The effect of PSI on missing trade and trade mis-invoicing

	Discrepancy	Orphan Imports	Lost Exports	
	(1)	(2)	(3)	(4)
PSI	-1.13**	-0.06	-0.88***	6.24**
	(0.55)	(0.22)	(0.28)	(2.65)
PSI x Customs Efficiency				-2.54***
				(0.92)
Exporter-Product-Time FE	✔	✔	✔	✔
Country-Pair FE	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔
Importer-Product FE	✔	✔	✔	✔
Observations	615,926	1,014,833	939,036	938,269

Source: TRAINS, 2021; COMTRADE, 2021; World Bank, 2022.
Notes: OLS estimations, standard errors in parentheses are clustered at the importer-product level. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.

We conclude that PSI *per se* has only relatively limited effect on trade mis-invoicing at the intensive margin, and on lost exports at the extensive margin. These effects are line with prior findings in the literature (Yang, 2008b). PSI has some disciplining effect on data recording on the importer side (conditional on the trade flow having been reported by the exporter) in importing countries with efficient customs, indicating some degree of complementary between PSI requirements and customs efficiency in incentivizing the reporting of import flows.

8 Conclusion

This paper addresses the channels through which PSI may hamper or foster trade, and therefore affect the welfare of consumers in developing countries. This is the first attempt to structurally estimate and quantify the trade effects of pre-shipment inspections, addressing the two sides of the same coin – the additional cost of exporting and conformity signaling. On average the net effect of the additional cost (inspection) and demand shifter (signal of conformity) is negative. PSI requirements reduce bilateral trade by -4.9% on average. Effects are remarkably heterogeneous across economic sectors, with the most negative impact on trade in differentiated manufacturing goods. Conversely, PSI increase trade in food products by 13.8%. Specifically, PSI even double imports that are subject to SPS conformity assessments. Our results rest on PPML, instrumental variable, and propensity score matching approaches and withstand a battery of robustness checks that make any sort of endogeneity bias highly unlikely. Counterfactual analysis shows that the significant reduction in PSI requirements by most importers led to a 2.6-3.1% increase in their total imports. PSI has also been shown to reduce trade mis-invoicing and the probability of missing trade, but only by small margins. An implication of this is that negative effects associated with the elimination of PSI between 2010 and 2018 on tariff revenues and on the statistical accuracy of trade data are relatively limited.

As recent anecdotal evidence suggests, PSI agencies increasingly focus on conformity assessment and regulatory compliance checks. Our results show that PSI facilitates international trade in the presence of sanitary and phytosanitary measures. Thus, this paper suggests that narrowing the scope of PSI to such purposes could help unfold its full potential as trade catalyst. It is of course an open question to what extent such a new focus on conformity assessment requires government interventions in the form of mandatory PSI. Conceivably, under certain conditions, private market outcomes could reliably lead to voluntary pre-shipment inspections in order to reduce the likelihood of shipment rejections at destination. We leave these issues for future research.

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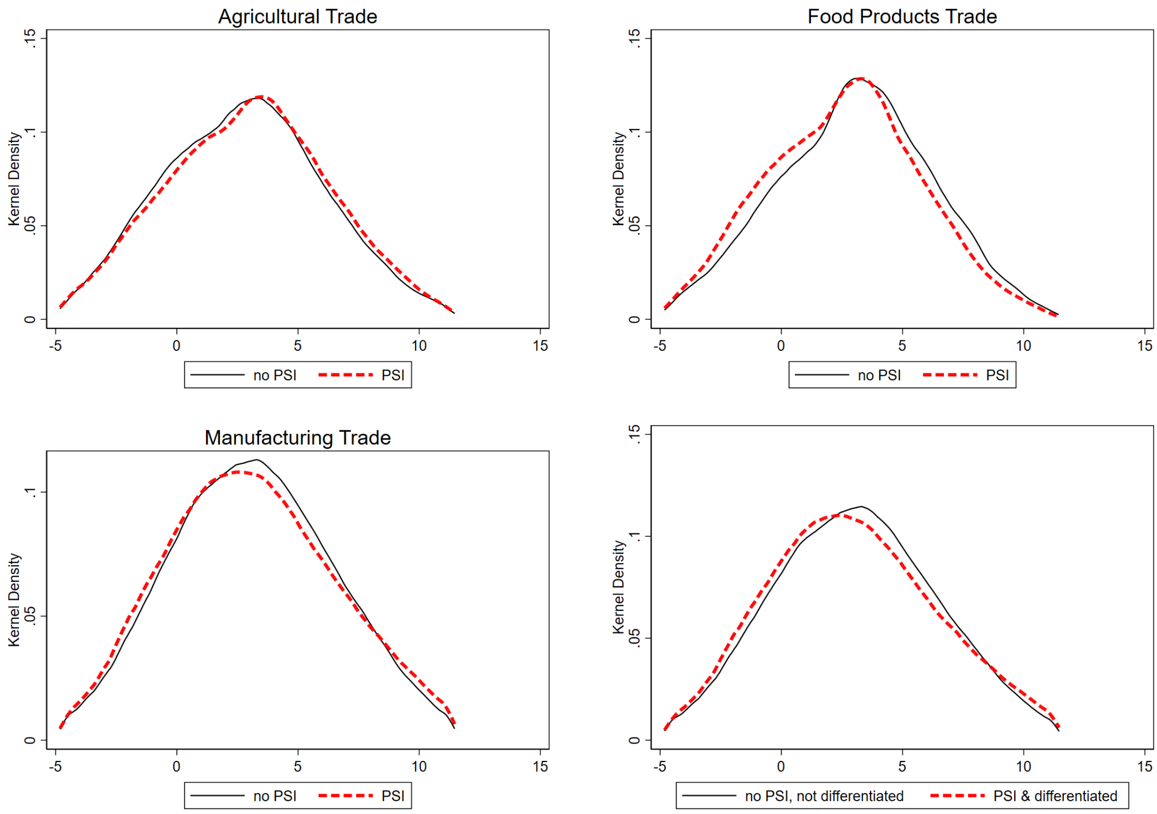
Appendix

Table A-1: Number of HS4 Products affected by PSI, by importer, 2010-2018

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bahrain	2	2	2	2	2	2	0	0	0
Benin	14	13	14	16	16	0	0	0	0
Burkina Faso	988	981	997	0	0	0	0	0	0
China	177	217	217	266	266	265	265	0	0
Cote d'Ivoire	141	140	138	0	0	0	0	0	0
Dominica	26	24	28	19	19	22	0	0	0
Ecuador	5	5	5	5	5	5	5	5	5
Ethiopia	912	915	930	918	925	931	0	0	0
Grenada	24	21	23	20	0	0	0	0	0
Guinea	851	879	881	0	0	0	0	0	0
India	177	177	178	179	179	179	179	178	0
Indonesia	94	114	115	136	199	346	364	429	428
Lebanon	7	11	10	10	10	16	15	0	0
Liberia	0	0	0	8	8	0	0	0	0
Mali	998	985	968	928	924	0	0	0	0
Mauritania	3	3	4	3	3	3	0	0	0
Mauritius	3	3	3	3	3	3	3	3	0
Myanmar	25	26	26	26	26	26	26	111	111
New Zealand	1	2	2	2	2	2	2	0	0
Niger	973	946	956	950	962	0	0	0	0
Nigeria	0	0	0	837	0	0	0	0	0
Pakistan	1	1	1	1	1	2	2	0	0
Panama	0	0	0	0	0	0	0	4	10
Peru	0	8	9	9	9	8	8	9	11
Philippines	2	2	2	2	2	2	2	2	2
Saudi Arabia	7	11	11	10	11	11	11	0	0
Sri Lanka	0	0	0	0	4	4	4	0	0
Tunisia	109	102	103	110	105	111	108	0	0
Uganda	0	0	0	0	5	5	5	5	0
United Arab Emirates	78	79	79	84	85	85	0	0	0
Uruguay	0	0	0	0	0	0	0	8	9
Zimbabwe	0	0	0	0	1	2	2	1	0
Total	5,618	5,667	5,702	4,544	3,772	2,030	1,001	755	576

Source: TRAINS, 2021.

Figure A-1: Kernel Density Plot: Ln Trade Value by PSI treatment



Source: TRAINS, 2021; UN COMTRADE, 2021; own calculations.
Notes: See Figure 2 for Kernel density plots for the whole sample and differentiated by SPS intensity.

Table A-2: IV validity check: the effect of IV on bilateral imports.

	Imports (ln)	
	(1)	(2)
PSI^{IV}	-0.05	-0.03
	(0.27)	(0.27)
PSI		-0.58***
		(0.19)
Exporter-Product-Time FE	✔	✔
Importer-Year FE	✔	✔
Importer-Product FE	✔	✔
Country-Pair FE	✔	✔
Observations	7,628	7,628

Source: TRAINS, 2021; COMTRADE, 2021.

Notes: standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. $<$ 0.01, p-val. $<$ 0.05, and p-val.$<$ 0.1.

Table A-3: PSM balancing for years 2010 and 2018.

	2010		2018	
	PSI	(no-PSI)	PSI	no-PSI
GDP (ln)	11.0	13.9	14.3	14.3
Population (ln)	3.2	5.2	5.1	5.1
Price (ln)	-0.9	-0.9	-1.0	-1.0
Political Stability	-0.7	-1.3	-0.6	-0.6
Government Effectiveness	-0.7	-0.6	-0.1	-0.1
Regulatory Quality	-0.6	-0.6	-0.2	-0.2

Source: TRAINS, 2021; COMTRADE, 2021.

Table A-4: Robustness: Removal of largest exporters, PPML

	Top Exporter	Top 2 Exporters	Top 3 Exporters	Top 4 Exporters	Top 5 Exporters
	(1)	(2)	(3)	(4)	(5)
PSI	-0.09***	-0.12***	-0.12***	-0.12***	-0.12***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Exporter-Product-Time FE	✔	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔	✔
Importer-Product FE	✔	✔	✔	✔	✔
Country-Pair FE	✔	✔	✔	✔	✔
Observations	1,298,255	1,234,509	1,181,039	1,144,525	1,097,437

Source: TRAINS, 2021; COMTRADE, 2021.

Notes: PPML estimations, standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. $<$ 0.01, p-val. $<$ 0.05, and p-val.$<$ 0.1.

Table A-5: Robustness: Removal of importers with high import concentration, PPML

	Top 10 % Importers	Top 20 % Importers	Top 30 % Importers
	(1)	(2)	(3)
PSI	-0.05**	-0.05***	-0.05**
	(0.02)	(0.02)	(0.02)
Exporter-Product-Time FE	✔	✔	✔
Importer-Time FE	✔	✔	✔
Importer-Product FE	✔	✔	✔
Country-Pair FE	✔	✔	✔
Observations	1,363,694	1,359,796	1,352,687

Source: TRAINS, 2021; COMTRADE, 2021.

Notes: PPML estimations, standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.

Table A-6: Robustness: the role of RTAs and ijk-specific factors.

	PPML			
	(1)	(2)	(3)	(4)
PSI	-0.08***	-0.05**	-0.06***	-0.04*
	(0.02)	(0.02)	(0.02)	(0.02)
RTA		0.01		
		(0.05)		
MFN Tariff variation				-0.01**
				(0.00)
Exporter-Product-Time FE	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔
Importer-Product FE	✔	✔		✔
Country-Pair FE		✔		✔
Country-Pair-Year	✔			
Country-Pair-Product FE			✔	
Observations	1,358,157	1,272,368	1,364,596	817,521

Source: TRAINS, 2021; COMTRADE, 2021; Egger and Larch (2008).

Notes: PPML estimations,standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.

Table A-7: Effects of PSI, by sector and type of product. Controlling for tariffs.

	PPML			PSM		
	(1)	(2)	(3)	(4)	(5)	(6)
PSI	-0.07***	-0.07***	-0.01	-0.05**	-0.06***	0.02
	(0.02)	(0.02)	(0.04)	(0.01)	(0.02)	(0.04)
PSI x Agri	-0.15**			-0.10		
	(0.07)			(0.07)		
PSI x Food	0.10			0.14**		
	(0.07)			(0.07)		
PSI x SPS Conformity Assessment		1.25***			1.07***	
		(0.23)			(0.23)	
PSI x Differentiated Product			-0.06**			-0.09**
			(0.04)			(0.04)
ln(1+τ)	-0.52**	-0.13	-0.44**	-0.44**	0.04	-0.38*
	(0.21)	(0.22)	(0.21)	(0.21)	(0.22)	(0.21)
Exporter-Product-Time FE	✔	✔	✔	✔	✔	✔
Importer-Time FE	✔	✔	✔	✔	✔	✔
Importer-Product FE	✔	✔	✔	✔	✔	✔
Country-Pair FE	✔	✔	✔	✔	✔	✔
Observations	902,008	902,008	752,229	696,358	696,358	576,308

Source: TRAINS, 2021; COMTRADE, 2021.

Notes: PPML estimations, standard errors in parentheses are clustered at the importer-product-year level. ***, ** and * respectively indicate statistical significance levels for p-val. < 0.01, p-val. < 0.05, and p-val.< 0.1.