Do Standards Improve the Quality of Traded Products?*

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Abstract

We examine whether standards raise the quality of traded products by correcting market failures associated with information asymmetry on product attributes. Our predictions on their quality and selection effects are based on a new trade model under uncertainty about product quality in which heterogeneous firms can strategically invest in quality signaling. Matching French firm-product-destination export data with a dataset on SPS and TBT measures, we find that such quality standards enforced on products by destination countries (i) favor the exit of low-productivity firms and increase the export probability of high-quality firms provided that their productivity is high enough; (ii) raise the export sales of high-productivity high-quality firms; (iii) improve the average quality of consumption goods exported by France.

JEL Codes: D21, D22, F12, F14
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1 Introduction

Quality standards (QSs), such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBTs) are increasingly used by national governments and lead to many international trade disputes (WTO, 2012).[1] Even though QSs are not *a priori* discriminatory measures (as they have to be met by both foreign and domestic firms), the bulk of the empirical evidence suggests that they are trade reducing and, potentially, welfare decreasing (e.g. Andriamananjara et al., 2004; Disdier et al., 2008; Hoekman and Nicita, 2011). Indeed, fewer varieties are traded as fewer foreign firms are able to export to the domestic market due to additional production and distribution costs (compliance costs).[2] In addition, these costs are also likely to raise the prices of the remaining varieties.[3] As a result, consumers may be worse off following the introduction of QSs not only because their favorite varieties are excluded from the market but also because more standards lead to higher prices.

Nevertheless, standards may also be welfare-improving tools, addressing market failures such as information asymmetry between consumers and producers with respect to quality, safety and other product characteristics. Typically under asymmetric information, quality is under-provided. Since buyers only observe the average quality of goods, high-quality products are forced out of the market by low-quality ones (Akerlof (1970)'s lemons principle). In this context, the introduction of QSs should increase the quality of products that are actually consumed. Except few authors (Leland, 1979; Shapiro, 1983; Ronnen, 1991; Crampes and Hollander, 1995), the vast majority of the literature has disregarded this fact. We lack empirical evidence on the ability of QSs to address asymmetric information problems in a context of international trade.

This paper explores the selection and quality effects of standards on traded products. More precisely, we examine whether the enforcement of QSs in a country (i) favors the entry of foreign firms selling high-quality goods (the effect on the extensive margin of trade), (ii) increases the market share of high-quality firms (the effect on the intensive margin of trade), and (iii)

[1] For example, national policy makers set rules on additives and contaminants in the food and drink sector, impose safety regulations for toys, define minimum energy efficiency standards for many household appliances, require that motor vehicles be equipped with airbags and antilock braking systems, or specify labelling requirements directly related to the safety or the composition of products. Between 1995 and 2017, 470 SPS-related and 549 TBT-related trade concerns were raised (Sources: WTO, http://spsims.wto.org/ and http://tbtims.wto.org/).

[2] This effect is exacerbated when standards differ among countries, which significantly increases the cost of doing business internationally.

[3] Accordingly, QSs have usually been treated as pure trade barriers in the literature, equivalent to ad valorem taxes. One exception is Beghin et al. (2015) who start from an agnostic prior on the impact of regulatory policies on trade and welfare.

raises the average quality of foreign products perceived by domestic consumers.

We first build a new firm-based trade model identifying the mechanisms at work in the presence of QSs and uncertainty about product quality. Firms can strategically undertake investment in quality signaling (Dranove and Jin, 2010). They can truthfully and credibly disclose information about the quality of their varieties. In the model, firms are characterized by the productivity and quality of their products, which are horizontally and vertically differentiated. Product quality is endogenously set by firms and tailored to each market. The marginal cost of production increases with quality for a given productivity and decreases with productivity for a given quality. For a given price, there might be various combinations of productivity and quality.[4]

The effects of QSs on the quality of traded products depend on firms' productivity. First and as expected, low-productivity firms supply low-quality products and do not disclose information on quality of their products. Hence, the enforcement of QSs forces low-productivity firms to improve the quality of their products or to exit the market when they are not able to keep up with the regulations. Second, medium-productivity firms cannot profitably undertake investments in quality signaling, but can profitably export. Thus, the non-signaling exporters operate under quality uncertainty and their export sales increase with productivity, but decrease with product quality (cost effect). Indeed, foreign consumers do not know the true quality of their products whereas their prices are relatively high. Exporters which do not disclose have therefore an incentive to supply the minimum quality to meet the QSs. Under these circumstances, the quality of the varieties supplied by medium-productivity (non-signaling) firms may decline with QSs' enforcement because the market competition becomes tougher. Third, signaling activity which implies fixed costs is only profitable for high-productivity firms selling high-quality products. The export sales of these signaling firms increase with their productivity, the quality of their products, and the restrictiveness of QSs (due to a reallocation of market shares).

We then assess empirically the main predictions derived from our model. We match a dataset on public QSs (SPS and TBT measures) enforced in 53 non-European countries with French firm-product-destination export data. We estimate the effect of QSs on both the extensive and intensive trade margins of individual French exporters with respect to the productivity and the quality of their products. We also consider the impact of QSs on aggregate

[4] Our framework extends the model developed in Bagwell and Staiger (1989) and Cagé and Rouzet (2015) by considering firm heterogeneity, horizontal differentiation, and signaling activity.

exports and on the average quality of exported products. The estimation of product quality using firm-level trade data when information asymmetry prevails is challenging. We cannot use input prices at the firm level as in Bastos et al. (2018b) to infer quality at the firm-product level. Verhoogen (2008) and Kugler and Verhoogen (2012) show that firms use high-quality inputs to produce high-quality products. Thus, assuming that input markets are competitive, higher input prices should reflect higher quality inputs and, in turn, higher quality output. Unfortunately, the majority of firms in our sample are multi-product firms and our dataset does not report input prices for each product separately. As information on both price and quantity is available, we therefore rely on the approach usually used in the literature and consider demand equations (Khandelwal, 2010; Khandelwal et al., 2013). For a given price in a firm-product-destination triplet, a variety with higher sales is assigned a higher quality. However, this approach does not allow to infer the latent quality of products that are not exported, which is needed to evaluate the role of quality at the extensive trade margin. Consequently, we adjust the approach and compute the quality at the firm-product level for the extensive margin.

According to our results, the effect of QSs on the export probability and export sales of firms depends on their productivity and product quality. A large number of QSs in the destination country increases the presence and export sales of high-quality French exporters provided that their productivity is high enough (higher than the median productivity). In addition, more QSs force low-productivity firms to exit the market, regardless of the quality of their products.

To simulate the impact of QSs on aggregate exports, we proceed as follows. First, we classify in quartiles the current number of QSs imposed by various destinations j on product k, to account for the heterogeneity in imposing standards across destinations. Then, we set the number of QSs on product k to the maximum number observed across all destinations j in a given quartile. Our simulation exercise suggests that the number of French exporters per product-destination pair would decrease by 0.4% (extensive margin effect). At the intensive margin, 57.5% of surviving firms would experience a fall in their export sales to non-EU countries. Hence, 42.5% of surviving firms would benefit from this rise in the number of QSs. The winners are high-quality high-productivity firms. Their export sales to non-EU countries would increase on average by 4.6%. The overall effect on French exports to non-EU markets would be positive (5.2% of exports, i.e. 1.5 billion euros). Therefore, QSs do not necessarily act as pure trade barriers, and by correcting market failures, they contribute to raise French exports to non-EU markets.

When it comes to the average quality of exported products perceived by foreign consumers, the effect of QSs is dependent on the classes of goods and sectors considered. QSs increase the average quality of consumption goods such as food and beverages as well as textile products, but have no significant impact on capital and intermediate goods.

Literature Review

Recent papers have estimated the impact of trade policy on product quality. Amiti and Khandelwal (2013) find that lower US tariffs promote quality upgrading for products that are initially close to the technology frontier. Relying on disaggregated Chinese data, Fan et al. (2015) show that firms upgrade the quality of their products when tariffs are reduced. However, this strand of the literature assumes perfect information and disregards the effects of standards on the quality of traded products.

The role of QSs on firms' exports has been explored in few papers. On the theoretical side, Das and Donnenfeld (1989), Gaigné and Larue (2016) and Bastos et al. (2018a) develop international trade models with vertical differentiation but assume perfect information. While these theoretical papers take into account both the quality and productivity characteristics of firms, the existing empirical studies solely consider productivity features. Their results show that QSs raise the export probability and export value of high-productivity firms at the expense of low-productivity firms (Fontagné et al., 2015; Fugazza et al., 2018; Fernandes et al., 2019). In addition, the export probability is reduced in TBT-imposing destinations, especially for multi-destination firms, which can choose TBT-free destinations (Fontagné and Orefice, 2018). Compared to this strand of the empirical literature, we go one step further. We theoretically and empirically study how both the productivity and quality characteristics of the firms shape their export decisions in the presence of QSs and in a context of information asymmetry between consumers and producers with respect to product quality. Moreover, we also analyze the role of QSs on aggregate exports and on the average quality of exported products.

This paper also pursues investigations on the link between product quality and trade at the firm level. Building on Melitz (2003)'s framework, several papers consider vertical differentiation to explain the quality sorting found in international trade. Conditional on size, exporting firms sell high quality goods at high prices (Hallak and Sivadasan, 2013). Besides, the competitiveness of the firms is determined by their quality-adjusted prices (Kugler and Verhoogen, 2012) and high quality products are able to enter more distant markets (Baldwin and Harrigan, 2011). Bastos et al. (2018a) analyze in a dynamic setting how learning about demand and quality choices shapes the evolution of firm performance and prices over the life cycle. However, all these papers assume perfect information. By contrast, we account for information asymmetry between buyers and sellers with respect to product quality, as in Akerlof (1970). We consider that consumers can neither correlate product quality with price nor perfectly judge it even after consumption (credence goods).[5] Credence attributes are of a very different nature: (i) attributes that have health/safety consequences and (ii) consumer demand (willingness to pay) for attributes that are related to human health and production processes such as the environmental cost of production, the use of child labor, and animal welfare standards (Dulleck et al., 2011). Given the type of products, our model considers that firms rely on a costly certification process to credibly signal quality (see Dranove and Jin, 2010, for a survey on the theoretical and empirical literature on quality disclosure and certification).

Finally, this paper complements the literature on adverse selection. While the theoretical contributions on adverse selection and the under-provision of quality have increased significantly since the seventies, empirical tests using data on *tangible* goods remain rather scarce compared to those focusing on insurance markets. Some studies have tested for adverse selection in durable goods markets (Bond, 1982; Genesove, 1993; Hendel et al., 2005; Engers et al., 2009; Peterson and Schneider, 2014, 2017). Our data allows us to exploit the differences across countries to identify adverse selection. As the presence of QSs reduces the information asymmetry problem, the differences in the number of QSs across countries should drive the probability of serving a destination and the volume of transactions for a given firm-product pair. Our estimations confirm this prediction.

Our paper is organized as follows. Section 2 exposes the theoretical model. Section 3 describes the data and the computation of quality. Section 4 estimates the effects of QSs on the extensive and intensive trade margins and discusses the results. Section 5 investigates the impact of QSs on aggregate exports and on the average quality of products. Section 6 concludes.

2 Theory

This section provides the microeconomic foundations of the impact of QSs on the export decisions (extensive margin) and export sales (intensive margin) of firms according to the productivity and quality of their products in a context of information asymmetry between consumers

[5] Our theory disregards cases where consumers can learn about the quality level prior to the purchase (search good) or after the purchase and use (experience good).

and producers with respect to product quality. The theoretical model is an extension of a standard heterogeneous firm trade model in which firms engage in costly quality-signaling and set strategically the quality of their products for each foreign market.[6]

2.1 General framework

We consider an economy with information asymmetry on product quality and heterogeneous firms.[7] If producers know the quality of their products, this quality may not be observed by consumers.

Preferences and demand. Consumers are assumed to be risk-neutral and have identical Cobb-Douglas preferences for differentiated products. We use a CES sub-utility function for the differentiated products:

$$U_j^k = \left[\sum_i \int_{\mathcal{V}_{ij}^k} \left[\lambda_{ij}^k(\nu) q_{ij}^k(\nu) \right]^{\frac{\sigma^k - 1}{\sigma^k}} \mathrm{d}\nu \right]^{\frac{\sigma^k}{\sigma^k - 1}} \tag{1}$$

where $\mathcal{V}_{ij}^k$ is the set of varieties ν of product k available in country j and produced in country i, q_{ij}^k is the demand expressed in country j for a variety of product k imported from country i, and $\sigma^k > 1$ is the elasticity of substitution between varieties and is assumed to be constant. As in Kugler and Verhoogen (2012) and Hallak and Sivadasan (2013), $\lambda_{ij}^k(\nu)$ represents the quality of variety ν from i *perceived* by consumers in j (it captures all attributes of a product other than price, which consumers value). However, $\lambda_{ij}^k(\nu)$ depends on the information available to consumers. We consider two polar cases. First, if credible and truthful disclosure is feasible, consumers know the exact attributes of any variety and $\lambda_{ij}^k(\nu) = [\theta_{ij}^k(\nu)]^{\beta^k}$, where $\theta_{ij}^k(\nu)$ is the true quality supplied by sellers and β^k signals greater appreciation for vertically differentiated products. Second, if this quality cannot be precisely observed, consumers – who are risk-neutral – do not consider the quality of each variety but rather the average quality $\bar{\theta}_{ij}^k$, as in the standard literature on information asymmetry. Hence, under this configuration, $\lambda_{ij}^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta^k}$.

The equilibrium demand for a variety produced in country i and exported to country j is given by:

$$r_{ij}^k \equiv p_{ij}^k q_{ij}^k = \left(\lambda_{ij}^k\right)^{\sigma^k - 1} A_j^k \left(p_{ij}^k\right)^{1-\sigma^k} \tag{2}$$

[6] In a working paper version (Disdier et al., 2018), we propose a model in which product quality provided by a firm does not vary across countries as in Bernard et al. (2011), Baldwin and Harrigan (2011), and Fajgelbaum et al. (2011). In other words, it is assumed that quality cannot be adjusted by firms as often as prices are.

[7] We consider a single period of production, but we can easily extend our framework to multiple periods by assuming an exogenous probability for the survival of firms, as in Melitz (2003).

with $A_j^k \equiv E_j^k \left(P_j^k\right)^{\sigma^k-1}$, where p_{ij}^k is the price of a variety of product k produced in country i prevailing in country j, E_j^k is the amount of income allocated to the differentiated product sector and P_j^k is the price index in country j, which is defined as:

$$P_j^k = \left[\sum_i \int_{\Omega_{ij}^k} \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\sigma^k-1)} [p_{ij}^k(\nu)]^{1-\sigma^k} \mathrm{d}\nu + \int_{\widetilde{\Omega}_{ij}^k} \left(\theta_{ij}^k(\nu)\right)^{\beta_j^k(\sigma^k-1)} [p_{ij}^k(\nu)]^{1-\sigma^k} \mathrm{d}\nu\right]^{\frac{-1}{\sigma^k-1}}. \tag{3}$$

where Ω_{ij}^k (resp., $\widetilde{\Omega}_{ij}^k$) is the set of varieties ν for which the perceived quality is the true quality (resp. the average quality). The price index reacts negatively to an increase in the average quality of the products. It follows that the demand for a variety imported from a country is also conditional on the average quality of the products imported from the other countries, through the price index. More precisely, for a given number of exporters, if the average quality of the products imported from a country increases unilaterally, the price index declines, decreasing the demand faced by firms located in other countries where the average quality remains unchanged.

Technology, market structure, and profit. We consider a continuum of firms producing under monopolistic competition. Each variety is produced by a single firm, but a firm can produce more than one differentiated product (multi-product firms).[8] Each firm-product pair is characterized by a level of productivity φ^k (the ability to produce output using few variable inputs). Firms producing in country i choose the price p_{ij}^k and quality θ_{ij}^k of their product k for each market j. Product markets are internationally segmented, meaning that the price and quality of a variety (a firm-product pair) vary across destination countries.

Firms may also undertake investments in quality signaling and strategically choose to disclose information about the quality of their product to uninformed consumers. For simplicity, we assume that truthful and credible disclosure is feasible, whereas misrepresentation is impossible. Quality disclosure can take different forms. Sellers may make known the quality of their products to the purchaser through the guarantee issued by a third independent party (*certification*) or may voluntarily advertise it. Formally, if a firm located in country i producing product k invests in quality signaling for consumers living in country j, then the quality of the variety supplied by the firm (θ_{ij}^k) is perfectly observed by foreign consumers. However,

[8] Consistently, in the empirical section, we use the firm-product pair (i.e. variety) as the basic unit of our analysis. In the remainder of the text, we use the terms firm and firm-product pair interchangeably.

quality-signaling activities undertaken by the firm imply a sunk cost F_{ij}^k which varies across origin countries, destination markets, and products (e.g. the cost of obtaining a certification of the product quality from an independent third party).

The profit of a firm located in country i is given by $\pi_i = \sum_k \sum_j \pi_{ij}^k(\varphi^k)$ with

$$\pi_{ij}^k \equiv p_{ij}^k q_{ij}^k / T_{ij}^k - c_{ij}^k(\theta_{ij}^k, \varphi^k)\tau_{ij}^k q_{ij}^k - \phi_{ij}^k(\theta_{ij}^k) - \mathbb{I}^k F_{ij}^k \tag{4}$$

where $T_{ij}^k \equiv 1 + t_{ij}^k$ with t_{ij}^k the ad valorem tariff applied by country j on product k imported from country i, τ_{ij}^k represents an iceberg trade cost, ϕ_{ij}^k is the fixed cost of distribution, $c_{ij}^k(\theta_{ij}^k, \varphi^k)$ is the *marginal* cost of production, and $\mathbb{I}^k = 1$ if the firm invests in quality signaling and 0 otherwise. The marginal cost increases with quality for a given productivity and decreases with productivity for a given quality. More specifically, $c_{ij}^k = (\theta_{ij}^k)^{\alpha^k}\omega_i^k/\varphi^k$, where ω_i^k is the price of the production factors, and α^k is the quality-elasticity of the variable costs (with $\alpha^k \geq 0$). The fixed distribution costs are given by $\phi_{ij}^k = f_{ij}^k(\theta_{ij}^k)^{\eta^k}$, where η^k is common to all firms selling product k. f_{ij}^k is specific to each origin-destination country pair and corresponds to the costs of maintaining a presence in foreign markets (e.g., maintaining a distribution and service network and monitoring foreign customs procedures and product standards). These costs increase with the quality of the products to be exported.[9]

QS. Each destination country j introduces a standard setting a minimum quality ($\underline{\theta}_j^k$). A firm can serve foreign market j if and only if $\theta_{ij}^k > \underline{\theta}_j^k$. In addition, we must have $\bar{\theta}_{ij}^k \geq \underline{\theta}_j^k$ in equilibrium. As in the standard literature, QSs can solve "lemons" type problems in markets with asymmetric information by increasing the average quality of products (Leland, 1979; Ronnen, 1991). In our case, the effects are however more complex because of firm heterogeneity and consumer preference for variety.

2.2 Selection, sorting and trade in presence of QSs with endogenous quality

Given the specifications of production technology and demand, the profit-maximizing prices are given by:

$$p_{ij}^k = \frac{\sigma^k}{\sigma^k - 1}\omega_i^k \tau_{ij}^k T_{ij}^k \frac{(\theta_{ij}^k)^{\alpha^k}}{\varphi^k}, \tag{5}$$

[9] Firms have to train labor and make other adjustments in their production process before producing/exporting a single unit of a high-quality product. For example, firms selling perishable products (e.g. fresh fruits and vegetables) may have to invest in better storage facilities to meet a QS over an extended period.

regardless of the signaling strategy. Hence, equilibrium prices decrease with product quality (θ_{ij}^k) and the quality-elasticity of the variable cost (α^k) and increases with productivity (φ^k). By contrast, the choice of quality depends on whether the firm invests in signaling quality.

Quality choice and export sales of signaling firms. If a firm undertakes investments in quality signaling, its profit and export sales are given by

$$\tilde{\pi}_{ij}^k = \tilde{r}_{ij}^k/\sigma^k - f_{ij}^k(\theta_{ij}^k)^{\eta^k} - F_{ij}^k \quad \text{and} \quad \tilde{r}_{ij}^k = (\theta_{ij}^k)^{\Lambda^k}(\varphi^k)^{\sigma^k-1}Z_{ij}^k \tag{6}$$

where $\Lambda^k \equiv (\beta^k - \alpha^k)(\sigma^k - 1)$ and

$$Z_{ij}^k \equiv A_j^k \left(\frac{\sigma^k}{\sigma^k-1}\omega_i^k\tau_{ij}^k T_{ij}^k\right)^{1-\sigma^k}. \tag{7}$$

The impact of quality on profits of signaling firms depends on the foreign consumers' attitudes towards quality (β^k) relative to the cost elasticities of quality (α^k and η^k). In accordance with the trade theory under perfect information, we assume $\beta^k > \alpha^k$ to ensure that the quality of varieties is higher than the minimum quality for a fraction of firms in equilibrium. In this case, export sales increase with product quality for a given productivity when consumers perfectly observe the quality of the variety.

When a firm invests in quality signaling, the first-order condition with respect to quality implies that its optimal quality θ_{ij}^k is such that $\eta^k f_{ij}^k(\theta_{ij}^k)^{\eta^k} = \Lambda\tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k$, given its profits (6). Hence, the pricing decision of the firms interacts with their vertical differentiation strategy. A firm must improve its quality until the increase in its operating profits is equal to the increase in its fixed costs associated with the quality of its product. To obtain an interior solution, the second order condition requires that $\eta^k > \Lambda^k$. If the last inequality was not satisfied, firms would produce at the minimum quality level. Although each firm operates under monopolistic competition, their quality is related to the quality of their rivals through the price index. In equilibrium, we have

$$\theta_{ij}^k = \left(\frac{\Lambda^k}{\eta^k}\frac{Z_{ij}^k}{\sigma^k f_{ij}^k}\right)^{\frac{1}{\eta^k-\Lambda^k}}\left(\varphi^k\right)^{\frac{\sigma^k-1}{\eta^k-\Lambda^k}} \quad \text{and} \quad \tilde{r}_{ij}^k = \frac{\eta^k\sigma^k f_{ij}^k}{\Lambda^k}(\theta_{ij}^k)^{\eta^k} \tag{8}$$

The level of quality adopted by a signaling firm and its export sales increase with its productivity and market size in line with the empirical evidence. Note also that higher productivity directly lowers prices by reducing the marginal cost of production. However, higher productivity induces the firm to upgrade quality, which increases marginal costs and prices. Whether high-productivity firms charge higher or lower prices than low-productivity firms depends on the strength of incentives to upgrade quality and product differentiation. Inserting (8) in (5) shows that the price is decreasing (resp., increasing) in productivity if $\beta^k\sigma^k < \eta^k$ (resp., $\beta^k\sigma^k > \eta^k$), that is, if consumers' appreciation of quality is low (resp., high) enough.

Quality choice and export sales of non-signaling firms. The quality of the varieties sold by non-signaling firms is not observed by consumers. The latter only know the average quality of products (for each origin country). Due to information asymmetry, incentives exist for producers to pass off low-quality goods as high-quality ones. However, consumers account for these incentives by judging the quality of goods as uncertain. Inserting (2), (5), and $\lambda^k(\nu) = (\bar{\theta}^k_{ij})^{\beta^k}$ in (4), the profit of a non-signaling firm producing a variety of product k in country i and serving market j is:

$$\pi^k_{ij} = r^k_{ij}/\sigma^k - f^k_{ij}(\theta^k)^{\eta^k} \qquad \text{with} \quad r^k_{ij} = \left(\bar{\theta}^k_{ij}\right)^{\beta_k(\sigma^k-1)} \left(\frac{\varphi^k}{(\theta^k)^{\alpha^k}}\right)^{\sigma^k-1} Z^k_{ij}. \tag{9}$$

A firm serves country j if and only if $\pi^k_{ij} \geq 0$. As expected, exports are increasing with the firm's productivity ($\partial r^k_{ij}/\partial\varphi^k > 0$) and with the average quality ($\partial r^k_{ij}/\partial\bar{\theta}^k_{ij} > 0$). Hence, when the average quality in the destination market increases, consumers are willing to pay more for all goods imported from country i. Under these circumstances, high-quality non-signaling producers share their benefits with low-quality non-signaling producers. In addition, we have $\partial r^k_{ij}/\partial\theta^k < 0$ for a given productivity. As a consequence, under information asymmetry, the best strategy for all non-signaling firms, whatever their levels of productivity, is to produce at the minimum quality level.

The quality supplied by non-signaling firms is lower under information asymmetry than under perfect information.[10] Since consumers only know the average quality of the products, their demand for (expensive) top-quality products is lower. Although they are preferred by consumers, high-quality products are therefore driven out of the market by low-quality ones (Akerlof's lemons principle).

Using our assumptions on technology and preferences, we can determine the *productivity*

[10] Under perfect information, the quality supplied by non-signaling firms would be given by (8).

cutoff ($\underline{\varphi}_{ij}^k$) to meet the QS prevailing in the foreign country. The latter variable is defined such that $\pi_{ij}^k(\varphi_{ij}^k, \underline{\theta}_j^k) = 0$ or, equivalently,

$$\underline{\varphi}_{ij}^k = \left(\frac{\sigma^k f_{ij}^k}{Z_{ij}^k}\right)^{\frac{1}{\sigma^k-1}} \left(\underline{\theta}_j^k\right)^{\frac{\eta^k-\Lambda^k}{\sigma^k-1}}. \tag{10}$$

where $\eta^k > \Lambda^k$ (as shown below). As all non-signaling firms adopt the QS, $\bar{\theta}_{ij}^k = \underline{\theta}_j^k$ in equilibrium. Hence, the quality-adjusted price is a function of $(\underline{\theta}_j^k)^{\Lambda^k}(\varphi^k)^{\sigma^k-1}$. It follows that a QS yields a higher productivity cutoff because of a direct effect (due to higher cost) and an indirect effect through a lower price index (lower Z_{ij}^k).

The profit and export sales of non-signaling firms in equilibrium conditional on exporting are given by:

$$\pi_{ij}^k(\varphi^k, \underline{\theta}_j^k) = r_{ij}^k/\sigma^k - f_{ij}^k(\underline{\theta}_j^k)^{\eta^k} \qquad \text{with} \quad r_{ij}^k = \sigma^k f_{ij}^k \left(\underline{\theta}_j^k\right)^{\eta^k} \left(\frac{\varphi^k}{\underline{\varphi}_{ij}^k}\right)^{\sigma^k-1} \tag{11}$$

where we have used (10). A QS increases the export sales of incumbent firms having no signaling activity. This response is more pronounced for more productive incumbents.

Disclosure choice and export decision. A firm invests in quality signaling activity if and only if $\tilde{\pi}_{ij}^k = \tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k - f_{ij}^k(\theta_{ij}^k)^{\eta^k} - F_{ij}^k > \pi_{ij}^k(\varphi^k, \underline{\theta}_j^k)$. It follows that, if a firm chooses to disclose, then this firm can profitably export as $\tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k - f_{ij}^k(\theta_{ij}^k)^{\eta^k} > 0$. Using (8) implies that $\tilde{\pi}_{ij}^k = (\eta^k - \Lambda^k) f_{ij}^k(\theta_{ij}^k)^{\eta^k}/\Lambda^k - F_{ij}^k$. Hence, a firm discloses (and exports) if and only if $\theta_{ij}^k > \widehat{\theta}_{ij}^k$ where $\widehat{\theta}_{ij}^k$ (called *signaling cutoff*) is such that $\tilde{\pi}_{ij}^k(\varphi^k, \theta_{ij}^k) = \pi_{ij}^k(\varphi^k, \underline{\theta}_j^k)$ or, equivalently,

$$\left(\widehat{\theta}_{ij}^k\right)^{\eta^k} = \left(\tilde{\theta}_{ij}^k\right)^{\eta^k} + \frac{\Lambda^k}{\eta^k - \Lambda^k}\left(\underline{\theta}_j^k\right)^{\eta^k}\left[\left(\frac{\varphi^k}{\underline{\varphi}_{ij}^k}\right)^{\sigma^k-1} - 1\right] \quad \text{with} \quad \tilde{\theta}_{ij}^k \equiv \left(\frac{\Lambda^k}{\eta^k - \Lambda^k}\frac{F_{ij}^k}{f_{ij}^k}\right)^{\frac{1}{\eta^k}} \tag{12}$$

Firms with a quality above this threshold $\widehat{\theta}_{ij}^k$ (or, equivalently, a productivity above $\hat{\varphi}_{ij}^k$ such that $\tilde{\pi}_{ij}^k(\widehat{\varphi}_{ij}^k, \theta_{ij}^k) = \pi_{ij}^k(\widehat{\varphi}_{ij}^k, \underline{\theta}_j^k)$) earn positive profits by exporting and invest in signaling activity, while firms below this threshold do not disclose.

It is worth stressing that, even though $F_{ij}^k = 0$, exporters disclose the quality of their varieties to consumers if and only if $\varphi^k > \breve{\varphi}_{ij}^k$ (to ensure that $\widehat{\theta}_{ij}^k > \underline{\theta}_{ij}^k$) with

$$\breve{\varphi}_{ij}^k \equiv \left(\frac{\eta^k}{\Lambda^k}\right)^{\frac{1}{\sigma^k-1}} \underline{\varphi}_{ij}^k. \tag{13}$$

where $\breve{\varphi}_{ij}^k > \underline{\varphi}_{ij}^k <$ as $\eta^k > \Lambda^k$. Only high-productivity incumbents have a strong incentive to disclose as they provide high-quality products while low-productivity incumbents prefer to hide in the pool of firms selling varieties with a higher quality. This result is in line with the industrial organization literature (Dranove and Jin, 2010). It is also straightforward to check that $\widehat{\varphi}_{ij}^k$ increases with F_{ij}^k (thus, $\widehat{\varphi}_{ij}^k > \breve{\varphi}_{ij}^k$). As expected, lower certification costs induce quality upgrading as more firms can invest in quality signaling.

The next proposition and Figure 1 summarize our main results,

Proposition 1. *Under information asymmetry on product quality, firms with no signaling activity serve country j if and only if $\underline{\varphi}_{ij}^k < \varphi^k < \widehat{\varphi}_{ij}^k$ and their export sales increase with productivity and decrease with product quality. Firms invest in quality signaling activity and export to country j if and only if $\widehat{\varphi}_{ij}^k < \varphi^k$ and $\widehat{\theta}_{ij}^k < \theta_{ij}^k$ and their export sales increase with productivity and product quality.*

The optimal quality supplied by signaling firms can be rewritten as follows

$$\theta_{ij}^k = \underline{\theta}_j^k \left(\frac{\Lambda^k}{\eta^k}\right)^{\frac{1}{\eta^k-\Lambda^k}} \left(\frac{\varphi^k}{\underline{\varphi}_{ij}^k}\right)^{\frac{\sigma^k-1}{\eta^k-\Lambda^k}} = \underline{\theta}_j^k \left(\frac{\varphi^k}{\breve{\varphi}_{ij}^k}\right)^{\frac{\sigma^k-1}{\eta^k-\Lambda^k}} \tag{14}$$

Hence, $\theta_{ij}^k = \underline{\theta}_j^k$ when $\varphi^k = \breve{\varphi}_{ij}^k$ so that $\theta_{ij}^k > \underline{\theta}_j^k$ when $\varphi^k > \widehat{\varphi}_{ij}^k$. As a result and as shown in Figure 1, firms with a medium level of productivity ($\varphi^k \in [\breve{\varphi}_{ij}^k, \widehat{\varphi}_{ij}^k]$) would provide a higher quality than the minimum quality imposed by the QS if there is no information asymmetry. By contrast, low-productivity firms ($\varphi^k < \breve{\varphi}_{ij}^k$) supply a higher quality than they would under certainty.

Insert Figure 1 here

Impact of QS on average quality, signaling activity, and export decision. We now discuss the impact of a QS under information asymmetry on the average quality of varieties available on a market and the number of exporters. This impact is quite complex as we capture different competing effects.

Assume first there is no QS. In this case, firms that do not disclose exit the market. Indeed, we have $\partial \pi_{ij}^k / \partial \theta^k < 0$ and $\theta_{ij}^k \to 0$ so that each non-signaling firm has an incentive to reduce the quality of its variety and $\bar{\theta}_{ij}^k \to 0$. As a consequence, the demand for varieties supplied by non-signaling firms tends to zero and, in turn, these firms exit the market. A firm invests in quality signaling if and only if $\tilde{\pi}_{ij}^k = (\eta^k - \Lambda^k) f_{ij}^k (\theta_{ij}^k)^{\eta^k} / \Lambda^k > F_{ij}^k$. Hence, a firm discloses (and exports) if and only if $\theta_{ij}^k > \tilde{\theta}_{ij}^k$ or, equivalently, $\varphi^k > \tilde{\varphi}_{ij}^k$ with

$$\tilde{\varphi}_{ij}^k = \left(\frac{\tilde{\theta}_j^k}{\underline{\theta}_j^k} \right)^{\frac{\eta^k - \Lambda^k}{\sigma^k - 1}} \breve{\varphi}_{ij}^k. \tag{15}$$

Thus, without QS, firms with a productivity $\varphi^k < \tilde{\varphi}_{ij}^k$ do not enter market j while firms with a productivity $\varphi^k > \tilde{\varphi}_{ij}^k$ invest in quality signaling and export (Figure 2, panel (a)).

Insert Figure 2 here

Assume now the enforcement of a QS (Figure 2, panel (b)). The QS is not "too" strict and is such that $\underline{\theta}_j^k < \tilde{\theta}_{ij}^k$. Under these circumstances, different forces are at play. First, firms having a productivity $\varphi^k \in [\underline{\varphi}_{ij}^k, \tilde{\varphi}_{ij}^k]$ can now profitably export to country j without signaling activity. Hence, the introduction of a QS tends to increase the number of varieties available in market j. Second, firms having a productivity $\varphi^k \in [\tilde{\varphi}_{ij}^k, \widehat{\varphi}_{ij}^k]$ cease to disclose, reduce the quality of their varieties ($\theta_{ij}^k = \underline{\theta}_j^k$), and still export even if their profits decline. Third, more productive firms ($\varphi^k > \widehat{\varphi}_{ij}^k$) maintain their signaling activity and their exports. Hence, all in all, the introduction of a QS has an ambiguous effect on the average quality. Indeed, the QS forces low-productivity firms to improve the quality of their products whereas the quality of the varieties supplied by medium-productivity firms declines because the market competition becomes tougher. Moreover, the QS allows the entry of new exporters and limits the range in which sellers can differentiate the quality of their products. As a result, the medium-productivity firms have to downgrade the quality of their products with the enforcement of a QS.[11] Clearly, there are winners and losers among low-productivity firms ($\varphi^k < \widehat{\varphi}_{ij}^k$), while high-productivity firms ($\varphi^k > \widehat{\varphi}_{ij}^k$) benefit from the QS.

Last, we study the effects of a stricter QS. A marginal increase in $\underline{\theta}_j^k$ forces low-productivity firms to exit (the productivity cutoff ($\underline{\varphi}_{ij}^k$) increases) because of higher costs to comply with the requirements. In addition, the effect of a QS on the signaling cutoff ($\widehat{\theta}_{ij}^k$) is unclear. A QS has

[11] Ronnen (1991) obtains a different result as he considers that firms use the same technology and do not disclose. A QS favors the exit of high-quality firms as they do not invest in signaling. By contrast in our framework, medium-quality sellers are worse off – even though they already provided a quality above the QS before its enforcement – as they suffer from more intense price competition.

both a direct effect on the signaling cutoff and an indirect effect through the productivity cutoff (φ_{ij}^{k}). For a given productivity cutoff, the signaling cutoff shifts upward. However, by raising the productivity cutoff, a QS may reduce the signaling cutoff. In this case, more firms disclose and the average quality of varieties may increase. In other words, a QS implies fewer exporters and has an ambiguous effect on the average quality of the products available on the market.[12]

The next proposition and Figure 2 summarize our main results,

Proposition 2. *Under information asymmetry on product quality, the impact of a QS on average quality of varieties delivered in a country is ambiguous and the mass of exporters declines.*

3 Empirical implementation

We first present the data used in the empirical analysis. Our study combines trade policy data (QSs and tariffs) defined at the product-destination pair with French export data computed at the firm-product-destination level. We then infer firm-product productivity and quality.

3.1 Datasets

QSs. Our empirical study relies on the TRAINS NTM database released by the UNCTAD.[13] It is currently the most comprehensive NTMs database, providing all the measures in force by country, product and type of instruments at the time of data collection (between 2012 and 2016, depending on the country). This database encompasses not only measures of well-identified trade objectives (e.g. quotas and price controls) but also regulatory and technical instruments aimed at protecting human health and the environment by improving the production process and/or the product quality (e.g. SPS and TBTs). Even without trade objectives, these regulatory and technical standards may impact international flows.

The measures included in the TRAINS NTM database are broken up into 16 chapters, depending on their scope and/or design. Each chapter is further differentiated into subgroups to

[12]When the QS becomes very strict so that $\underline{\theta}_j^k > \tilde{\theta}_{ij}^k$, the average quality increases with a marginal rise in $\underline{\theta}_j^k$ because only firms having a signaling activity can profitably export.

[13]TRAINS stands for TRade Analysis Information System and UNCTAD for United Nations Conference on Trade and Development. TRAINS NTMs data are available here: `http://i-tip.unctad.org/`. We use the version of the database that was made available in April 2016. This database includes 56 countries, with the 27 countries of the European Union (EU) aggregated into the EU (see Table A1 in the Appendix for the list of countries).

allow for a finer classification of the measures.[14] For our analysis, we retain the first 15 chapters, which deal with countries' requirements regarding their imports and exclude the last chapter covering countries' requirements regarding their exports. Furthermore, we classify the NTMs into two categories: i) QSs defined as SPS and TBT measures and ii) all other import-related NTMs. As previously mentioned, our study focuses on the impact of QSs on French firms' exports. However, as other NTMs may also affect export flows, we include them as control variables in our estimations.

For each country, the products targeted by the NTM measures are usually available at the 6-digit level of the Harmonized System (HS) classification and thus can be easily matched with French firm export data, which are also defined at that level of aggregation (see below). If the NTMs are defined at a more aggregated level (e.g. HS2 or HS4), we assume – as implemented in practice by policymakers – that all HS6 products within that HS2 or HS4 are affected by the measure. On the other hand, if the NTMs are available at a more detailed level (e.g. HS8 or HS10), we aggregate them at the HS6 digit level. With very few exceptions, all tariff lines within a given HS6 product are covered by the NTMs. Therefore, this aggregation procedure does not bias our analysis. Finally, we count the number of SPS and TBTs (e.g. QSs), as well as other import-related NTMs imposed by each importing country on a given HS6 product.[15] This simple count of measures is the common approach in the literature on NTMs (UNCTAD, 2018). Indeed, the databases on NTMS – and among others the TRAINS NTM database – list the existing NTMs but unfortunately do not provide information on their restrictiveness. However, the number of measures imposed by an importing country on a given HS6 product can be seen as a proxy for their restrictiveness. It is likely to be more costly and therefore more difficult for an exporter to enter a product-destination market with a high number of QSs and other import-related NTMs.

Taking into account the core principle of mutual recognition within the EU, we exclude EU

[14]Table A2 in the Appendix lists the 16 chapters. See UNCTAD (2016) for a more refined decomposition of the classification. For example, chapter A on SPS measures is decomposed into nine two-digit codes (from A1 to A9). Two-digit codes are then differentiated into three-digit codes. Some groupings are then further decomposed; however, most of the groupings stop at three digits. In our analysis, we focus on the two-digit codes and if more than one measure belongs to the same subgroup and affects the same product in the same country, we group them (for example, two A11 measures on product k in country j are aggregated into a single measure). These measures usually have the same purpose and are strongly connected and cannot be seen as two different measures. The robustness checks using measures defined at the one-digit level (e.g. aggregated at the chapter level) provide similar results.

[15]We consider only unilateral NTMs (e.g. NTMs imposed by importing countries on all exporting countries – including France –) and exclude bilateral NTMs that specifically affect only European or French products. However, this approach does not bias our study because for almost all bilateral measures targeting French or European products (e.g. 98.8%), a unilateral counterpart measure is also in force.

countries from our sample of destinations. Our paper is indeed about firms facing additional costs when exporting. Since French firms already have to comply with standards at home, they do not face any additional cost when serving other EU countries.

French firm-product level data. In addition to the QS data, we use French firm-product level data. French customs provide export data by firm, HS6 product and destination country. As mentioned above, the TRAINS NTM database provides information on all NTMs in force in each destination country at the time of data collection (between 2012 and 2016). Working on the annual flows of newly adopted measures does not make much sense. The time-variation in the notification of measures by countries is rather small and most of the variation in standards occurs across countries and products.[16] We therefore use data on French firms' exports in 2011 and perform a cross-section analysis using the stock of QSs and other import-related NTMs in force at the time of the data collection in each destination country, on each product and potentially affecting these exports.[17] For each firm located in the French metropolitan territory, French customs data include the volume (in tons) and value (in thousands of euros) of exports for each HS6 product-destination pair.

Table A3 in the Appendix presents the number of HS6 products exported by French firms to each destination country included in the TRAINS NTM database, as well as the share of products affected by at least one QS (SPS and TBT measures) in that destination, and the average number of QSs in force on each product. The shares are simply obtained by dividing the number of HS6 products subject to QSs by the total number of HS6 products. To compute the average number of QSs per HS6 product, we consider only products subject to at least one standard. Products without standards are not included in the calculation. For comparison purposes, these statistics are provided for all products imported by the destination country and for the ones exported by France to that destination.[18] The last column reports the share of French exports (in value) subject to QSs in the destination country. These results highlight four main facts. First, the number of products exported by French firms varies significantly across destinations. On average, in our sample, 1,294.1 HS6 products are exported to each destination, with a minimum of 204 products exported to Laos and a maximum of 3,555 products exported

[16]Furthermore, in the TRAINS NTM database, a start date is associated with each measure. However, this date is subject to inconsistencies.

[17]Our results are the same if we consider 2012 exports. In addition, new QSs often update and therefore replace existing measures, meaning that the stock of QSs remains unchanged even if new measures are adopted after 2012.

[18]Table A4 in the Appendix reports the same statistics for other import-related NTM measures.

to the United States. Second, the share of French products effectively affected by at least one NTM in the destination market is on average similar to what would have been observed if all products would have been exported by French firms to all destinations (52.9% vs. 53.0%). Thus, the presence of NTMs does not necessarily hamper French firms' exports. Third, French firms tend to export products affected by a small number of number of QSs. Indeed, the average number of measures per product is smaller for products exported by France compared to that reported for all products (3.7 vs. 5.1). Interestingly, French products tend to face an higher number of QSs on developed markets (on average 7.8 QSs in Australia, 7.1 in Canada, and even 10.7 in the US) or on emerging ones (8.3 in Brazil, 6.1 in China) than on developing markets. QSs being usually more restrictive in developed or emerging than in developing countries, this observation suggests that the use of the number of QSs as a measure of their restrictiveness is a good proxy. Fourth, on average, 64.5% of French exports are subject to QSs. However, strong differences are observed across destination countries.

Tariff data. Our empirical analysis also controls for tariffs. Tariff barriers may of course impact French firms' exports. In their absence, one cannot distinguish the effects of QSs and other import-related NTMs on exports from those of tariffs. To avoid this bias, we include a bilateral measure of market access. The data were obtained from the Market Access Map (MAcMap) database, which is jointly developed by the International Trade Centre (UNCTAD-WTO) and the CEPII.[19] This database incorporates not only applied tariffs but also specific duties, tariff quotas and anti-dumping duties. All these barriers are converted into an ad valorem equivalent and summarized in one measure. This measure is computed at the HS 6-digit level. Tariff data are for the year 2010, which is currently the last available year in the MAcMap database.[20] Tariff data are not available for Liberia and Thailand, which are dropped from our analysis.

Overall, our final sample includes 46,248 French firms exporting 4,393 HS6 products to 53 destination countries (EU excluded). On average, a firm exports 3.0 HS6 products per destination (median =1) and serves 1.9 destinations per HS6 product (median = 1). The data show that 53.0% of the firms serve only one destination (mono-destination firms) and 48.5% export only one product (mono-product firms).

[19] CEPII stands for Centre d'Etudes Prospectives et d'Informations Internationales. http://www.cepii.fr/anglaisgraph/bdd/macmap.htm.

[20] As for QSs and other import-related NTMs, most of the variation in tariffs is observed across products and countries rather than over time.

3.2 Evaluating productivity and quality

Productivity To measure productivity, we rely on productivity. However in our dataset, proxies for physical productivity are available only at the firm level. Using official firm identifiers, we merge the customs data with the BRN (Bénéfices réels normaux) dataset compiled by the French Statistical Institute, which provides firm balance-sheet data (e.g. value added, total sales, and employment). We compute the firm's productivity as the ratio between the firm's sales and its number of employees. As a robustness check, we also consider the value added per worker.[21]

In the absence of information on productivity at the firm-product pair level, we have to control for the heterogeneity in productivity for each firm across its varieties. In accordance with the industrial organization literature (Prahalad and Hamel, 1990; Eckel and Neary, 2010; Eckel et al., 2016), multi-product firms have a core competence product that is produced with the highest productivity φ_f^k (its rank 1).[22] Expanding the product lines and moving away from the core competence of the firm decreases productivity. The within-firm ranking of each product is computed as follows. The exports of a product by a firm are summed across all destinations. The export values for each product are then sorted in descending order. The first rank is assigned to the product with the highest export value. The product with the lowest export value is ranked last. The productivity of each product-firm pair is then simply computed by dividing the productivity of the firm by the rank of the product: $\varphi_f^k = \varphi_f / \text{rank}_f^k$

Quality The measurement of quality is a major challenge. Various approaches are available but some of them cannot be implemented here. We cannot directly use unit values (the ratio of the value to the quantity sold) as a higher price does not necessarily reflect higher product quality. In our case, higher prices can be induced by a higher horizontal product differentiation (lower σ^k), a lower productivity (φ^k), or a higher unit cost (ω_i^k), even though product quality is lower. Furthermore, we cannot rely on input prices at the firm level as in Bastos et al. (2018b). Indeed, we need to infer quality at the firm-product level while our dataset does not report the list of inputs used for each variety supplied by firms. Because information on both price

[21] Data limitations – especially regarding the inputs used in production – make it difficult to compute total factor productivity. Nevertheless, total factor productivity and productivity computed as sales per worker or as value added per worker are strongly correlated.

[22] This assumption does not necessarily imply that the rank 1 is characterized by the lowest marginal cost (as in Eckel et al., 2016; Manova and Yu, 2017) because the firm's core product can be the variety with the highest quality and, in turn, with the highest marginal cost.

and quantity is available, we therefore focus on the approach usually used in the literature and relying on demand equations (Khandelwal, 2010; Khandelwal et al., 2013).[23] For a given price in a firm-product-destination triplet, a variety with higher sales is assigned a higher quality.

Using (2), quality at the firm-product-destination level can be estimated relying on the following OLS regression:

$$\ln q^k_{fj} + \sigma^k \ln p^k_{fj} = \alpha^k_j + \alpha^k_f + \varepsilon^k_{fj} \tag{16}$$

where q^k_{fj} represents the volume of exports of product k by firm f to destination j and p^k_{fj} the price of exports (proxied by the unit values). For the elasticity of substitution σ^k, we rely on the elasticities reported by Broda et al. (2006). Imposing these elasticities of substitution across products allows us to avoid having to estimate demand for each good before inferring quality. The fixed effects α^k_j capture destination j's expenditures and price index for product k ($\ln(A^k_j)$) and are common to all exporters producing the same product and serving the same destination country. Hence, given (2), $\ln(\lambda^k_{fj})^{\sigma^k-1} = \alpha^k_f + \varepsilon^k_{fj}$ where the term α^k_f represents a firm-product fixed effect that captures the quality perceived that is specific to each firm-product pair and is common across destinations, while the term ε^k_{fj} is a deviation across foreign countries. The latter term plays the role of the estimation error. Hence, we define the estimated quality as $\ln \widehat{\lambda}^k_{fj} = (\widehat{\alpha}^k_f + \widehat{\varepsilon}^k_{fj})/(\sigma^k - 1) \equiv \zeta^k_{fj}$. Conditional on price, a variety with a higher quantity is assigned higher quality. This quality measure defined at the firm-product-destination level will be further used in our empirical analysis for the intensive trade margin (volume and value of exports to a certain product-destination market).

Unfortunately, the methodology proposed by Khandelwal (2010) and Khandelwal et al. (2013) does not allow us to infer the latent quality of products which are not exported (because we do not know the latent demand). However, we need this information to evaluate the role of quality at the extensive margin (the probability of serving a foreign country). As a result, we consider the quality at the firm-product level which is captured by the firm-product fixed effects and compute the quality as $\ln \widehat{\lambda}^k_f = \widehat{\alpha}^k_f/(\sigma^k - 1) \equiv \zeta^k_f$ when we analyze the extensive margin.

In the empirical analysis, the quality and productivity measures are further interacted with

[23] For non-signaling firms, this approach may not be the most appropriate since consumers cannot observe precisely their quality. However in our sample, we cannot explicitly disentangle signaling and non-signaling firms. Furthermore, quality measures based on supply side appear to be highly correlated with those inferred using demand equations (Disdier et al., 2018).

the number of QSs to study the impact of such standards across firms with different quality and productivity levels. We also normalize our quality measures.

4 Econometric analysis and results at the firm level

This section empirically tests for the theoretical predictions reported in Proposition 1 on the impact of QSs on the extensive and intensive export margins according to the characteristics of the firms.

4.1 Extensive margin

Econometric specification. We explore the impact of QSs on the presence of a firm in a given product-destination market.[24] Our dependent variable (y_{fj}^k) is the probability that firm f exports product k to destination j. Our counterfactual scenario considers the firms that do not export in the same product-destination pair kj. We estimate this export equation using a linear probability model and control for unobservable characteristics at the firm, product and destination levels using different sets of fixed effects. The linear probability model avoids the incidental parameter problem affecting the probit model. The estimated equation is as follows:

$$\begin{aligned} y_{fj}^k &= \beta_1 QS_j^k \times \varphi_1 \times \zeta_1 + \beta_2 QS_j^k \times \varphi_1 \times \zeta_2 + \beta_3 QS_j^k \times \varphi_1 \times \zeta_3 \\ &+ \beta_4 QS_j^k \times \varphi_2 \times \zeta_1 + \beta_5 QS_j^k \times \varphi_2 \times \zeta_2 + \beta_6 QS_j^k \times \varphi_2 \times \zeta_3 \\ &+ \text{controls}_j^k + \text{controls}_{fj}^k + \text{FE}_f^k + \text{FE}_{fj} + \varepsilon_{fj}^k, \end{aligned} \tag{17}$$

where QS_j^k is the number of QSs (SPS and TBT measures) applied to product k by destination country j.

To account adequately for the fact that high-productivity high-quality firms may disclose information about the quality of their products to foreign consumers, we distinguish firms according to their productivity and quality. More precisely, we define φ_1 (resp. φ_2) a dummy set to 1 if the firm-product's productivity is below (resp. above) the median productivity observed in our sample (0 otherwise). Similarly, we consider three dummies (ζ_1, ζ_2 and ζ_3) respectively equal to 1 if the firm-product's quality is in the lower quartile, in the middle range or in the upper quartile of quality (0 otherwise). These dummies are then interacted with QSs. We can

[24] When using cross-section data, one cannot test for the entry/exit of firms.

thus investigate the impact of QSs for six different types of firms (low- vs. high-productivity and low- vs. medium- vs. high- quality firms).

According to Proposition 1, we expect that β_1, β_2, and β_3 to be negative, and β_4, β_5, and β_6 to be positive. Besides, we implicitly assume that firms with higher (resp. lower) than median productivity invest (resp. do not invest) in quality signaling. Consequently, if high-productivity firms disclose, then our model predicts that the profits associated with a destination increase with product quality so that we expect $\beta_6 > \beta_5 > \beta_4 > 0$. By contrast, the profit of low-productivity firms should decrease with the quality of their product as consumers cannot identify product quality. Hence, low-productivity high-quality firms should be more negatively impacted by the presence of QSs than low-productivity firms selling products with a medium quality ($0 > \beta_2 > \beta_3$).

Equation (17) includes additional explanatory variables. The product-destination controls (controls_j^k) consist in the number of other import-related NTMs and the protection applied (in logs) on product k by destination j, as well as the maximum price observed for product k on market j such that the profit of firm f for that price and a minimum quality level is equal to zero. This maximum price is however likely to be endogenous. In the estimations, we therefore rely on the imports defined at the product-destination level to proxy the demand of a product-destination pair. Finally, controls_{fj}^k account for some hysteresis effect in the trade flows by examining whether firm f was already exporting product k to destination j in the previous year (e.g. in 2010 in our case, since the cross-section analysis is done using 2011 trade data).[25]

Fixed effects are incorporated in the estimation to capture unobservable characteristics at the firm, product and destination levels. Consistent with the theoretical model, we use the firm-product pair as the basic unit of our analysis. We therefore include firm-product fixed effects (FE_f^k). With this specification, we absorb any firm-product-specific factors (e.g. productivity or quality). We include a separate firm-destination fixed effect (FE_{fj}) to control for any firm-destination heterogeneity.[26] Finally, ε_{fj}^k is the error term. In addition, we account for the correlation of errors by clustering at the product-destination level. Furthermore, our estimations retain only groups with more than one observation. As shown by Correia (2015),

[25]The cross-section analysis is affected by the restriction on QS and other import-related NTM data (see Section 3.1). However, French customs data are available for several years. Therefore, we can easily identify whether a firm was already serving a product-destination in previous years.

[26]These firm-destination fixed effects also control for any characteristic specific to each destination, and for instance for the fact that the demand for quality is on average higher in developed countries. They therefore capture a significant part of the potential correlation between the QSs imposed by destination countries and other aspects of these destination markets.

the inclusion of single groups in linear regressions where fixed effects are nested within clusters might lead to incorrect inferences. Therefore, the number of observations differs across estimations.[27]

Results. Table 1 presents the estimation results. Two different measures are used for the computation of the productivity at the firm level: sales per employee (column 1) and value added per employee (column 2). Results clearly show that QSs have a negative and significant impact on the export participation of low-productivity firms, whatever the quality level of their product. Indeed, the coefficient estimates on the first three interactions (e.g. with a productivity level below the median) are all negative and significant. By contrast, firms with a productivity level above the median benefit from the presence of QSs.

Regarding the other explanatory variables, we document a negative but not significant effect of the other import-related measures on the export participation of French firms. As expected, the higher the tariffs are for a product in a given destination, the lower the export participation of French firms. Besides, the higher the demand is for a product in a given destination (proxied through imports), the higher the presence of French exporters. Finally, the past presence of a firm in a product-destination pair significantly and drastically increases export participation.

Insert Table 1 here

4.2 Intensive margin

Econometric specification. We now consider the intensive margin of trade and investigate the effect of QSs on the export volume and value of a firm for a given product-destination market. According to the results associated with the extensive margin, we have to consider two types of firms with respect to their productivity. Low-productivity firms do not seem to disclose information on the quality of their product while high-productivity firms act as if they invest in quality signaling. We therefore expect that the export sales of high-productivity (resp. low-productivity) firms increase (resp. decrease) with quality (see Proposition 1). As a result,

[27] The Stata package REGHDFE is used for the estimations (Correia, 2014). The inclusion of single groups in the estimations leads to similar results (available from the authors upon request). Since our quality and productivity measures at the firm-product level are estimated, standard errors should be ideally estimated using bootstrapping. However, the size of our sample prevents us using this approach.

we estimate the following specification:

$$\begin{aligned} \ln r_{fj}^{k} &= \delta_1 QS_j^k \times \varphi_1 \times \zeta_1 + \delta_2 QS_j^k \times \varphi_1 \times \zeta_2 + \delta_3 QS_j^k \times \varphi_2 \times \zeta_1 + \delta_4 QS_j^k \times \varphi_2 \times \zeta_2 \\ &\quad + \text{controls}_j^k + \text{controls}_{fj}^k + \text{FE}_f^k + \text{FE}_{fj} + \varepsilon_{fj}^k, \end{aligned} \tag{18}$$

where r_{fj}^{k} denotes exports (logs) either in value or in volume of product k by firm f to destination country j. As previously described, QS_j^k is the number of standards applied by destination country j on product k. The variable φ_1 (resp. ζ_1) is a dummy set to 1 if the firm-product's productivity (resp. quality) is below the median value and φ_2 (resp. ζ_2) is a dummy equal to 1 if the firm-product's productivity (resp. quality) is above the median value. We expect that $\delta_2 < \delta_1 < 0$ and $\delta_4 > \delta_3 > 0$.

The controls included in equation (18) at the product-destination and firm-product-destination levels are almost the same as those used for the estimation of the extensive trade margin. One exception is the quality defined here at the firm-product-destination level and which is now part of the controls.[28] Finally, ε_{fj}^{k} is the error term, and errors are clustered at the product-destination level.

Results. Table 2 reports results by groups of firms, depending on their productivity and quality levels. Columns 1 and 3 describe the effect of QSs on firms' export volume, while columns 2 and 4 show the impact on the export value. Sales per employee (columns 1 and 2) and value added per employee (columns 3 and 4) are alternatively used for the computation of firm's productivity. In line with our theoretical predictions, the sales (in volume and value) of low-productivity incumbents are negatively impacted by QSs, while high-productivity firms benefit from QSs, in particular if they provide high-quality products. The high-productivity high-quality firms seem to disclose information on quality in the foreign markets and enjoy higher exports when the number of QS increases.

The estimated coefficient on the quality variable is positive and significant when the value of exports is considered (columns 2 and 4) but not significant if one focuses on the volume of exports (columns 1 and 3). This result can be easily explained. A high-quality firm usually sells its products at a higher price, which raises its exports in value, but does not necessarily sell more products (no impact on the export volume).

[28] At the extensive margin, the quality is computed at the firm-product level and therefore absorbed by the firm-product fixed effects.

Finally, other import-related NTMs do not have a significant influence on the export volume and value. Tariffs negatively impact the export sales of firms (both in volume and value), while the demand in the destination for a given product and the past presence of a firm with product k in market j positively influence its current exports (both in volume and value terms).

Insert Table 2 here

4.3 Robustness checks

We proceed to a series of sensitivity tests to confirm the robustness of our results.

We investigate whether our results at the extensive margin of trade are sensitive to the quality computation. As previously discussed, our quality variable at the extensive margin is defined at the firm-product level. In section 3.2 (equation 16), quality was defined using the firm-product fixed effects (e.g. $\ln \widehat{\lambda}_f^k = \widehat{\alpha}_f^k/(\sigma - 1)$). As an alternative measure, we rely on the residuals ($\widehat{\varepsilon}_{fj}^k$). We first average them over all destinations for each firm-product pair and then compute quality as $\sum_j \ln \widehat{\lambda}_{fj}^k / n_j$ where $\ln \widehat{\lambda}_{fj}^k = (\widehat{\alpha}_f^k + \widehat{\varepsilon}_{fj}^k)/(\sigma^k - 1)$ and n_j is the number of destinations served by each firm-product pair. The correlation between the two measures is almost 1. Results of the estimations based on this alternative quality measure (available upon request) are very similar to those reported in Table 1, suggesting that our estimates at the extensive margin are not affected by the method used for the computation of the quality.

Furthermore, we test for the validity of our main results using alternative specifications. We present the results in Table A5 (extensive margin), Table A6 (intensive margin, export volume), and Table A7 (intensive margin, export value) in the Appendix.[29]

First, firm's productivity and quality may differ across products. To account for this heterogeneity, we define bins for productivity and quality for each HS6 product separately, instead of pooling all products together (column 1). Second, we select the maximum price of a product in a given destination to proxy the demand of a product-destination pair instead of using imports (column 2). The use of the maximum price is driven by the theoretical model, but unfortunately, is likely to be endogenous. In column 3, we cluster our standard errors at the firm level. In column 4, we use an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level (see footnote 14 in the data section). We then test the robustness of our previous conclusions, relying only on SPS measures (column 5). Indeed,

[29] We also performed estimations relying on value added per worker for the computation of the productivity at the firm level. Our results are robust to this alternative measure and available upon request.

some of the TBTs do not necessarily affect the quality of products (e.g. some labels). Finally, column 6 includes the number of French firms exporting to a given product-destination pair. Some of the differences in the results may be explained by the market structure. In the model, there is a continuum of firms, so firms do not take into account other firms' behavior. However in a market with few firms, strategic behavior may be important, and in particular, responses to QSs may be very different.

The results are very much in line with those obtained in the baseline estimations, suggesting that the previous results are robust. One notable exception should be mentioned. In the estimations for export volume (Table A6), the higher the demand (proxied through maximum price) is for a product-destination pair, the lower the export volume (column 1). This counterintuitive result confirms the potential endogeneity of the maximum price and validates its replacement by imports (in logs) computed at the product-destination level in all other estimations. Interestingly, the estimated coefficients are stronger when we use an alternative count for QSs and when we consider only SPS measures (columns 3 and 4). Lastly, clustering at the firm level (column 2) or controlling for the number of French exporters (column 5) do not affect our results.

5 Impact of QSs on aggregate exports and average quality

We now investigate the impact of QSs on aggregate French exports and on the average quality of products exported by French firms to the different markets. As in section 4, we consider the French exports to the 53 non-EU countries included in our sample.

5.1 Aggregate exports

To simulate the impact of QSs on aggregate exports, we consider a slight variation in the number of QSs faced by French firms when exporting abroad. More precisely, we proceed as follows: To account for the heterogeneity in imposing standards across destinations, we first classify the current number of QSs enforced by destinations j on product k into quartiles. We then set the number of QSs on product k to the maximum number observed across all destinations j in a given quartile.

The motivation for this exercise is as follows. If the number of QSs affecting product k increases to the highest level observed across all destinations in a quartile, firms have to comply with additional and potentially different standards when exporting. Their compliance costs increase, and their exports are likely to be affected. By contrast, QSs may also address market failures, reduce the information asymmetry between consumers and producers, rise demand and thus boost firms' exports. The net effect depends on the type of firms. The high-productivity high-quality firms are better-off while low-productivity firms are worse-off when the number of QSs increases. With our simulation exercise, we derive order of magnitude predictions regarding exports. We also consider the expected changes at the extensive and intensive margins.

Methodology Total bilateral exports of French firms can be expressed as $R_j^k = N_j^k \bar{r}_j^k$ where N_j^k is the total number of firm-product pairs exporting to j and $\bar{r}_j^k$ the average value of exports. Thus, the expected change in the value of exports in a product-destination pair can be written as follows $\Delta R_j^k = \widehat{N}_j^k \widehat{\bar{r}}_j^k - N_j^k \bar{r}_j^k$ where $\widehat{N}_j^k$ and $\widehat{\bar{r}}_j^k$ represent the expected number of exporters and average exports respectively, when the number of QSs affecting product k increases to the highest level observed across all destinations in a quartile ($QS_j^k = QS^k_{\max \text{ Q1-Q4}}$). ΔR_j^k can be further decomposed as follows $\Delta R_j^k = \widehat{N}_j^k \Delta \bar{r}_j^k + \bar{r}_j^k \Delta N_j^k$, where $\Delta \bar{r}_j^k \equiv \widehat{\bar{r}}_j^k - \bar{r}_j^k$ is the expected change in the average exports (intensive margin) and $\Delta N_j^k \equiv \widehat{N}_j^k - N_j^k$ is the expected change in the number of exporters (extensive margin). To implement this counterfactual analysis, we use the results associated with the estimation of two equations: the export values for a firm-product-destination triplet r_{fj}^k in order to compute the average exports at the product-destination level $\bar{r}_j^k$ and the number of exporters in a destination-product pair N_j^k.

Export values We estimate the following equation.

$$\begin{aligned} \ln r_{fj}^k &= \gamma_1 QS_j^k + \gamma_2 QS_j^k \times \varphi_f^k + \gamma_3 QS_j^k \times \zeta_{fj}^k + \gamma_4 QS_j^k \times \varphi_f^k \times \zeta_{fj}^k \\ &\quad + \text{controls}_j^k + \text{controls}_{fj}^k + \text{FE}_f^k + \text{FE}_{fj} + \varepsilon_{fj}^k, \end{aligned} \tag{19}$$

The controls at the product-destination and at the firm-product-destination levels are similar to those included in (18). The results are presented in Table A8 in the Appendix.[30] Relying on our estimation results, if all export destinations served by French firms adopted the maximum

[30] Results confirm that the effect of QSs on export sales can be positive for the more efficient firms as $\hat{\gamma}_2 = 0$ and $\hat{\gamma}_4 > 0$ so that $\frac{\partial^2 r_{fj}^k}{\partial QS_j^k \partial \varphi_f^k > 0}$. Furthermore, we find that the effect of QSs on export sales with respect to quality depends also on firm's productivity. Since $\hat{\gamma}_3 < 0$ and $\hat{\gamma}_4 > 0$, $\frac{\partial^2 r_{fj}^k}{\partial QS_j^k \partial \zeta_f^k} = \hat{\gamma}_3 + \hat{\gamma}_4 \times \varphi_f^k$ is negative for the less productive firms and positive for the more productive ones.

number of QSs observed for a product in a quartile ($QS^k_{\text{max Q1-Q4}}$), the expected change in export values for a given firm-product-destination triplet can be computed as follows:

$$\Delta r^k_{fj} = \left[e^{(\widehat{\gamma}_1 + \widehat{\gamma}_2 \times \varphi^k_f + \widehat{\gamma}_3 \times \zeta^k_{fj} + \widehat{\gamma}_4 \times \varphi^k_f \times \zeta^k_{fj})(QS^k_{\max} - QS^k_j)} - 1 \right] r^k_{fj} \tag{20}$$

Using (19) and (20), we identify losing (resp., winning) firms as firms encountering a decrease (resp., an increase) in their exports when the number of QSs for product k is set to the maximum number observed across all destinations j in a quartile compared to their exports with the actual number of QSs, *e.g.* $\sum_j \sum_k \Delta r^k_{fj} < 0$ (resp., $\sum_j \sum_k \Delta r^k_{fj} > 0$).[31] It follows that 57.5% of French exporters would suffer from this change and the overall exports of a losing firm to non-EU countries would decrease on average by 0.14% (513 euros). By contrast, 42.5% of firms would benefit from this rise in the number of QSs and the aggregate exports of a winning firm to non-EU markets would increase on average by 4.6% (106,302 euros). Figure 3 draws the bivariate distribution of productivity and quality for losing and winning firms.[32] Winning firms are more productive and provide higher quality products, as expected.

Insert Figure 3 here

Number of exporters We now estimate the following equation[33]

$$\ln N^k_j = \mu QS^k_j + \text{controls}^k_j + \text{FE}_j + \text{FE}_k + \varepsilon^k_j, \tag{21}$$

The results are reported in Table A9 in the Appendix and suggest an overall negative effect of QSs on the number of firms. One additional QS involves a decrease in the number of firms in a product-destination pair by 4 percentage points. If all destinations served by French firms adopted the maximum number of QSs observed for a product in a quartile ($QS^k_{\text{max Q1-Q4}}$), the expected change in the number of firm-product-destination triplets would equal $\sum_j \sum_k [e^{\widehat{\mu}(QS^k_{\max} - QS^k_j)} - 1]N^k_j = -1,071$ (*e.g.* -0.4%).

[31]The overall exports of a firm (with the actual vs. maximum number of QSs in a quartile) are computed by summing the predicted vs. simulated export values across all product-destination pairs served by the firm. Quantifications rely on results obtained when firm's productivity is computed using the sales per employee (e.g. column 1 of Table A8).

[32]Continuous measures of productivity and quality at the firm-level are obtained as follows: for productivity, we compute the mean across all products for a given firm; For quality, we compute the mean across all products and destinations for a given firm

[33]Our controls at the product-destination level include the number of other import-related NTMs, the applied protection applied and imports, as well as the average productivity and the average quality. These measures are computed as the mean of $productivity^k_f$ and $quality^k_{fj}$ across all firms f within a product-destination pair kj, respectively.

The expected change in aggregate exports. The expected change in overall French exports is then given by $\Delta R = \sum_j \sum_k \Delta R_j^k$ and the contribution of the intensive (resp., extensive) margin is equal to $\sum_j \sum_k \tilde{N}_j^k \Delta \bar{r}_{ij}^k$ (resp., $\sum_j \sum_k \bar{r}_{ij}^k \Delta N_j^k$). According to our estimations, if the number of QSs for product k is set to the maximum number observed across all destinations j in a quartile ($QS^k_{\text{max Q1-Q4}}$), then $\Delta R = 1.5$ billions euros. Our counterfactual analysis also suggests that QSs yield a positive effect on the intensive margin (1.7 billions euros) and negative effect on the extensive margin (0.2 billion euros).

How can we explain these large export gains and reconcile them with the potential negative impact of QSs on flows largely emphasized in the trade literature? First, our results confirm that QSs reduce the number of exporters. The difference arises from the intensive margin. Second, we focus on French exports. French firms must comply with European QSs – which are among the most restrictive in the world – on their domestic market and therefore often already satisfy the requirements imposed by non-EU destinations. Thus, foreign QSs do not necessarily increase firms' compliance costs but may boost French exports by correcting some market failures. Third, our analysis is conducted at the firm level. A large strand of the trade literature of QSs deals with bilateral flows between countries and does not consider firm-level exports. One exception is Fontagné and Orefice (2018), but the authors consider a specific group of standards, which are shown to be very trade restrictive (e.g. standards related to a WTO trade concern). By using firm-level data and all QSs, we are able to capture the reallocation effects within firms across product-destination pairs, as well as among firms. Our results suggest that some firms may loose from the implementation of QSs in certain product-destination pairs and gain in others. Furthermore, some QSs are likely to address market failures and boost the exports. This result can be observed if one consider all QSs and not just the most stringent ones as in Fontagné and Orefice (2018). Fourth, our sample focuses on exports of French firms to 53 countries located outside the EU. Because of the mutual recognition on QSs within the EU, we excluded EU countries from our sample of destinations. As a consequence, our sample mainly includes large firms exporting several products to many destinations. 38.8% of the firms in our sample are multi-product and multi-destination firms. These firms are able to more than compensate losses on one market by gains on other markets and overall gains are positive.

5.2 Average quality

We now test for the theoretical predictions reported in Proposition 2 and investigate the impact of QSs on the average quality of products exported by French firms to the different markets. We first present the computation of this average quality and the estimated equation. The results are then reported and discussed.

Evaluating average quality at the country pair-product level We use tools-based demand equations to infer the average quality of the traded products at the country pair-product level (Khandelwal, 2010; Khandelwal et al., 2013). More precisely, to evaluate the average quality of products originating from country i and perceived by the consumers in country j ($\bar{\lambda}_{ij}^k$), we use a macro-level bilateral trade equation. Bilateral country-level trade and unit value data provide information on the volume Q_{ij}^k and import unit values $\overline{P}_{ij}^k$ (which include all trade costs except tariffs). Note that the unit value is $\overline{P}_{ij}^k = R_{ij}^k / Q_{ij}^k$ where R_{ij}^k is the total value of exports. Because $R_{ij}^k = N_{ij}^k \overline{r}_{ij}^k$ where N_{ij}^k is the total number of firm-product pairs in country i exporting to j and $\overline{r}_{ij}^k$ the average value of exports, we have $Q_{ij}^k / N_{ij}^k = \overline{r}_{ij}^k / \overline{P}_{ij}^k$ with

$$\overline{r}_{ij}^k = \left(\bar{\lambda}_{ij}^k\right)^{\sigma^k - 1} A_j^k \left(\overline{P}_{ij}^k T_{ij}^k\right)^{1-\sigma^k}. \tag{22}$$

where T_{ij}^k represents the applied protection set by country j on its imports of product k from country i.[34] Equation (22) allows us to infer an index of average quality by adapting the strategy used in Khandelwal et al. (2013). Conditional on the average price of these varieties, higher overall demand (i.e. quantity) for the product in question occurs because of higher average quality. However, consumers could also value varieties differently according to their geographical origin (e.g. consumers could prefer products imported from countries sharing common cultural characteristics). Therefore, we control for whether trading partners share a common language (CL_{ij}), a common border (CB_{ij}), or past colonial ties (CT_{ij}). Hence, the quality perceived by the consumers in each destination j for product k originating from country i and adjusted by the number of exporters $N_{ij}^k \left(\bar{\lambda}_{ij}^k\right)^{\sigma^k - 1}$ can be estimated as the residual of the following regression:

$$\ln(Q_{ij}^k / N_{ij}^k) + \sigma^k \ln\left(\overline{P}_{ij}^k T_{ij}^k\right) = \alpha_i^k + \alpha_j^k + \rho_1 CL_{ij} + \rho_2 CB_{ij} + \rho_3 CT_{ij} + \epsilon_{ij}^k, \tag{23}$$

[34] We implicitly assume that the average value of quality-adjusted prices $p_{ij}^k / \lambda_{ij}^k$ is equal to the average price $\overline{P}_{ij}^k$ divided by the average quality ($\bar{\lambda}_{ij}^k$).

where $\epsilon_{ij}^k = (\sigma^k - 1)\ln(\bar{\lambda}_{ij}^k)$ and $\alpha_j^k = A_j^k$. Thus, the average quality perceived by the foreign consumers can be expressed as $\ln(\widehat{\lambda}_{ij}^k) = \epsilon_{ij}^k/(\sigma^k - 1)$.

Equation (23) is estimated by merging five different data sources. First, $\overline{P}_{ij}^k$ are proxied using the Trade Unit Values database provided by the CEPII. We consider the HS 6-digit import unit values for the year 2011 and select all the importing countries for which QS data are available and their trading partners. These data are then combined with HS 6-digit bilateral trade data for the year 2011 (Q_{ij}^k), which are extracted from the CEPII BACI database. Since we consider all trading partners and not just France, we cannot use French customs data. Data on import-demand elasticities (σ^k) come from Broda et al. (2006), while tariff data are extracted from the Market Access Map (MAcMap) database. Besides, information on common language, contiguity and past colonial ties is obtained from the CEPII GeoDist database.[35] FE_i^k and FE_j^k stands for both origin country-product and destination country-product fixed effects. Some countries are unfortunately missing in the trade elasticities data, and our final sample is restricted to 25 countries (instead of 53).[36]

Finally, we compute the average quality of each HS6 product exported by France to each destination. To do so, we keep from the estimation of equation (23), the $\widehat{\lambda}_{ij}^k$, where France is the exporting country. Relying on French Customs data, we compute the number of firms in each product-destination pair. Finally, using $\epsilon_{ij}^k = \ln N_{ij}^k + (\sigma^k - 1)\ln(\bar{\lambda}_{ij}^k)^{\beta_j^k}$, we derive $\ln \widehat{(\bar{\theta}_{ij}^k)^{\beta_j^k}}$, i.e. the average quality of each product k exported by France to each destination j.

Econometric specification and results To study the effect of QSs on the average quality, we estimate the following equation

$$\ln \widehat{\bar{\lambda}_{ij}^k} = \gamma QS_j^k + \text{controls}_j^k + \text{FE}^k + \text{FE}_j + \epsilon_j^k, \tag{24}$$

where $\bar{\theta}_{ij}^k$ is the average quality perceived by consumers in each destination j for product k originating from France (see above). We regress this average quality on the number of QSs enforced by destination j on product k. The estimation also controls for the number of other

[35]Data on import unit values rely on importers' declarations and include all trade costs (except tariffs and domestic taxes after the border); Source: http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=2. Baci database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=1. MacMap database: see section 3.1. Trade elasticities: http://www.columbia.edu/~dew35/TradeElasticities/TradeElasticities.html; These elasticities are computed at the 3-digit level using HS 6-digit import data from the COMTRADE database for the years 1994-2003. GeoDist database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6.

[36]Note that our previous results at the extensive and intensive margins of trade remain valid when we restrict our sample to these 25 countries.

import-related NTMs and includes product and destination fixed effects (FE^k and FE_j). ϵ_j^k is the error term.

Table 3 presents the empirical results. According to the theoretical model, QSs have an ambiguous effect on the average quality of exported products, due to the exit of low-quality firms (regardless of their productivity) as well as of high-quality (but low-productivity) firms. Therefore, we do not have any prior regarding the conclusion of the empirical test.

Column 1 includes all products. We then decompose the effects between consumption versus capital/intermediate goods (column 2). The identification of the different classes of goods is based on the Broad Economic Categories (BEC) classification. In our estimations, we interact the number of QSs with two dummies set to 1 for consumption and capital/intermediate goods (0 otherwise). In column 3, the effect of QSs on the average quality is investigated for different sectors: food products (HS 01-24 sectors), manufacturing without textiles (HS 25-97 sectors, except HS 50-67), and textiles (HS 50-67 sectors). We treat textiles separately because this sector includes a large number of consumption goods. Finally, column 4 includes the third interaction terms and breaks up the effect of QSs by classes of goods and sectors. In column 1, our findings suggest that the larger the number of QSs is, the higher the average quality of exported products. This result is however not statistically significant. The other results show that QSs significantly improve the average quality of consumption goods and of food & beverages and textile products, while a non-significant effect is obtained for capital/intermediate goods and manufactured (without textiles) products (columns 2 and 3). Column 4 highlights that the positive effect of QSs on average quality is concentrated in food and beverages used for consumption, as well as in textile products used for consumption.[37] In all other cases, the effect is almost not significant or not significant at all. If we quantify the elasticity of the average quality of the exported products with respect to the number of QSs by multiplying the estimated coefficient γ_1 (column 4) by the average number of QSs enforced by the destinations, we obtain an effect of 1.24 for food and beverage products used for consumption and of 0.44 for textile products used for consumption.[38]

Furthermore, we obtain positive and significant estimated coefficients for the other import-related measures. The mechanism at play is however different from the one previously highlighted for QSs. Other NTMs do not reduce information asymmetries with respect to the qual-

[37] Our results confirm empirical results from European food data showing that the enforcement of QSs boosts product quality upgrading (Olper et al., 2014; Curzi et al., 2015).

[38] For comparison, the elasticity of the average quality of exported products to a change in the number of the other NTMs is 1.37*0.193=0.26.

ity of the incumbent firms staying in the market. The NTMs increase variable trade costs and therefore induce some selection effects among French exporters. As a result, the average quality of exported products is expected to increase with respect to this variable.

Insert Table 3 here

6 Conclusion

This paper studies the effects of QSs enforced by destination countries on the exports of firms (extensive and intensive margins) according to the productivity and quality of their varieties, as well as on aggregate exports and the average quality of exported products. First, we develop a theoretical model based on monopolistic competition, where firms are heterogeneous in terms of their productivity and the quality of their products. We assume information asymmetry regarding product quality. While consumers only observe the average quality available on the market, producers know exactly the quality of their product and can undertake costly signaling activity. Under this setting, the enforcement of a QS by a policy maker to correct for market failures leads to the exit of low-quality firms that are not able to satisfy the requirements, regardless of their productivity. By contrast, high-productivity firms selling high-quality products can profitably disclose information about their quality and therefore exhibit a high export probability and large export sales.

Second, we test for the predictions of our model, relying on French firm export data. We find that QSs in the destination country increase the export probability and export sales of high-quality French exporters provided that their productivity is high enough (e.g. above the median productivity). Considering exporters with a lower than median productivity, their sales decrease with the quality of their products. QSs also increase the average quality of food and beverage products as well as that of textile products used for consumption.

From a policy perspective, this paper suggests that the enforcement of QSs leads to a rise in average quality of traded products and the exit of less productive firms. By contrast, high quality high-productivity exporters may benefit from QSs. All in all, QSs do not necessarily act as pure trade barriers, and by correcting market failures, they may contribute to raise exports of countries hosting competitive firms.

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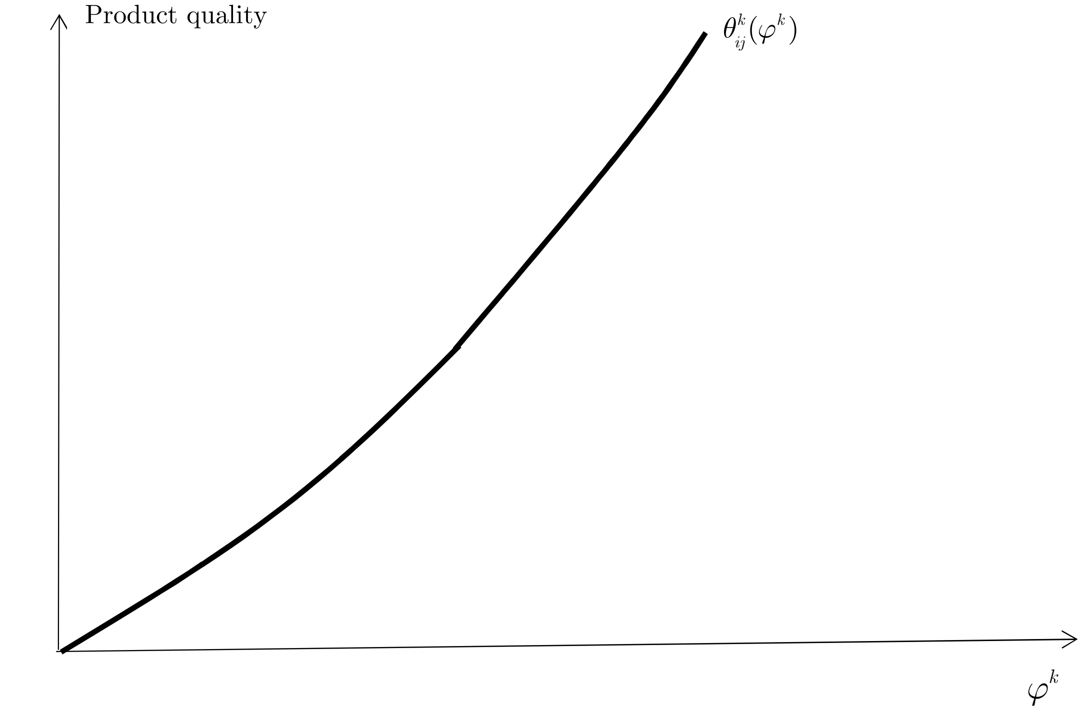
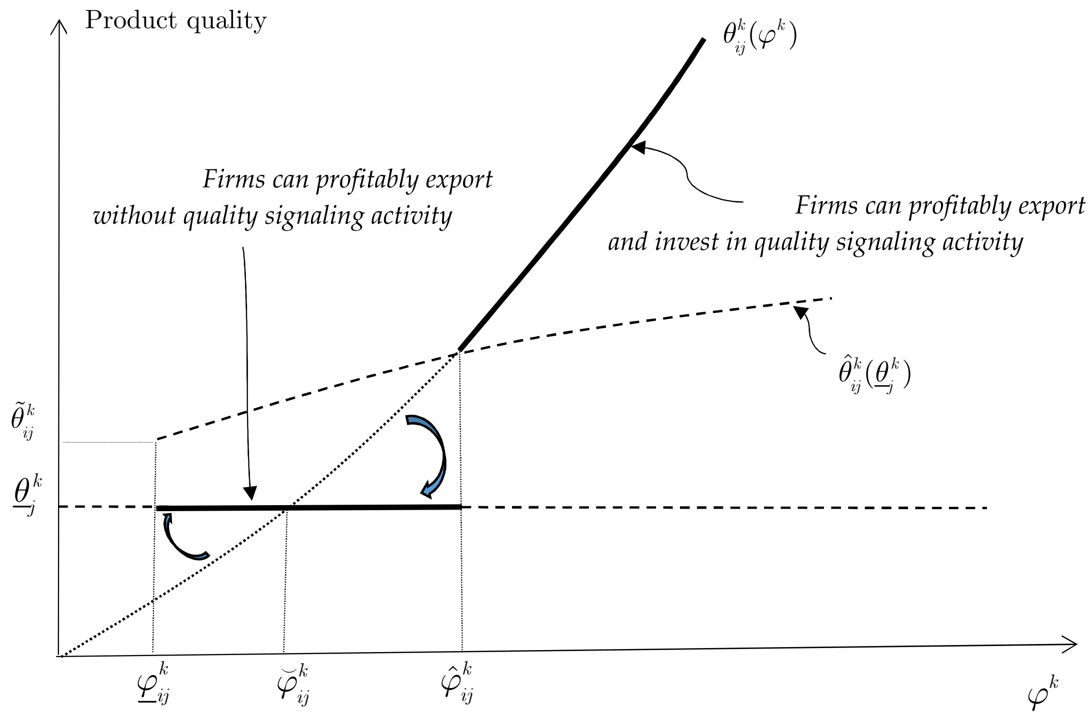
Figure 1: Information asymmetry, QS, and firms' decisions

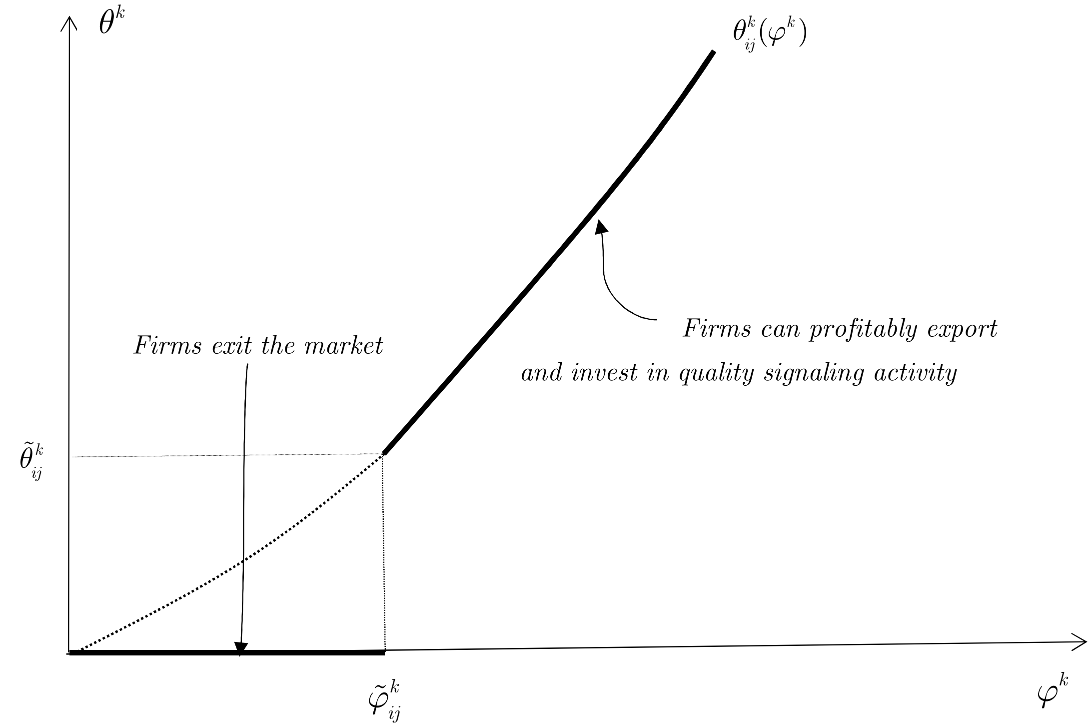


(a) no information asymmetry

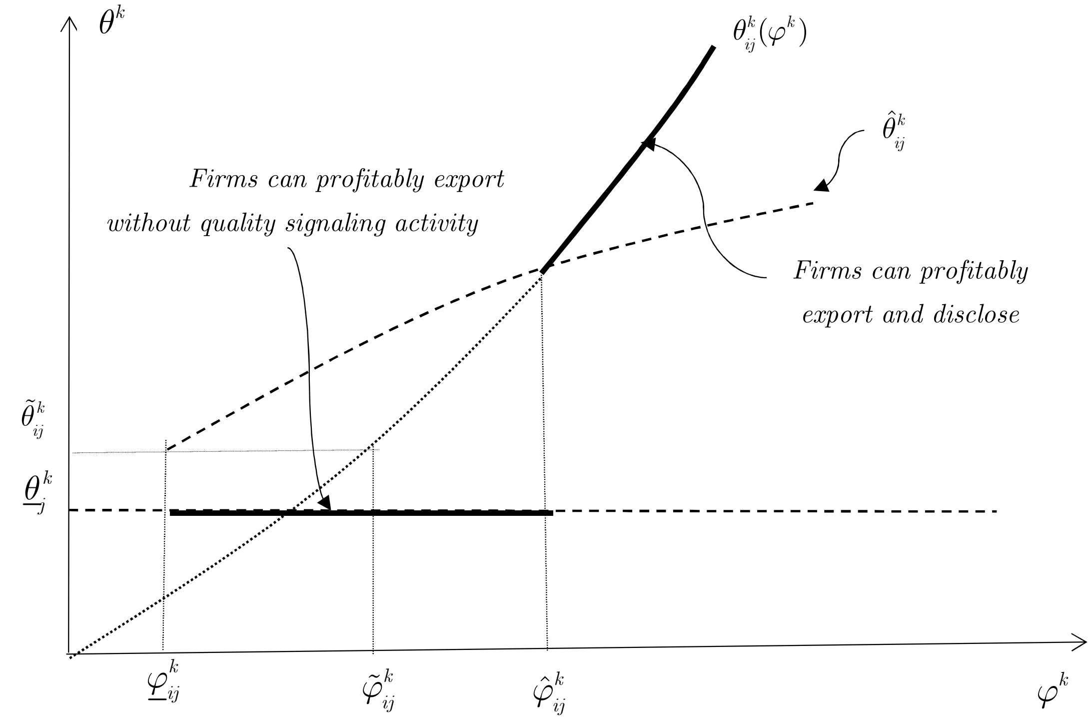


(b) With information asymmetry

Figure 2: Impact of QS under information asymmetry



(a) No standard



(b) Introduction of quality standard

Figure 3: Bivariate distribution of productivity and quality for losing and winning firms

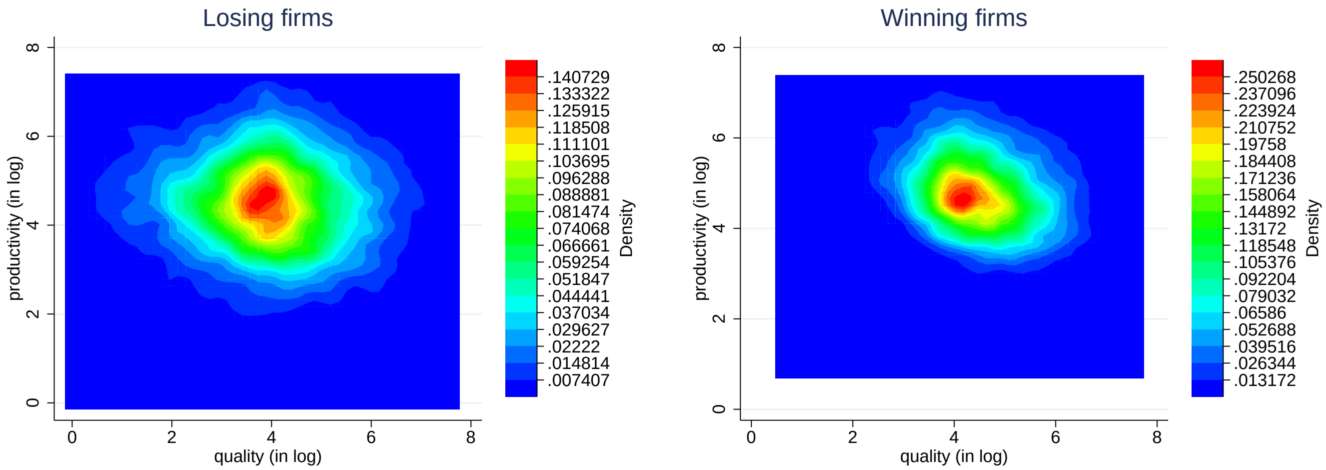


Table 1: Extensive margin: Export participation, by type of firms

Productivity measure	Export participation Sales per employee	Value added per employee
	(1)	(2)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ bottom 25%	-0.0010^a	-0.0008^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ middle range	-0.0012^a	-0.0011^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ top 25%	-0.0016^a	-0.0015^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ bottom 25%	0.0013^a	0.0012^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ middle range	0.0015^a	0.0015^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ top 25%	0.0011^a	0.0010^a
	(0.0001)	(0.0001)
Nb. other import-related $NTMs_j^k$	-0.0002	-0.0003
	(0.0002)	(0.0002)
Ln applied $protection_j^k$	-0.0044^a	-0.0044^a
	(0.0016)	(0.0016)
Ln $imports_f^k$	0.0011^a	0.0011^a
	(0.0001)	(0.0001)
Firm already present in $t\text{-}1_{fj}^k$	0.4158^a	0.4149^a
	(0.0017)	(0.0017)
Observations	6,034,342	5,898,748
Adjusted R^2	0.466	0.465
Fixed effects:		
Firm-$Product_{fk}$ & Firm-$Destination_{fj}$	Yes	Yes

Note: The dependent variable is the probability that firm f exports product k to destination j in 2011. The number of QSs is the sum of SPS and TBT measures enforced on product k by destination j. See the text for the definition of variables and data sources. Productivity is computed using sales per employee (column 1) and value-added per employee (column 2). Robust standard errors in parentheses, clustered by HS6 product-destination level, with [a] denoting significance at the 1% level.

Table 2: Intensive margin: Volume and value of exports, by type of firms

Productivity measure	Volume (logs) of exports	Value (logs) of exports	Volume (logs) of exports	Value (logs) of exports
	Sales per employee		Value added per employee	
	(1)	(2)	(3)	(4)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ < median	-0.019[a]	-0.018[a]	-0.020[a]	-0.019[a]
	(0.004)	(0.004)	(0.004)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ > median	-0.036[a]	-0.030[a]	-0.033[a]	-0.028[a]
	(0.005)	(0.004)	(0.005)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ < median	0.006	0.006	0.008	0.008[c]
	(0.005)	(0.004)	(0.005)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ > median	0.032[a]	0.024[a]	0.031[a]	0.024[a]
	(0.004)	(0.004)	(0.004)	(0.004)
Ln $quality_{fj}^k$	0.006	0.641[a]	0.006	0.642[a]
	(0.011)	(0.008)	(0.011)	(0.009)
Nb. other import-related $NTMs_j^k$	-0.003	0.007	0.002	0.009
	(0.012)	(0.011)	(0.012)	(0.011)
Ln applied $protection_j^k$	-0.286	-0.358[b]	-0.438[b]	-0.492[a]
	(0.193)	(0.176)	(0.193)	(0.177)
Ln $imports_j^k$	0.073[a]	0.073[a]	0.072[a]	0.071[a]
	(0.009)	(0.008)	(0.009)	(0.008)
Firm already present in $t\text{-}1_{fj}^k$	0.638[a]	0.555[a]	0.642[a]	0.557[a]
	(0.021)	(0.017)	(0.021)	(0.018)
Observations	101,014	101,014	97,656	97,656
Adjusted R^2	0.726	0.725	0.727	0.725
Fixed effects:				
Firm-$Product_{fk}$ & Firm-$Destination_{fj}$	Yes	Yes	Yes	Yes

Note: In columns 1 and 3 (resp. in columns 2 and 4), the dependent variable is the export volume in logs (resp. export value in logs) by firm f of product k to destination j in 2011. The number of QSs is the sum of SPS and TBT measures enforced on product k by destination j. See the text for the definition of variables and data sources. Productivity is computed using sales per employee (columns 1-2) and value-added per employee (columns 3-4). Robust standard errors in parentheses, clustered by HS6 product-destination level, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% level respectively.

Table 3: Average quality

	Average Quality			
	(1)	(2)	(3)	(4)
Nb. of QSs_j^k	0.013			
	(0.010)			
Nb. of QSs_j^k X Consumption goods		0.050^a		
		(0.013)		
Nb. of QSs_j^k X Capital/Intermediate goods		0.002		
		(0.011)		
Nb. of QSs_j^k X Food and beverages			0.078^a	
			(0.016)	
Nb. of QSs_j^k X Manufacturing (without textile)			-0.009	
			(0.011)	
Nb. of QSs_j^k X Textile			0.075^b	
			(0.033)	
Nb. of QSs_j^k X Food and beverages X Consumption goods				0.094^a
				(0.013)
Nb. of QSs_j^k X Food and beverages X Capital/Intermediate goods				0.055^c
				(0.033)
Nb. of QSs_j^k X Manufacturing (wo. textile) X Consumption goods				-0.028
				(0.020)
Nb. of QSs_j^k X Manufacturing (wo. textile) X Capital/Intermediate goods				-0.006
				(0.012)
Nb. of QSs_j^k X Textile X Consumption goods				0.125^a
				(0.036)
Nb. of QSs_j^k X Textile X Capital/Intermediate goods				0.038
				(0.048)
Nb. of other import-related $NTMs_j^k$	0.172^a	0.181^a	0.192^a	0.193^a
	(0.032)	(0.032)	(0.033)	(0.033)
Observations	26,672	26,672	26,672	26,672
Adjusted R^2	0.338	0.338	0.338	0.338
Fixed effects:				
$Product_k$ & $Destination_j$	Yes	Yes	Yes	Yes

Note: The dependent variable is the average quality of product k in destination j. The number of QSs is the sum of SPS and TBT measures enforced on product k by destination j. See the text for the definition of variables and data sources. In column 2, the number of QSs is interacted with dummies respectively set to 1 for final and other goods. In column 3, the number of QSs is interacted with dummies respectively set to 1 for food, manufacturing (without textile) and textile products. Column 4 includes triple interactions between the number of QSs, the type of goods (final vs. other) and the type of goods (food, manufacturing, textile). Robust standard errors in parentheses, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% level respectively.

Appendix

Table A1: Countries included in the TRAINS NTMs database

Afghanistan	Japan
Argentina	Kazakhstan
Australia	Lao PDR
Benin	Liberia
Bolivia	Malaysia
Brazil	Mali
Brunei Darussalam	Mexico
Burkina Faso	Myanmar
Cambodia	Nepal
Canada	New Zealand
Cape Verde	Nicaragua
Chile	Niger
China	Nigeria
Colombia	Pakistan
Costa Rica	Panama
Cote d'Ivoire	Paraguay
Cuba	Peru
Ecuador	Philippines
El Salvador	Senegal
Ethiopia	Singapore
European Union	Sri Lanka
Gambia	Tajikistan
Ghana	Thailand
Guatemala	Togo
Guinea	United States
Honduras	Uruguay
India	Venezuela
Indonesia	Vietnam

Source: UNCTAD (http://i-tip.unctad.org/). Note: Based on the data made available in April 2016.

Table A2: NTMs classification, by chapter

Chapter	Description
A	Sanitary and phytosanitary measures
B	Technical barriers to trade
C	Pre-shipment inspection and other formalities
D	Contigent trade-protective measures
E	Non-automatic licensing, quotas, prohibitions and quantity-control measures (other than for SPS/TBT reasons)
F	Price-control measures, including additional taxes and charges
G	Finance measures
H	Measures affecting competition
I	Trade-related investment measures
J	Distribution restrictions
K	Restrictions on post-sales services
L	Subsidies (excluding export subsidies under P7)
M	Government procurement restrictions
N	Intellectual property
O	Rules of origin
P	Export-related measures

Source: UNCTAD (2016). Note: Our analysis focuses on the 15 first chapters (from A to O), which deal with countries' requirements on their imports. Chapter (P) covering countries' requirements on their exports is excluded.

Table A3: Share (%) of HS6 products subject to QSs and average number of measures per HS6 product, by country

Country	Nb. of HS6 products	Share (%) of HS6 products with at least one QS		Avge. number of QS per HS6 product		Share (%) of French exports
	exported by France	All products	Products exported by France	All products	Products exported by France	impacted by a QS
Mean	*1294.1*	*53.0*	*52.9*	*5.1*	*3.7*	*64.5*
Afghanistan	435	12.8	16.3	3.6	3.3	37.9
Argentina	1733	91.1	92.7	5.0	4.4	97.3
Australia	2482	100.0	99.5	8.4	7.8	99.9
Benin	1659	37.9	42.5	4.6	2.3	90.9
Bolivia	358	35.4	25.1	6.4	6.3	45.8
Brazil	2484	81.1	81.7	8.8	8.3	89.4
Brunei	272	43.0	50.0	4.3	2.4	60.7
Burkina Faso	1561	26.2	24.1	2.3	0.6	47.0
Cambodia	556	71.1	79.0	5.3	4.1	92.5
Canada	2713	100.0	99.4	7.5	7.1	99.9
Cape Verde	379	28.6	42.7	5.1	1.7	54.9
Chile	1734	66.1	65.9	3.4	2.8	59.9
China	3098	65.5	63.3	6.5	6.1	83.1
Colombia	1575	46.5	43.9	6.3	3.2	31.4
Costa Rica	695	32.1	24.2	3.7	2.4	47.4
Cote d'Ivoire	2224	9.7	8.7	1.3	0.1	21.4
Cuba	600	97.1	96.7	1.3	1.3	30.4
Ecuador	791	33.4	31.4	5.2	4.8	34.4
El Salvador	406	34.0	26.1	2.9	2.8	19.0
Ethiopia	585	43.9	51.6	4.7	1.7	82.4
Gambia	300	13.4	9.7	14.2	1.1	57.8
Ghana	1056	41.3	41.3	6.8	2.9	61.7
Guatemala	604	20.2	18.9	10.0	9.8	44.4
Guinea	1299	97.5	96.8	3.3	3.3	97.2
Honduras	376	33.6	18.9	4.8	3.9	45.6
India	2547	99.8	99.3	3.3	2.4	99.8
Indonesia	1662	56.5	55.1	4.5	4.1	74.8
Japan	2928	99.8	99.3	5.4	5.1	99.9
Kazakhstan	1269	42.2	45.6	2.9	2.4	73.0
Lao	204	28.5	42.2	4.8	2.2	3.3
Liberia	346	100.0	99.7	4.7	5.0	100.0
Malaysia	1824	38.3	36.6	4.9	4.1	34.2
Mali	1559	28.4	26.0	2.8	0.7	51.3
Mexico	2237	38.8	35.9	5.2	3.9	64.4
Myanmar	222	27.2	27.0	6.3	3.6	56.3
Nepal	229	100.0	100.0	2.5	2.5	100.0
New Zealand	1535	62.7	64.2	6.8	3.5	90.1
Nicaragua	282	20.9	14.2	7.9	2.7	33.0
Niger	1233	34.8	42.6	1.9	0.7	70.1
Nigeria	1489	31.6	39.7	5.7	2.3	50.9
Pakistan	1061	37.0	27.7	1.1	0.3	21.3
Panama	901	22.6	17.5	5.3	4.0	48.8
Paraguay	515	29.7	23.7	4.2	3.6	73.3
Peru	1151	39.1	28.4	6.5	4.8	44.2
Philippines	1391	74.8	83.0	7.1	5.5	92.5
Senegal	2412	15.3	15.2	3.0	1.5	19.6
Singapore	2432	100.0	99.7	3.0	3.1	99.9
Sri Lanka	758	54.0	58.6	3.9	1.9	83.0
Tajikistan	216	62.9	79.2	2.1	2.4	96.4
Thailand	2185	33.2	30.4	7.1	7.0	33.3
Togo	1510	17.5	21.0	3.8	0.8	55.1
United States	3555	100.0	99.2	11.1	10.7	99.9
Uruguay	943	57.1	47.7	3.7	3.2	29.3
Venezuela	987	99.7	99.0	7.9	7.4	99.95
Vietnam	1620	100.0	99.6	5.9	5.7	99.9

Note: The share of HS6 products with at least one QS is computed by dividing the number of HS6 products subject to at least one QS and the total number of HS6 products. The average number of QSs per HS6 product is computed only on HS6 products subject to at least one QS. Products without QS are not included in the calculation. In the last column, the exports in value are used for the computation of the share.

Table A4: Share (%) of HS6 products subject to other import-related NTMs and average number of measures per HS6 product, by country

Country	Share (%) of HS6 products with at least one measure		Avge. number of measure per HS6 product	
	All products	Products exported by France	All products	Products exported by France
Mean	*57.2*	*56.9*	*2.7*	*2.2*
Afghanistan	11.1	14.0	1.5	0.9
Argentina	100.0	99.5	3.2	3.2
Australia	100.0	99.5	3.2	3.3
Benin	100.0	99.6	5.2	5.3
Bolivia	1.9	3.4	1.5	0.3
Brazil	38.3	42.6	2.9	1.7
Brunei	20.9	15.1	1.4	0.3
Burkina Faso	100.0	99.6	2.1	2.1
Cambodia	100.0	99.8	1.5	1.4
Canada	99.5	98.7	2.2	2.1
Cape Verde	100.0	99.7	7.1	7.1
Chile	4.9	6.4	1.1	0.1
China	22.3	19.9	1.5	0.4
Colombia	71.1	70.7	2.1	1.8
Costa Rica	5.8	11.9	1.0	0.4
Cote d'Ivoire	100.0	99.5	1.1	1.2
Cuba	96.2	96.5	1.0	1.0
Ecuador	10.6	6.3	1.6	0.3
El Salvador	0.04	0.0	2.0	0.0
Ethiopia	100.0	99.8	9.9	10.0
Gambia	99.9	100.0	2.1	2.2
Ghana	100.0	99.9	4.1	4.1
Guatemala	1.0	1.7	1.1	0.1
Guinea	97.4	96.7	9.1	9.1
Honduras	0.3	1.9	1.0	0.1
India	100.0	99.3	3.3	3.3
Indonesia	37.7	33.0	1.5	1.0
Japan	31.3	28.4	2.2	0.6
Kazakhstan	24.0	23.2	1.2	0.6
Lao	100.0	100.0	2.5	2.7
Liberia	20.7	41.9	1.9	0.8
Malaysia	19.7	15.1	1.5	0.5
Mali	100.0	99.6	8.0	8.0
Mexico	11.8	9.0	1.2	0.3
Myanmar	38.3	23.0	1.5	0.9
Nepal	100.0	100.0	6.1	6.2
New Zealand	100.0	99.4	3.0	3.1
Nicaragua	13.7	17.0	1.1	0.7
Niger	100.0	99.8	6.1	6.1
Nigeria	76.0	84.0	1.1	1.0
Pakistan	100.0	99.5	2.4	2.5
Panama	15.2	9.8	1.1	0.5
Paraguay	10.5	12.4	1.1	0.6
Peru	8.0	8.5	1.1	0.3
Philippines	100.0	99.8	7.3	7.0
Senegal	21.0	15.5	1.1	0.6
Singapore	39.4	41.4	1.2	0.5
Sri Lanka	100.0	99.6	4.3	4.3
Tajikistan	2.9	4.6	1.0	0.1
Thailand	16.5	13.5	1.2	0.5
Togo	100.0	99.8	4.0	4.0
United States	64.2	60.0	1.3	0.7
Uruguay	11.6	12.5	1.1	0.3
Venezuela	99.9	99.4	2.8	2.6
Vietnam	100.0	99.6	3.1	3.1

Note: The share is computed by dividing the number of HS6 products subject to at least one other import-related NTM and the total number of HS6 products. The average number of other import-related NTMs per HS6 product is computed only on HS6 products subject to at least one of these measures. Products without measures are not included in the calculation.

Table A5: Extensive margin: Export participation - Robustness checks

Productivity measure	Export participation Sales per employee					
	(1)	(2)	(3)	(4)	(5)	(6)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ bottom 25%	-0.0008[a]	-0.0007[a]	-0.0010[a]	-0.0018[a]	-0.0006[a]	-0.0011[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ middle range	-0.0010[a]	-0.0013[a]	-0.0012[a]	-0.0021[a]	-0.0012[a]	-0.0012[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ top 25%	-0.0014[a]	-0.0016[a]	-0.0016[a]	-0.0027[a]	-0.0019[a]	-0.0016[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ bottom 25%	0.0012[a]	0.0015[a]	0.0013[a]	0.0023[a]	0.0018[a]	0.0011[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ middle range	0.0014[a]	0.0013[a]	0.0015[a]	0.0027[a]	0.0014[a]	0.0015[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ top 25%	0.0012[a]	0.0011[a]	0.0011[a]	0.0021[a]	0.0012[a]	0.0011[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Nb. other import-related $NTMs_j^k$	-0.0002	-0.0001	-0.0002	-0.0002[b]	-0.0002[b]	-0.0001
	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
Ln applied $protection_j^k$	-0.0044[a]	-0.0062[b]	-0.0044[a]	-0.0045[a]	-0.0044[a]	0.0007
	(0.0015)	(0.0025)	(0.0015)	(0.0016)	(0.0016)	(0.0016)
Ln maximum $price_f^k$		0.0031[a]				
		(0.0001)				
Ln $imports_f^k$	0.0011[a]		0.0011[a]	0.0011[a]	0.0012[a]	0.0001[c]
	(0.0001)		(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ln number French $exporters_j^k$						0.0165[a]
						(0.0002)
Firm already present in $t\text{-}1_{fj}^k$	0.4161[a]	0.3981[a]	0.4158[a]	0.4158[a]	0.4171[a]	0.4125[a]
	(0.0017)	(0.0018)	(0.0042)	(0.0017)	(0.0017)	(0.0017)
Observations	6,034,342	4,010,707	6,034,342	6,034,342	6,034,342	6,034,342
Adjusted R^2	0.466	0.468	0.465	0.466	0.466	0.468
Fixed effects:						
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the probability that firm f exports product k to destination j in 2011. The robustness checks are as follows: In Column 1, the bins for quality and productivity are created for each HS6 product separately. Column 2 uses of the maximum price of a product in a given destination to proxy the demand of a product-destination pair (instead of using imports). In column 3, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 4, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 5, the number of QSs is computed relying only on the number of SPS measures enforced on product k by destination j (instead of the sum of SPS and TBT measures). Column 6 includes the number of French firms exporting to a given product-destination pair. See the text for the definition of variables and data sources. Productivity is computed using sales per employee. Robust standard errors in parentheses, with [a], [b] and [c] denoting significance at the 1%, 5% and 10% level respectively.

Table A6: Intensive margin: Volume exports - Robustness checks

Productivity measure	Volume (logs) exports Sales per employee					
	(1)	(2)	(3)	(4)	(5)	(6)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ < median	-0.021[a]	-0.018[a]	-0.019[a]	-0.036[a]	-0.050[a]	-0.020[a]
	(0.004)	(0.004)	(0.004)	(0.009)	(0.012)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ > median	-0.028[a]	-0.037[a]	-0.036[a]	-0.068[a]	-0.068[a]	-0.037[a]
	(0.004)	(0.005)	(0.005)	(0.009)	(0.012)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ < median	-0.006	0.007	0.006	0.006	0.007	0.006
	(0.005)	(0.005)	(0.005)	(0.009)	(0.010)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ > median	0.034[a]	0.032[a]	0.032[a]	0.056[a]	0.067[a]	0.032[a]
	(0.004)	(0.004)	(0.005)	(0.009)	(0.010)	(0.004)
Ln $quality_{fj}^k$	0.399[a]	-0.001	0.006	0.006	0.008	0.005
	(0.008)	(0.011)	(0.016)	(0.011)	(0.010)	(0.011)
Nb. other import-related $NTMs_j^k$	0.000	-0.002	-0.003	0.002	-0.003	-0.001
	(0.012)	(0.012)	(0.011)	(0.012)	(0.003)	(0.012)
Ln applied $protection_j^k$	-0.265	-0.359[c]	-0.286	-0.283	-0.276	-0.261
	(0.193)	(0.194)	(0.187)	(0.194)	(0.194)	(0.194)
Ln maximum $price_f^k$		-0.054[a]				
		(0.009)				
Ln $imports_j^k$	0.073[a]		0.073[a]	0.073[a]	0.073[a]	0.061[a]
	(0.009)		(0.010)	(0.009)	(0.009)	(0.009)
Ln number French $exporters_j^k$						0.134[a]
						(0.020)
Firm already present in $t\text{-}1_{fj}^k$	0.640[a]	0.642[a]	0.638[a]	0.638[a]	0.636[a]	0.633[a]
	(0.021)	(0.021)	(0.030)	(0.021)	(0.021)	(0.021)
Observations	101,014	101,423	101,014	101,014	101,014	101,014
Adjusted R^2	0.726	0.726	0.705	0.726	0.725	0.726
Fixed effects:						
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the export volume in logs by firm f of product k to destination j in 2011. The robustness checks are as follows: In Column 1, the bins for quality and productivity are created for each HS6 product separately. Column 2 uses of the maximum price of a product in a given destination to proxy the demand of a product-destination pair (instead of using imports). In column 3, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 4, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 5, the number of QSs is computed relying only on the number of SPS measures enforced on product k by destination j (instead of the sum of SPS and TBT measures). Column 6 includes the number of French firms exporting to a given product-destination pair. See the text for the definition of variables and data sources. Productivity is computed using sales er employee. Robust standard errors in parentheses, with [a] and [c] denoting significance at the 1% and 10% level respectively.

Table A7: Intensive margin: Value exports - Robustness checks

Productivity measure	Value (logs) exports Sales per employee					
	(1)	(2)	(3)	(4)	(5)	(6)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ < median	-0.025^a	-0.018^a	-0.018^a	-0.030^a	-0.047^a	-0.018^a
	(0.004)	(0.004)	(0.004)	(0.007)	(0.010)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_{fj}^k$ > median	-0.021^a	-0.030^a	-0.030^a	-0.053^a	-0.061^a	-0.030^a
	(0.004)	(0.004)	(0.004)	(0.008)	(0.011)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ < median	-0.002	0.005	0.006	0.011	0.005	0.006
	(0.004)	(0.004)	(0.004)	(0.008)	(0.009)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_{fj}^k$ > median	0.026^a	0.025^a	0.024^a	0.045^a	0.048^a	0.024^a
	(0.004)	(0.004)	(0.004)	(0.007)	(0.009)	(0.004)
Ln $quality_{fj}^k$	0.398^a	0.665^a	0.641^a	0.641^a	0.642^a	0.640^a
	(0.007)	(0.009)	(0.013)	(0.009)	(0.008)	(0.008)
Nb. other import-related $NTMs_j^k$	0.014	0.008	0.007	0.004	-0.001	0.008
	(0.012)	(0.011)	(0.009)	(0.011)	(0.003)	(0.011)
Ln applied $protection_j^k$	-0.256	-0.343^b	-0.358^b	-0.347^b	-0.340^c	-0.339^c
	(0.193)	(0.172)	(0.163)	(0.176)	(0.175)	(0.176)
Ln maximum $price_f^k$		0.157^a				
		(0.008)				
Ln $imports_j^k$	0.055^a		0.073^a	0.073^a	0.073^a	0.064^a
	(0.009)		(0.009)	(0.008)	(0.008)	(0.008)
Ln number French $exporters_j^k$						0.102^a
						(0.018)
Firm already present in $t\text{-}1_{fj}^k$	0.582^a	0.552^a	0.555^a	0.555^a	0.554^a	0.552^a
	(0.018)	(0.017)	(0.025)	(0.017)	(0.017)	(0.017)
Observations	101,014	101,423	101,014	101,014	101,014	101,014
Adjusted R^2	0.704	0.727	0.704	0.725	0.724	0.725
Fixed effects:						
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the export value in logs by firm f of product k to destination j in 2011. The robustness checks are as follows: In Column 1, the bins for quality and productivity are created for each HS6 product separately. Column 2 uses of the maximum price of a product in a given destination to proxy the demand of a product-destination pair (instead of using imports). In column 3, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 4, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 5, the number of QSs is computed relying only on the number of SPS measures enforced on product k by destination j (instead of the sum of SPS and TBT measures). Column 6 includes the number of French firms exporting to a given product-destination pair. See the text for the definition of variables and data sources. Productivity is computed using sales per employee. Robust standard errors in parentheses, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% level respectively.

Table A8: Simulation: Value of exports

Productivity measure	Value (logs) of exports	
	Sales per employee	Value added per employee
	(1)	(2)
Nb. QSs_j^k	-0.023^b	-0.024^a
	(0.011)	(0.008)
Nb. QSs_j^k X Ln $productivity_f^k$	-0.002	-0.001
	(0.003)	(0.003)
Nb. QSs_j^k X Ln $quality_{fj}^k$	-0.010^a	-0.003^c
	(0.003)	(0.002)
Nb. QSs_j^k X Ln $productivity_f^k$ X Ln $quality_{fj}^k$	0.005^a	0.004^a
	(0.001)	(0.001)
Ln $quality_{fj}^k$	0.619^a	0.621^a
	(0.009)	(0.009)
Nb. other import-related $NTMs_j^k$	0.005	0.009
	(0.011)	(0.011)
Ln applied $protection_j^k$	-0.361^b	-0.482^a
	(0.177)	(0.178)
Ln $imports_j^k$	0.071^a	0.070^a
	(0.008)	(0.008)
Firm already present in $t\text{-}1_{fj}^k$	0.557^a	0.559^a
	(0.017)	(0.018)
Observations	101,014	97,656
Adjusted R^2	0.726	0.726
Fixed effects:		
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	Yes	Yes

Note: The dependent variable is the export value in logs by firm f of product k to destination j in 2011. The number of QSs is the sum of SPS and TBT measures enforced on product k by destination j. See the text for the definition of variables and data sources. Productivity is computed using sales per employee (column 1) and value-added per employee (column 2). Robust standard errors in parentheses, clustered by HS6 product-destination level, with [a], [b] and [c] denoting significance at the 1%, 5% and 10% level respectively.

Table A9: Simulation: Number of firms

Productivity measure	Number (logs) of exporters	
	Sales per employee	Value added per employee
	(1)	(2)
Nb. QSs_j^k	-0.004[a]	-0.004[a]
	(0.001)	(0.001)
Ln average $productivity_j^k$	0.068[a]	0.066[a]
	(0.003)	(0.003)
Ln average $quality_j^k$	0.169[a]	0.167[a]
	(0.006)	(0.006)
Nb. other import-related $NTMs_j^k$	-0.009[b]	-0.008[b]
	(0.004)	(0.004)
Ln applied $protection_j^k$	-0.150[b]	-0.144[b]
	(0.068)	(0.068)
Ln $imports_j^k$	0.109[a]	0.109[a]
	(0.003)	(0.003)
Observations	36,014	35,892
Adjusted R^2	0.669	0.669
Fixed effects:		
$Product_k$ & $Destination_j$	Yes	Yes

Note: The dependent variable is the number of firms in logs within a product-destination pair *kj*. The number of QSs is the sum of SPS and TBT measures enforced on product *k* by destination *j*. See the text for the definition of variables and data sources. Average productivity and quality are computed as the mean of $productivity_f^k$ and $quality_{fj}^k$ across all firms *f* within a product-destination pair *kj*, respectively. Productivity is computed using sales per employee (column 1) and value-added per employee (column 2). Robust standard errors in parentheses, with [a] and [b] denoting significance at the 1% and 5% level, respectively.