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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. Using French firm-level data, we exploit information on prices and productivity to estimate the quality of exported products. Higher quality is assigned to products supplied by an exporter with higher marginal costs conditional on productivity. In accordance with our theory, quality standards enforced on products by destination countries (i) reduce the export probability of low-quality firms but also that of high-quality low-productivity firms; (ii) increase the export participation and sales of high-productivity high-quality firms; (iii) improve the average quality of consumption goods exported by France.

JEL Codes: D21, D22, F12, F14
Keywords: Firm exports; quality standards; information asymmetry; product quality

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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 quality standards 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 minimum energy efficiency standards for many household appliances or the maximum amount of pesticide residues allowed for food products or require that motor vehicles be equipped with airbags and antilock braking systems. More generally, these measures usually aim at protecting human health, human safety, and the environment. Between 1995 and 2017, 470 SPS-related and 549 TBT-related trade concerns were raised (Source: 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. 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]

As expected, the presence of QSs forces low-quality firms – which are not able to keep up with the regulation – to exit, regardless of their productivity. Signaling activity, which is costly, is only profitable for high-productivity firms selling products with a quality above the average quality. The export sales of these signaling firms increase with productivity, product quality, and a stricter QSs (because of reallocation of market share). By contrast, under quality uncertainty, the fixed export costs induce the existence of a quality cutoff above which non-signaling firms cannot profitably export their product. Low-productivity high-quality firms are excluded from a destination market. The presence of these firms is blocked as foreign consumers do not know the true quality of their products whereas their prices are relatively high. The export sales of these non-signaling firms decrease with their product quality (cost effect) as consumers only observe the average quality and increase with their product productivity (efficiency effect).

We then assess empirically the main predictions derived from our model. We match a dataset on public QSs (SPS and TBT measures) 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 their productivity and the quality of their products, as well as on the average quality of exported products. The estimation of product quality using firm-level trade data when information asymmetry prevails is challenging. Traditional tools based on demand equations (Khandelwal, 2010; Khandelwal et al., 2013) cannot be applied because such approaches implicitly assume perfect information on product quality. Furthermore, we cannot use input prices at the firm level as in Bastos et al. (2018) 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

[4] Our framework extends the model developed in Bagwell and Staiger (1989) and Cagé and Rouzet (1995) by considering firm heterogeneity, horizontal differentiation, and signaling activity.

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. We therefore rely on our theoretical model and information on price at the firm-product-destination level and productivity to infer quality at the firm-product (e.g. variety) level. Higher quality is assigned to varieties that have a higher marginal cost conditional on productivity.

According to our results, the effect of QSs on the export probability and export sales of firms selling high-quality products depends on their productivity. 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). Among firms with a lower than median productivity, medium-quality firms exhibit the highest export probabilities and export sales. Furthermore, our simulation exercise suggests that if all export destinations served by French firms adopted the maximum number of QSs observed for a product, the overall effect on French exports would be negative (- 20% of exports, i.e. 17.1 billion euros). However, high-productivity high-quality firms would gain from this rise in the number of QSs and their export value would increase by 21% (4.8 billion euros). 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) and Gaigné and Larue (2016) 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 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). 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

[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).

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 computation of the quality cost and the data. 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 the average quality of products. Section 6 concludes.

2 Theoretical model

This section provides the microeconomic foundations of the impact of QSs in a context of information asymmetry on the export decisions (extensive margin) and export sales (intensive margin) of firms according to their productivity and the quality of their varieties. Our model is also useful for inferring marginal cost associated with product quality and average product quality perceived by consumers. We first omit signaling activity (subsections 2.1 and 2.2). In subsection 2.3, we extend our framework by considering that firms may disclose information about the quality of their products.

2.1 Framework

We consider an economy with information asymmetry on product quality and heterogeneous firms.[6] Producers know the quality of their products, but this quality is not observed by consumers. More precisely, the latter only know the distribution of quality and not the quality of each product. 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. Consumers are assumed to be risk-neutral and only their perceptions about the average quality are considered. In this subsection, we consider that there is no potential for signaling or screening. Despite information asymmetry, a trade equilibrium is reached as products are also horizontally differentiated and firms differ in terms of productivity.

[6] 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).

Preferences and import demand. Consumers have identical Cobb-Douglas preferences for differentiated products and a homogeneous aggregate good. We use a CES sub-utility function for the differentiated products:

$$U_j^k = \left[\sum_i \int_{\Omega_{ij}^k} \left[\left(\bar{\theta}_{ij}^k \right)^{\beta_j^k} q_{ij}^k(\nu) \right]^{\frac{\varepsilon_j^k - 1}{\varepsilon_j^k}} \mathrm{d}\nu \right]^{\frac{\varepsilon_j^k}{\varepsilon_j^k - 1}} \tag{1}$$

where Ω_{ij}^k is the set of varieties ν of product k available in country j and produced in country i, and $\bar{\theta}_{ij}^k$ represent their average quality. Quality captures all attributes of a product other than price, which consumers value. q_{ij}^k is the demand expressed in country j for a variety of product k imported from country i. $\varepsilon_j^k > 1$ is the elasticity of substitution between varieties and is assumed to be constant. An increase in β_j^k signals greater appreciation for vertically differentiated products. The utility function aligns with Kugler and Verhoogen (2012) and Hallak and Sivadasan (2013), except that in our case, because of information asymmetry, the consumer does not consider the quality of each variety but rather the average quality.

In Appendix A.1, we show that the equilibrium demand for a variety produced in country i and exported to country j is such that:

$$p_{ij}^k q_{ij}^k = \left(\bar{\theta}_{ij}^k \right)^{\beta_j^k (\varepsilon_j^k - 1)} A_j^k \left(p_{ij}^k \right)^{1 - \varepsilon_j^k} \tag{2}$$

with $A_j^k \equiv E_j^k \left(P_j^k \right)^{\varepsilon_j^k - 1}$, where 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:

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

where p_{ij}^k is the price of the variety of product k supplied by a firm. 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, profit and price. Each variety is produced by a single firm, but a firm can produce more than one differentiated product (multi-product firms).[7] Each firm-product pair is characterized by a level of productivity (φ^k) and a level of quality (θ^k). The characteristics of the different varieties cannot be easily customized for each foreign market, and therefore, the quality of the varieties is not adjusted by firms as often as prices are.[8] In addition, we make no assumptions about the *ex ante* correlation between productivity and quality and do not specify the distributions of these two parameters. We could consider that φ and θ are drawn simultaneously from a joint distribution function or use the theory of copulas to allow for either a positive or negative correlation between both parameters while maintaining their marginal distributions (Davis and Harrigan, 2011; Harrigan and Reshef, 2015). Our results are not affected by the correlation between the values of the marginal distribution functions of productivity and quality.

Product markets are internationally segmented, meaning that the price of a variety varies across destination countries. Firms produce under monopolistic competition. Being negligible to the market, each firm sets its price while accurately treating the market aggregates (price index and average quality) as given. The profit of a firm located in country i is given by $\pi_i = \sum_k \sum_j \pi_{ij}^k(\varphi^k, \theta^k)$ with

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

where $T_{ij}^k \equiv 1 + t_{ij}^k$ with t_{ij}^k the ad valorem tariff applied by country j to product k imported from country i, τ_{ij}^k represents an iceberg trade cost, $\phi_{ij}^k(\theta^k)$ is the fixed cost of distribution and $c_{ij}^k(\theta^k, \varphi^k)$ is the *marginal* cost of production. The marginal cost increases with quality for a given productivity and decreases with productivity for a given quality. More specifically, $c_{ij}^k = \left(\theta^k\right)^{\alpha^k} \omega_i^k \tau_{ij}^k / \varphi^k$, 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 assumed to be given by $\phi_{ij}^k = f_{ij}^k(\theta^k)^{\eta^k}$, 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

[7] Consistently, in the empirical section, we use the firm-product pair (i.e. variety) as the basic unit of our analysis.

[8] The quality supplied by a multi-product firm varies across its varieties but is the same across countries. Bernard et al. (2011) use a similar assumption. While the valuation of quality by consumers may differ across countries (short-term perspective), this assumption is not too strong. Indeed, firms might need some adjustment time before starting to customize quality for each foreign market. In Appendix A.2, we relax the assumption of exogeneity of product quality and consider that firms determine the quality of their varieties according to the characteristics of their domestic market.

exported.[9]

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

$$p_{ij}^k = \frac{\varepsilon_j^k}{\varepsilon_j^k - 1}\omega_i^k \tau_{ij}^k T_{ij}^k \frac{(\theta^k)^{\alpha^k}}{\varphi^k}. \tag{5}$$

Hence, in our model, the relevant index is $\Phi^k \equiv \varphi^k/(\theta^k)^{\alpha^k}$, which is equivalent to a *cost competitiveness index*. This index decreases with product quality (θ^k) and the quality-elasticity of variable cost (α^k) and increases with productivity (φ^k).

2.2 Selection and trade in presence of QSs without quality disclosure

Each destination country j introduces a standard setting for minimum quality ($\underline{\theta}_j^k$). 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. In the remainder of the text, we use the terms firm and firm-product pair interchangeably.

Export decision. Evaluated at equilibrium prices, the profit of a firm producing a variety of product k in country i and serving market j is:

$$\pi_{ij}^k = \frac{r_{ij}^k}{\varepsilon_j^k} - f_{ij}^k(\theta^k)^{\eta^k} \tag{6}$$

where $r_{ij}^k \equiv p_{ij}^k q_{ij}^k$ is the export sales of the firm associated with destination j. A firm serves country j if and only if $\pi_{ij}^k \geq 0$. Since production and distribution costs are assumed to be non-negative with product quality and consumers do not know the quality of products, we have $\partial r_{ij}^k/\partial\theta^k < 0$ for a given productivity. As a consequence, there exists a maximum quality for a given productivity $\widehat{\theta}_{ij}^k(\varphi^k)$ above which it is not profitable for firms to serve market j. Thus and although they are preferred by consumers, high-quality products are driven out of the market by low-quality ones (Akerlof's lemons principle). However in our setup, the effect also depends on the productivity of the firm. A firm with high productivity (high φ^k) can profitably sell a high-quality product as long as its price (p_{ij}^k) is lower than the price of a firm selling the lowest quality.

[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.

Formally, $\widehat{\theta}_{ij}^k(\varphi^k)$ (called the *quality cutoff curve*) is such that $\pi_{ij}^k(\varphi^k, \widehat{\theta}_{ij}^k) = 0$ or, equivalently,

$$\widehat{\theta}_{ij}^k(\varphi^k) = \left[\frac{\left(\bar{\theta}_{ij}^k\right)^{\beta_j^k} A_j^k}{\varepsilon_j^k f_{ij}^k} \right]^{\frac{\rho^k}{\varepsilon_j^k - 1}} \left(\frac{\varphi^k}{\frac{\varepsilon_j^k}{\varepsilon_j^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k} \right)^{\rho^k} \quad \text{with } \rho^k \equiv \frac{\varepsilon_j^k - 1}{\eta^k + \alpha^k(\varepsilon_j^k - 1)}. \tag{7}$$

Using the implicit function theorem, it is straightforward to check that:

$$\left.\frac{\partial \widehat{\theta}_{ij}^k}{\partial \varphi^k}\right|_{\pi_{ij}^k = 0} = \frac{-\partial \pi_{ij}^k / \partial \varphi^k}{\partial \pi_{ij}^k / \partial \theta_{ij}^k} > 0. \tag{8}$$

Hence, market failures associated with information asymmetry hurt low-productivity high-quality firms as they charge high prices to consumers. By contrast, high-productivity high-quality firms can profitably export. Note that, under perfect information and endogenous product quality, trade literature shows that more productive firms specialize in higher quality products (Baldwin and Harrigan, 2011; Kugler and Verhoogen, 2012; Gaigné and Larue, 2016). From a different mechanism, we also show that high-quality firms are more likely to be high-productivity firms. Our result arises from a mechanism of *adverse selection*, which varies according to the firm's productivity.

The quality-cutoff curve $\widehat{\theta}_{ij}^k(\varphi^k)$ is displayed on Figure 1. Each firm-product pair is represented by a single point, *e.g.,* a (φ^k, θ^k) combination. Firms below the threshold $\widehat{\theta}_{ij}^k(\varphi^k)$ earn non-negative profits, while firms above the curve $\widehat{\theta}_{ij}^k(\varphi^k)$ exit the market. The firms along the curve have equal revenue and profits. The positive slope of the curve $\widehat{\theta}_{ij}^k(\varphi^k)$ indicates that firms with high productivity are more likely to export.

Insert Figure 1 here

Using our assumptions on technology and preferences, we can determine the quality cutoff curve $(\widehat{\theta}_{ij}^k)$ and the productivity cutoff (φ_{ij}^k) to meet the QSs prevailing in the foreign country. The latter variable is defined such that $\pi_{ij}^k(\varphi_{ij}^k, \underline{\theta}_j^k) = 0$, so that:

$$\varphi_{ij}^k = \left(\frac{\varepsilon_j^k f_{ij}^k}{A_j^k} \right)^{\frac{1}{\varepsilon_j^k - 1}} \frac{\left(\underline{\theta}_j^k\right)^{\frac{1}{\rho}}}{\left(\bar{\theta}_{ij}^k\right)^{\beta_j^k}} \frac{\varepsilon_j^k}{\varepsilon_j^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k. \tag{9}$$

Using (9), we can express the highest quality $\widehat{\theta}_{ij}^k$ that can be exported for a given productivity. The marginal firm, that is indifferent between exporting and exiting (i.e. with $\pi_{ij}^k(\varphi^k, \widehat{\theta}_{ij}^k) = 0$), offers the following quality (implicitly given):

$$\widehat{\theta}_{ij}^{k}(\varphi^{k}) = \underline{\theta}_{j}^{k} \left(\frac{\varphi^{k}}{\varphi_{ij}^{k}} \right)^{\rho^{k}} \tag{10}$$

which is the highest quality in market j supplied by a φ-firm based in country i. As a result, under information asymmetry and in the presence of a QS, a firm serves country j if and only if its productivity is higher than the productivity cutoff ($\varphi^k > \varphi_{ij}^k$) and its quality is higher than the minimum quality level imposed by the QS and lower than the quality cutoff ($\widehat{\theta}_{ij}^k > \theta^k > \underline{\theta}_j^k$) (see Figure 1). Therefore, the relationship between product quality and the probability of exporting is non-monotonic and bell-shaped. For a given productivity, firms supplying a medium-quality product are more likely to export than firms selling a low-quality (below the QS threshold) or high-quality (above the quality cutoff) product.

In addition, inserting (9) in (10) reveals that a lower fixed distribution cost and a lower bilateral trade cost increase the highest quality supplied by the marginal firm in country i and, in turn, increase the average quality. Hence, trade liberalization encourages quality upgrading. This outcome is also reported by Amiti and Khandelwal (2013) using a different mechanism. Furthermore, $\widehat{\theta}_{ij}^k / \underline{\theta}_j^k$ can be interpreted as the market's quality ladder, which is defined as the difference between the highest and the lowest quality (Khandelwal, 2010). The scope of quality differentiation in each country shrinks with trade costs and expands with market size.

Export sales. Using (2) and (5), it follows that

$$\frac{\partial r_{ij}^k}{\partial \varphi^k} > 0, \quad \frac{\partial r_{ij}^k}{\partial \bar{\theta}_{ij}^k} > 0 \quad \text{and} \quad \frac{\partial r_{ij}^k}{\partial \bar{\theta}_{ij}^k \partial \varphi^k} > 0 \tag{11}$$

As expected, exports are increasing with the firm's productivity and the average quality prevailing in the destination country j for product k coming from origin country i. 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 producers share their benefits with low-quality producers. Furthermore, the sales of high-productivity firms increase more with average quality than the sales of low-productivity firms because the former firms set lower prices than the latter firms (for a given quality θ^k). Thus, when consumption expenditures are held constant, a higher average product quality reallocates market shares to more productive incumbents (for a given quality θ^k).

Besides, it is straightforward to check that

$$\frac{\partial r_{ij}^k}{\partial \theta^k} < 0 \quad \text{and} \quad \frac{\partial r_{ij}^k}{\partial \theta^k \partial \bar{\theta}_{ij}^k} < 0 \tag{12}$$

Because of the information asymmetry on product quality and given that the production and distribution costs increase with product quality, the profits and sales associated with destination market j are lower for high-quality firms.[10] Furthermore, the sales of high-quality firms decrease more with average quality than the sales of low-quality firms (as prices of former firms are lower for a given productivity). Hence, when consumption expenditures are held constant, a higher average product quality reallocates market shares to incumbents supplying a lower quality (for a given productivity φ^k).

Export sales can also be expressed with respect to the QS. As shown in Appendix A.3, $\left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon_j^k-1)} A_j^k = \varepsilon_j^k f_{ij}^k \left(\underline{\theta}_j^k\right)^{\eta^k} \left(\widehat{p}_{ij}^k\right)^{\varepsilon_j^k-1}$ where $\widehat{p}_{ij}^k$ is the highest price of product k imported by country j from country i. By inserting this expression in (2) and using (5), it follows that the export sales of a firm-product pair (characterized by φ^k and θ^k) conditional on exporting are given by:

$$r_{ij}^k = \varepsilon_j^k f_{ij}^k \left(\underline{\theta}_j^k\right)^{\eta^k} \left(\widehat{p}_{ij}^k\right)^{\varepsilon_j^k-1} \left(\frac{\varepsilon_j^k}{\varepsilon_j^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k\right)^{-(\varepsilon_j^k-1)} \left(\varphi^k\right)^{\varepsilon_j^k-1} \left(\theta^k\right)^{-\alpha^k(\varepsilon_j^k-1)}. \tag{13}$$

According to equation (13), a QS increases the export sales of incumbent firms. This response is more pronounced for more productive incumbents and for firms supplying a level of quality just above the minimum quality.

To sum up,

Proposition 1 (without signaling activity). *Under information asymmetry on product quality, firms serve country j if and only if $\widehat{\theta}_{ij}^k > \theta^k > \underline{\theta}_j^k$ and $\varphi^k > \varphi_{ij}^k$, while their export sales increase with productivity and decrease with product quality.*

2.3 Selection and trade in presence of QSs with quality disclosure

Signaling activity. Firms may undertake investments in quality signaling and strategically choose to disclose information about the quality of their product to uninformed consumers.

[10] It is worth noting that the sales of high-quality firms are lower under information asymmetry than those under perfect information. Since consumers only know the average quality of the products, their demand for top-quality products is lower.

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^k) is perfectly observed by foreign consumers. However, quality-signaling activities undertaken by the firm imply a sunk cost F_{ij}^k which varies across origin countries, destination markets, and products. For example, F_{ij}^k can reflect the cost of obtaining a certification of the product quality from an independent third party.

Export sales of signaling firms. If a firm invests in signaling quality, its export sales are given by

$$\tilde{r}_{ij}^k = (\theta^k)^{(\beta_j^k-\alpha^k)(\varepsilon_j^k-1)}(\varphi^k)^{\varepsilon_j^k-1}A_j^k\left(\frac{\varepsilon_j^k}{\varepsilon_j^k-1}\omega_i^k\tau_{ij}^kT_{ij}^k\right)^{-(\varepsilon_j^k-1)}. \tag{14}$$

The impact of quality on profits of signaling firms depends on the foreign consumers' attitudes towards quality (β_j^k) relative to the cost elasticities of quality (α^k and η^k). In accordance with the trade theory under perfect information, we assume $\beta_j^k > \alpha^k$. Therefore, export sales increase with product quality for a given productivity when consumers perfectly observe the quality of the variety. In addition, $A_j^k = E_j^k(\tilde{P}_j^k)^{\varepsilon_j^k-1}$ where the price index in country j is now defined as:

$$\tilde{P}_j^k = \left\{\sum_i \int_{\Omega_{ij}^k}\left[p_{ij}^k(\nu)/(\bar{\theta}_{ij}^k)^{\beta_j^k}\right]^{1-\varepsilon_j^k}\mathrm{d}\nu + \int_{\tilde{\Omega}_{ij}^k}\left[p_{ij}^k(\nu)/(\theta^k)^{\beta_j^k}\right]^{1-\varepsilon_j^k}\mathrm{d}\nu\right\}^{\frac{-1}{\varepsilon_j^k-1}} \tag{15}$$

where $\tilde{\Omega}_{ij}^k$ is the set of varieties of product k available in country j supplied by a firm producing in country i and having a quality-signaling activity.

Endogenous disclosure choice and entry decision. If a firm invests in quality signaling activity, then its profit reaches

$$\tilde{\pi}_{ij}^k = \frac{\tilde{r}_{ij}^k}{\varepsilon_j^k} - f_{ij}^k(\theta^k)^{\eta^k} - F_{ij}^k \tag{16}$$

To characterize the configurations under which some firms choose quality signaling strategy, we have to consider two subcases: (a) $\underline{\theta}_j^k < \theta^k < \widehat{\theta}_{ij}^k$ and (b) $\theta^k > \widehat{\theta}_{ij}^k$.

(a) $\underline{\theta}_j^k < \theta < \widehat{\theta}_{ij}^k$**.** In this case, a firm producing a variety of product k for market j invests in quality signaling if and only if $\tilde{\pi}_{ij}^k(\varphi^k, \theta^k) > \pi_{ij}^k(\varphi^k, \theta^k)$ or, equivalently, $\theta^k > \tilde{\theta}_{ij}^{a,k}(\varphi^k)$ where $\tilde{\theta}_{ij}^k$ is such that $\tilde{\pi}_{ij}^k(\varphi^k, \tilde{\theta}_{ij}^{a,k}) = \pi_{ij}^k(\varphi^k, \tilde{\theta}_{ij}^{a,k})$. Hence, $\tilde{\theta}_{ij}^{a,k}$ (called *signaling cutoff curve*) is implicitely given by

$$\left[\varphi^k (\theta^k)^{\beta_j^k - \alpha^k}\right]^{\varepsilon_j^k - 1} \left[1 - \left(\frac{\bar{\theta}_{ij}^k}{\theta^k}\right)^{\beta_j^k(\varepsilon_j^k - 1)}\right] A_j^k = \varepsilon_j^k F_{ij}^k \left(\frac{\varepsilon_j^k}{\varepsilon_j^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k\right)^{\varepsilon_j^k - 1}. \tag{17}$$

When $\theta^k > \tilde{\theta}_{ij}^{a,k}$, a firm can profitably invest in signaling activities to serve foreign countries. As illustrated in Figure 2, the lowest quality ($\tilde{\theta}_{ij}^{a,k}$) that can be exported with a signaling activity decreases with productivity (with $\lim_{\varphi^k \to \infty} \tilde{\theta}_{ij}^{a,k} = \bar{\theta}_{ij}^k$ and $\lim_{\varphi^k \to 0} \tilde{\theta}_{ij}^{a,k} \to \infty$).

Some comments are in order. First, if a firm chooses to disclose, then this firm can profitably export as $\tilde{\pi}_{ij}^k(\varphi^k, \theta^k) > 0$. Second, if $F_{ij}^k = 0$, then all exporters disclose the quality of their varieties to consumers. Third and as expected, a firm invests in signaling activities only if its quality is above the average quality. High-quality firms have therefore a strong incentive to disclose while low-quality firms prefer to hide in pool of firms selling varieties with a higher quality. This result agrees with industry organization literature (Dranove and Jin, 2010). However, all high-quality firms do not disclose because disclosure is costly. For a given product quality, only more productive can profitably disclose.

Insert Figure 2 here

(b) $\theta^k > \widehat{\theta}_{ij}^k$**.** In this case, there is a new signaling cutoff curve, $\tilde{\theta}_{ij}^{b,k}(\varphi^k)$ such that $\tilde{\pi}_{ij}^k(\varphi^k, \tilde{\theta}_{ij}^{b,k}) = 0$ or, equivalently,

$$\tilde{\theta}_{ij}^{b,k} + \left(\frac{F_{ij}^k}{\varepsilon_j^k f_{ij}^k}\right)^{\rho^k/(\varepsilon_j^k - 1)} \left(\tilde{\theta}_{ij}^{b,k}\right)^{\alpha^k \rho^k} = \underline{\theta}_j^k \left(\frac{\tilde{\theta}_{ij}^{b,k}}{\bar{\theta}_{ij}^k}\right)^{\beta_j^k \rho^k} \left(\frac{\varphi^k}{\varphi_{ij}^k}\right)^{\rho^k} \tag{18}$$

Note that $\tilde{\theta}_{ij}^{b,k} = \tilde{\theta}_{ij}^{a,k}$ when $\theta^k = \widehat{\theta}_{ij}^k$. Using (16) and the implicit function theorem, it is straightforward to check that:

$$\left.\frac{\partial \tilde{\theta}_{ij}^{b,k}}{\partial \varphi^k}\right|_{\tilde{\pi}_{ij}^k = 0} = \left.\frac{-\partial \tilde{\pi}_{ij}^k / \partial \varphi^k}{\partial \tilde{\pi}_{ij}^k / \partial \tilde{\theta}_{ij}^{b,k}}\right|_{\tilde{\pi}_{ij}^k = 0} = \frac{\theta^k}{\varphi^k} \frac{-[f_{ij}^k (\tilde{\theta}_{ij}^{b,k})^{\eta^k} + F_{ij}^k]}{(\beta^k - \alpha^k) F_{ij}^k + (\beta^k - 1/\rho^k) f_{ij}^k (\tilde{\theta}_{ij}^{b,k})^{\eta^k}} < 0 \tag{19}$$

as long as the profits of signaling firms increase with product quality ($\beta^k > 1/\rho^k$ is a sufficient condition). As result, there exists a minimum quality for a given productivity $\widehat{\theta}_{ij}^{b,k}(\varphi^k)$ above which it is profitable to serve the destination market j (see Figure 2). Hence, high-productivity high-quality firms that can profitably disclose information are not hurt by the market failure associated with information asymmetry. Consumers perfectly value the quality of their varieties and signaling firms charge relatively low prices to consumers as they are more productive. As $\partial\tilde{\pi}_{ij}^k/\partial\theta^k > 0$, firms above this threshold $\widehat{\theta}_{ij}^{b,k}(\varphi^k)$ earn positive profits by exporting and investing in signaling activity, while firms below the curve $\widehat{\theta}_{ij}^{b,k}(\varphi^k)$ exit the market. The firms along the curve have equal revenue and profits. The negative slope of the curve $\widehat{\theta}_{ij}^{b,k}(\varphi^k)$ indicates that firms with high productivity are more likely to export.

The next proposition summarizes our main results,

Proposition 2 (endogenous signaling activity). *Under information asymmetry on product quality, firms with no signaling activity serve country j if and only if* $\min\{\widehat{\theta}_{ij}^k, \tilde{\theta}_{ij}^{b,k}\} > \theta^k > \underline{\theta}_j^k$ *while 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* $\theta^k > \tilde{\theta}_{ij}^k \equiv \max\{\tilde{\theta}_{ij}^{a,k}, \tilde{\theta}_{ij}^{b,k}\}$ *while their export sales increase with productivity and product quality.*

3 Empirical implementation

We first infer the quality cost at the firm-product level. We then 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.

3.1 Evaluating quality cost at the firm-product level

A major challenge is the measurement of quality at the firm-product level θ_f^k. 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 ε_j^k), a lower productivity (φ^k), or a higher unit cost (ω_i^k), even though product quality is lower. In addition, we cannot rely on the methodology developed in Khandelwal (2010) which assigns a higher quality to varieties with higher market shares, conditional on prices. This approach assumes that consumers identify the quality of each product. Under information asymmetry, consumers consider only average quality. Furthermore, we cannot use input prices at the firm level as in Bastos et al. (2018). 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.

Instead of estimating the quality of products perceived by foreign consumers, we evaluate the cost associated with quality $(\theta_f^k)^{\alpha^k}$. We rely on the price equation (5) in which the cost competitiveness index is specific to the firm-product pair, while the other components of price are specific either to the destination country-product pair or to the origin country-product pair. Taking logs in (5), we first regress prices as follows

$$\ln p_{ij,f}^k = FE_i^k + FE_j^k + FE_f^k + \epsilon_{ij,f}^k. \tag{20}$$

where f indexes individual firms and $\epsilon_{ij,f}^k$ represents the error term (firm-specific trade cost shocks) while $FE_i^k \equiv \log \omega_i^k$, $FE_j^k \equiv \log \frac{\varepsilon_j^k}{\varepsilon_j^k - 1} \tau_{ij}^k T_{ij}^k$, and $FE_f^k \equiv \log \Phi_f^k$. FE_i^k and FE_j^k are the origin country-product and destination country-product fixed effects, respectively. As our sample includes only one origin country (France), origin country-product fixed effects FE_i^k can be omitted (FE_i^k is a constant). The fixed effects FE_j^k capture trade costs and markups and are assumed to be common to all exporters producing the same product and serving the same destination country. According to (5), the estimated (denoted with a hat) fixed effects $\widehat{FE}_f^k$ from (20) should be equal to the log of the inverse of the cost competitiveness index defined at the firm level, e.g., $FE_f^k = \ln(\Phi_f^k)^{-1}$ (or, equivalently, the marginal production cost up to a constant). Hence, using the definition of $\Phi_f^k = \varphi_f^k(\theta_f^k)^{-\alpha^k}$, we have

$$FE_f^k = -\ln \varphi_f^k + \alpha^k \ln \theta_f^k. \tag{21}$$

Because we have information on productivity only at the firm level (and not at the firm-product pair level), we have to control for heterogeneity in productivity in 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 efficiency φ_f^k (its rank 1).[11] Expanding the product lines and moving away from the core competence of the firm decreases efficiency. The within-firm ranking of

[11] 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.

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. Hence, we assume that $\varphi_f^k = \varphi_f(\text{rank}_f^k)^{-\kappa}$, where κ is expected to be positive. Inserting this equality in (21), we use the following OLS regression to infer quality:

$$\widehat{FE}_f^k + \ln \varphi_f = \kappa \ln \text{rank}_f^k + \lambda^k + \lambda_f^k \tag{22}$$

where the term λ^k is a product fixed effect representing the quality cost that is specific to each product and is common across firms, while the term λ_f^k is a product-firm deviation. The latter term plays the role of the estimation error. Then, the estimated parameters and the residual of the regression define the estimated quality cost of product-firm pairs $\hat{\zeta}_f^k$ with

$$\hat{\zeta}_f^k \equiv \hat{\lambda}^k + \hat{\lambda}_f^k = \ln(\theta_f^k)^{\alpha^k}. \tag{23}$$

The intuition behind this approach is that a higher quality cost is assigned to firm-product pairs that have higher unit values, conditional on productivity. In addition, from (22), we can also infer the productivity of each product-firm pair, given by

$$\hat{\varphi}_f^k = \varphi_f(\text{rank}_f^k)^{-\hat{\kappa}}. \tag{24}$$

In the empirical analysis, the quality cost and productivity are further interacted with the number of QSs to study the impact of such standards across firms with different quality costs and productivity levels.

Discussion. Our strategy for the computation of the quality cost deserves some comments. First, our measure relies on productivity. If the latter is biased, our quality cost index will be impacted. As a result, we consider different measures of productivity to assess the robustness of our results.

Second, our functional form supposes that markups are captured through the destination country-product fixed effects. In other words, we assume that markups are common to all firms exporting the same product to the same destination. However, there is evidence showing that larger firms may charge higher markups (Edmond et al., 2015). If markups differ among firms, our quality cost index may be impacted. To make sure that our main results are not biased, we conduct a robustness test (see section 4.3) where we control for markups in the computation of the quality cost (e.g. in (22)). To build markups, we rely on Edmond et al. (2015) and proceed as follows: (i) we compute the market share of each firm in the total imports of a product in a given destination; (ii) we sum these market shares across all destinations; (iii) we compute the number of destinations where at least one firm exports the product in question; (iv) we divide the sum of the market shares by the number of destinations. This ratio is our proxy for markups.

Third, we compare our quality measure with those usually used in the literature and relying on demand equations (Khandelwal, 2010; Khandelwal et al., 2013). Such approaches assume perfect information on product quality so that higher quality is assigned to varieties with a higher price conditional on productivity. Even if these measures would be "inconsistent" with our theoretical model, they appear to be highly correlated with our quality measure (correlation around 0.7), suggesting that our approach provides suitable quality evaluation.

3.2 Datasets

QSs. Our empirical study relies on the TRAINS NTM database released by the UNCTAD.[12] 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 allow for a finer classification of the measures.[13] For our analysis, we retain the first 15 chapters,

[12] 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 B2 in Appendix B for the list of countries).

[13] Table B1 in Appendix B 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

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 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 SPSs and TBTs (e.g. QSs), as well as other import-related NTMs imposed by each importing country on a given HS6 product.[14] Unfortunately, the TRAINS NTM database lists the existing NTMs but does 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. Indeed, 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 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

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.

[14]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.

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.[15] 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.[16] 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. 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.[17]

Table B3 in Appendix B 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 to the United States. Second, the share of French products effectively affected by at least one

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

[16] 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.

[17] Unfortunately, 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.

[18] Table B4 in Appendix B reports the same statistics for other import-related NTM measures.

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). 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).

4 Econometric analysis and results

This section empirically tests for the theoretical predictions reported in Propositions 1 and 2 on the impact of QSs on the extensive and intensive export margins according to the characteristics of the firms. As we do not know in practice whether exporters in our sample hide or

[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.

disclose information in foreign markets, we have to consider three cases: (i) no firm invests in quality signaling; (ii) all firms disclose quality; (iii) only a fraction of firms (e.g. the high-productivity firms selling high-quality products) disclose information. This implies different empirical specifications.

4.1 Extensive margin

Econometric specification. We explore the impact of QSs on the presence of a firm in a given product-destination market.[21] Our dependent variable (y^k_{fj}) 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 becomes:

$$\begin{aligned} y^k_{fj} &= \alpha_1 QS^k_j + \alpha_2 QS^k_j \times \varphi^k_f + \alpha_3 QS^k_j \times \zeta^k_f + \alpha_4 QS^k_j \times (\zeta^k_f)^2 \\ &\quad + \text{controls}^k_j + \text{controls}^k_{fj} + \text{FE}^k_f + \text{FE}_{fj} + \varepsilon^k_{fj}, \end{aligned} \tag{25}$$

where QS^k_j is the number of QSs (SPS and TBT measures) applied to product k by destination country j. Among the explanatory variables, the estimated equation first includes three interaction terms. The interaction term between the number of QSs and the exporting firm-product's productivity in logs (φ^k_f) aims to capture a possible reallocation effect across low- and high-productivity exporters. We expect that $\alpha_1 < 0$ and $\alpha_2 > 0$, regardless of the disclosure choice made by exporters.

In addition, the effects of QSs for different levels of firm-product quality is identified by the interaction term between the number of standards and the quality cost (in logs) of the exporting firm for that product (ζ^k_f) and the interaction term between the number of QSs and the squared firm-product quality cost in logs ($(\zeta^k_f)^2$).[22] Hence, for a given productivity, we have $\frac{\partial y^k_{fj}}{\partial \zeta^k_f} = QS^k_j(\alpha_3 + 2\alpha_4 \zeta^k_f)$. If the majority of exporters (and even all of them) does not signal quality, we expect $\alpha_3 > 0$ and $\alpha_4 < 0$. Remember that, if firms do not disclose, the introduction of QSs under information asymmetry makes the relationship between product quality and the export probability non-monotonic and bell-shaped for a given productivity

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

[22] To avoid negative values, quality has been rescaled to a minimum of zero.

(Figure 1). Low- and high-quality firms are less likely to export than medium-quality firms for a given productivity. By contrast, if the majority of exporters (and even all of them) disclose, we expect $\alpha_3 > 0$ and $\alpha_4 \geq 0$. Indeed in case of information disclosure, the probability of export increases with quality for a given productivity (Figure 2).

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 then consider a second estimation in which 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 thus investigate the impact of QSs for six different types of firms (low- vs. high-productivity and low- vs. medium- vs. high- quality firms). The estimated equation is as follows:

$$\begin{aligned} y_{fj}^k &= \beta_1 QS_j^k \times \varphi_1 \times \zeta_1 + \beta_2 QS_j^k \times \varphi_1 \times \zeta_2 + \beta_3 QS_j^k \times \varphi_1 \times \zeta_3 \\ &\quad + \beta_4 QS_j^k \times \varphi_2 \times \zeta_1 + \beta_5 QS_j^k \times \varphi_2 \times \zeta_2 + \beta_6 QS_j^k \times \varphi_2 \times \zeta_3 \\ &\quad + \text{controls}_j^k + \text{controls}_{fj}^k + \text{FE}_f^k + \text{FE}_{fj} + \varepsilon_{fj}^k, \end{aligned} \tag{26}$$

According to Proposition 2, we expect that $\beta_1 < 0$, $\beta_3 < 0$, and $\beta_2 > \beta_1, \beta_3$ while $\beta_6 > \beta_5 > \beta_4 > 0$. We implicitly assume that firms with higher (resp. lower) than median productivity invest (resp. do not invest) in quality signaling. Consequently, the probability of export is higher for low-productivity medium-quality firms than for low-productivity firms selling products with either low quality or high quality. In addition, if high-productivity firms disclose, then our model predicts that the operating profits associated with a destination increase with product quality.

Both equations (25) and (26) include 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 (see Appendix A.3). 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).[23]

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. 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), 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.[24]

Results. Table 1 presents the results related to the estimation of equation (25). In columns 1 and 2, sales per employee are considered for the computation of the productivity at the firm level, while value added per employee is used in columns 3 and 4. Overall, QSs decrease the likelihood that a firm will participate in the export market. However, in line with our theoretical predictions, QSs increase the export participation of high-productivity and medium-quality firms at the expense of low-productivity and high-quality firms. Indeed, we obtain a negative and significant coefficient on the number of QSs but a positive and significant one on the interaction term between the number of QSs and the productivity of a firm (columns 1 and 2). Besides, the coefficient on the interaction term between the number of standards and the quality of a firm for a given product is positive and significant, while the one estimated on the interaction term between the number of QSs and the squared firm-product quality is negative and significant (column 2). These opposite effects for the two interaction terms between QSs and quality and QSs and squared quality also suggest that a large fraction of firms in our

[23] The cross-section analysis is affected by the restriction on QS and other import-related NTM data (see Section 3.2). 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.

[24] 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.

sample does not invest in quality signaling.

According to column 2, one additional QS reduces the probability that a firm exports product k to market j by 7 percentage points. However, the most productive firms benefit from a higher level of export participation compared to the least productive firms, which are negatively affected. One additional QS raises the export probability of the most productive firms by 1 percentage point. Furthermore, high-quality firms are negatively impacted by QSs. One additional QS decreases their export probability by 0.1 percentage point.

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

Table 2 presents the estimation results of equation (26). This table goes one step further and decomposes the effects highlighted in Table 1 by type of firms. Two differen 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 three first 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, and especially if they provide a medium or high quality product. The magnitude and significance of the coefficient estimates are stronger for the last two interaction terms (e.g. quality in the middle range and in the upper quartile). This result suggests that the product quality supplied by high-productivity firms seems to be observed by foreign consumers.

Insert Table 2 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 2). As a result, we estimate the following specification:

$$\begin{aligned} r^k_{fj} \quad &= \quad \delta_1 QS^k_j \times \varphi_1 \times \zeta_1 + \delta_2 QS^k_j \times \varphi_1 \times \zeta_2 + \delta_3 QS^k_j \times \varphi_2 \times \zeta_1 + \delta_4 QS^k_j \times \varphi_2 \times \zeta_2 \\ &\quad + \text{controls}^k_j + \text{controls}^k_{fj} + \text{FE}^k_f + \text{FE}_{fj} + \varepsilon^k_{fj}, \end{aligned} \tag{27}$$

where r^k_{fj} denotes exports (logs) either in value or in volume of product k by firm f to destination country j. As previously described, QS^k_j 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 (27) at the product-destination and firm-product-destination levels are the same as those used for the estimation of the extensive trade margin. Finally, ε^k_{fj} is the error term, and errors are clustered at the product-destination level.

Results. Table 3 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. These results confirm our previous findings on the extensive margin. 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.

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 3 here

Simulations. We conduct some simulations to quantify the economic effects of QSs on French firms according to their level of productivity and quality. To do so, we use an econometric model in which productivity and quality are continuous variables instead of discrete variables. Hence, we estimate the following specification:

$$\begin{aligned} r_{fj}^{k} &= \gamma_1 QS_j^k + \gamma_2 QS_j^k \times \varphi_f^k + \gamma_3 QS_j^k \times \zeta_f^k + \gamma_4 QS_j^k \times \varphi_f^k \times \zeta_f^k \\ &\quad + \text{controls}_j^k + \text{controls}_{fj}^k + \text{FE}_f^k + \text{FE}_{fj} + \varepsilon_{fj}^k, \end{aligned} \tag{28}$$

The estimation results of equation (28) are reported in Table B5 in Appendix B. Quantifications below rely on results obtained when firm's productivity is computed using the sales per employee (columns 1 and 2). We highlight an overall negative effect of QSs on the trade intensive margin ($\hat{\gamma}_1 + \hat{\gamma}_2\varphi_f^k + \hat{\gamma}_3\zeta_f^k + \hat{\gamma}_4\varphi_f^k\zeta_f^k < 0$). One additional QS leads to a decrease in the firm exports (in volume and value) by approximately 24 percentage points. Furthermore, QSs induce a reallocation effect in terms of export sales (volume and value) from the least productive firms to the most productive firms for a given quality of products. Indeed, we have $\frac{\partial^2 r_{fj}^k}{\partial QS_j^k \partial \varphi_f^k} = \hat{\gamma}_2 + \hat{\gamma}_4 \times \zeta_f^k > 0$ for all observations and $\hat{\gamma}_2 > 0$ and $\hat{\gamma}_4 < 0$ in all estimations. By contrast, the QS effect on export sales with respect to quality depend on firm's productivity, as expected. Indeed, $\frac{\partial^2 r_{fj}^k}{\partial QS_j^k \partial \zeta_f^k} = \hat{\gamma}_3 + \hat{\gamma}_4 \times \varphi_f^k$ is significantly negative for the less productive firms (40.1% of firms) and significantly positive for the more productive firms (59.9% of firms).

To quantify the impact of QSs on the export value at the intensive margin, we set the number of QSs for product k to the maximum number observed across all destinations j. 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, firms have to comply with additional and potentially different standards when exporting. Their compliance costs increase, and their exports are affected. With our simulation exercise, we derive order of magnitude predictions regarding firms' exports.

According to our results, if all export destinations served by French firms adopted the maximum number of QSs observed for a product, 54% of French firms would suffer from this change and their export value would decrease by 35.2% (21.9 billion euros). By contrast, 46% of firms would benefit from this rise in the number of QSs and their export value would increase by 21% (4.8 billion euros). All in all, the overall effect on French exports would be negative (- 20% of exports, i.e. 17.1 billion euros).

4.3 Robustness checks

We proceed to a series of sensitivity tests to confirm the robustness of our results. We focus on estimations including interaction terms between the number of QSs and the productivity and quality levels, which are our preferred ones. We present the results in Table B6 (extensive margin), Table B7 (intensive margin, export volume), and Table B8 (intensive margin, export value) in Appendix B.[25] All estimations rely on firm-product and firm-destination fixed effects, which is our preferred set of fixed effects because of its consistency with the unit of observation in the theoretical model and its ability to capture unobservable characteristics at the firm-product and firm-destination levels.

First, 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 1). The use of the maximum price is driven by the theoretical model, but unfortunately, is likely to be endogenous. In column 2, we cluster our standard errors at the firm level. In column 3, we use an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level (see footnote 13 in the data section). We then test the robustness of our previous conclusions, relying only on SPS measures (column 4). Indeed, some of the TBTs do not necessarily affect the quality of products (e.g. some labels). Column 5 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. Finally, column 6 controls for markups set by firms. We build markups as described in section 3.1.

[25]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.

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 B7), 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), controlling for the number of French exporters (column 5), and for markups set by firms (column 6) do not affect our results.

5 Average quality

We now investigate the impact of QSs on the average quality of products exported by French firms to the different markets.

5.1 Back to the model

Given our assumptions, the average quality of products delivered in a foreign country is solely affected by the extensive margin (the number of exporting firm-product pairs). The effect of a QS on this average quality is however quite complex as we capture different competing effects.

First, the introduction of a QS forces low-quality firms – unable to comply with the requirements – to exit, regardless of their productivity. Thus for unchanged quality cutoff curve ($\widehat{\theta}_{ij}^{k}(\varphi)$) and signaling cutoff curve ($\tilde{\theta}_{ij}^{k}(\varphi)$), the average quality of the products available on the market increases.

Second, the productivity cutoff (φ_{ij}^{k}) increases with the enforcement of QSs. Low-productivity firms that do not disclose exit the market. However, a rise in the productivity cutoff may induce a lower quality cutoff (equation (10)) for non-signaling firms. The formal demonstration is reported in Appendix A.4, while we provide the basic intuitions in what follows. For a given $\widehat{\theta}_{ij}^{k}(\varphi)$, a QS makes competition tougher among the incumbents by excluding low-quality firms from the market, as the quality ladder $\hat{\theta}_{ij}^{k}/\bar{\theta}_{j}^{k}$ shrinks (this effect is captured through a lower price index). This stronger competition induces the exit of high-price – e.g. high-quality low-productivity – firms that do not disclose, consumers' choice being based on price. This competition results in the reallocation of market shares from high-quality low-productivity to medium-quality low-productivity incumbents with no signaling activity. Indeed, the latter sell their products for lower prices than the former. Hence, following the enforcement of a QS, the productivity cutoff φ_{ij}^k increases and the quality cutoff curve $\widehat{\theta}_{ij}^k(\varphi^k)$ rotates in a clockwise direction about the point ($\varphi^k = 0$; $\theta^k = 0$).

Clearly, there are winners and losers among low-productivity firms that do not disclose following the introduction of the QS. A QS does not help high-quality low-productivity firms but rather makes low-productivity firms supplying a quality product at a level just above the QS more profitable. Hence, a QS drives low-quality and high-quality products supplied by low-productivity firms away from the market.[26]

The effect of a QS on signaling cutoff curve is also unclear. The formal discussion is reported in Appendix A.4. A stricter QS has two different effects on the signaling cutoff curve (a direct effect and an indirect effect through productivity cutoff φ_{ij}^k). For a given productivity cutoff, the curve shifts downward. However, by raising the productivity cutoff, a stricter QS may rise the signaling cutoff curve. In this case, less firms disclose and the average quality of varieties may decrease. Hence, *the impact of a QS on average quality is ambiguous under information asymmetry.* Even though low-quality products exit the market, high-quality varieties produced by low-productivity firms may also be excluded and the number of disclosing firms may decrease.

5.2 Evaluating average quality at the country pair-product level

We now explore which effect dominates empirically. This section first presents the computation of the average quality and the estimated equation. The results are then reported and discussed.

As consumers perfectly observe the average quality of all varieties of a foreign product available in their home market, we can use tools-based demand equations to infer the average quality of the traded products (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 ($(\bar{\theta}_{ij}^k)^{\beta_j^k}$), we use the macro-level bilateral trade equation given by $R_{ij}^k = N_i^k \int_{\Phi_{ij}^k}^{\infty} r_{ij}^k dG_i(\Phi^k)$, where N_i^k is the total number of firm-product pairs in country i and product

[26] Ronnen (1991) also obtains this result from a different framework. He considers that firms are price makers but use the same technology. The exit of high-quality firms occurs even if these firms can supply better quality. By its nature, a QS limits the range in which sellers can differentiate the quality of their products. As shown by Ronnen (1991), price competition becomes fiercer despite the high-quality sellers' efforts to relax it by increasing the quality of their products. We get a similar result by considering firms that differ in efficiency. Similar to Ronnen (1991), high-quality sellers are worse off even though they have already met the standard in the absence of regulation as they suffer from more intense price competition.

k. We use a specific parametrization process for this distribution to facilitate the computation of the analytical solutions. In particular, it is assumed that Φ^k follows a Pareto distribution $g_i(\Phi^k)$ with a low competitiveness index bound $\underline{\Phi}_i^k$ and a shape parameter h_i^k. Thus, using (5), the average export sale is given by:

$$\bar{r}_{ij}^k = \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon_j^k-1)} A_j^k \left(\frac{\varepsilon_j^k}{\varepsilon_j^k-1}\omega_i^k\tau_{ij}^k T_{ij}^k\right)^{-(\varepsilon_j^k-1)} \frac{h_i^k}{h_i^k-(\varepsilon_j^k-1)} \left(\Phi_{ij}^k\right)^{\varepsilon_j^k-1}. \tag{29}$$

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). T_{ij}^k represents the applied protection set by country j on its imports of product k from country i. It follows that $\overline{P}_{ij}^k T_{ij}^k = N_{ij}^k \bar{r}_{ij}^k / Q_{ij}^k$ with $Q_{ij}^k = N_{ij}^k \bar{q}_{ij}^k$ where N_{ij}^k is the total number of firms producing in country i and selling product k in country j and $\bar{q}_{ij}^k$ is the average export quantity. Standard calculations reveal that:

$$\overline{P}_{ij}^k = \frac{\int_{\Phi_{ij}^k}^{\infty}\left(p_{ij}^k\right)^{-(\varepsilon_j^k-1)} \mathrm{d}G_i(\Phi^k)}{\int_{\Phi_{ij}^k}^{\infty}\left(p_{ij}^k\right)^{-\varepsilon_j^k} \mathrm{d}G_i(\Phi^k)} = \frac{\varepsilon_j^k}{\varepsilon_j^k-1}\omega_i^k\tau_{ij}^k \frac{h_i^k-\varepsilon_j^k}{h_i^k-(\varepsilon_j^k-1)} \left(\Phi_{ij}^k\right)^{-1}. \tag{30}$$

Using $\bar{q}_{ij}^k = \bar{r}_{ij}^k / (\overline{P}_{ij}^k T_{ij}^k)$, (29) and (30) yield:

$$Q_{ij}^k = N_{ij}^k \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon_j^k-1)} A_j^k \frac{h_i^k}{h_i^k-\varepsilon_j^k} \left(\overline{P}_{ij}^k T_{ij}^k\right)^{-\varepsilon_j^k}. \tag{31}$$

Equation (31) 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 $N_{ij}^k \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon_j^k-1)}$ can be estimated as the residual of the following regression:

$$\ln Q_{ij}^k + \varepsilon_j^k \ln\left(\overline{P}_{ij}^k T_{ij}^k\right) = FE_i^k + FE_j^k + \lambda_1 CL_{ij} + \lambda_2 CB_{ij} + \lambda_3 CT_{ij} + \lambda_{ij}^k, \tag{32}$$

where $\lambda_{ij}^k = \ln N_{ij}^k + (\varepsilon_j^k - 1)\ln(\bar{\theta}_{ij}^k)^{\beta_j^k}$, $FE_i^k = \frac{h_i^k}{h_i^k - \varepsilon_j^k}$, and $FE_j^k = A_j^k$. Thus, the average quality perceived by the foreign consumers can be expressed as $\ln(\bar{\theta}_{ij}^k)^{\beta_j^k} = (\widehat{\lambda}_{ij}^k - \ln N_{ij}^k)/(\varepsilon_j^k - 1)$.

Equation (32) 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 (ε_j^k) come from Broda et al. (2006), while tariff data are extracted from the Market Access Map (MAcMap) database. Finally, information on common language, contiguity and past colonial ties is obtained from the CEPII GeoDist database.[27] 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).[28]

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 (32), 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 $\lambda_{ij}^k = \ln N_{ij}^k + (\varepsilon_j^k - 1)\ln(\bar{\theta}_{ij}^k)^{\beta_j^k}$, 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.

5.3 Econometric specification and results

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

$$\ln\widehat{(\bar{\theta}_{ij}^k)^{\beta_j^k}} = \gamma_1 QS_j^k + \text{controls}_j^k + \text{FE}^k + \text{FE}_j + \epsilon_j^k, \tag{33}$$

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

[27] 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 3.2. 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.

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

enforced by destination j on product k. The estimation also controls for the number of other import-related NTMs and includes product and destination fixed effects (FE^k and FE_j). ϵ_j^k is the error term.

Results. Table 4 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. 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.[29]

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 high-

[29] 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.

lighted for QSs. Other NTMs do not reduce information asymmetries with respect to the quality 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 4 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 and on 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 failure leads to the exit of low-quality firms that are not able to satisfy the requirements, regardless of their productivity. However, low-productivity high-quality firms are also excluded from the market. 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 implement a new method to infer quality at the firm-product level. 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). Among firms with a lower than median productivity, medium-quality firms exhibit the highest export probabilities and export sales. 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.

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Figure 1: Cutoff-quality curve (without signaling activity)

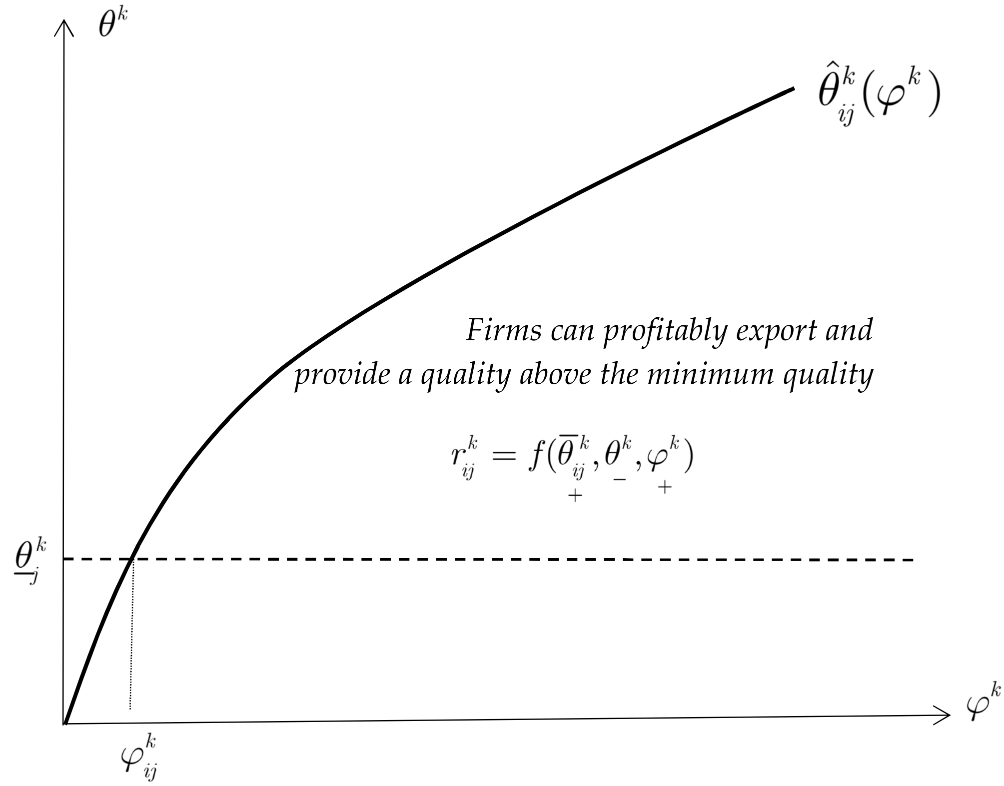

Figure 2: Cutoff-quality curve (with signaling activity)

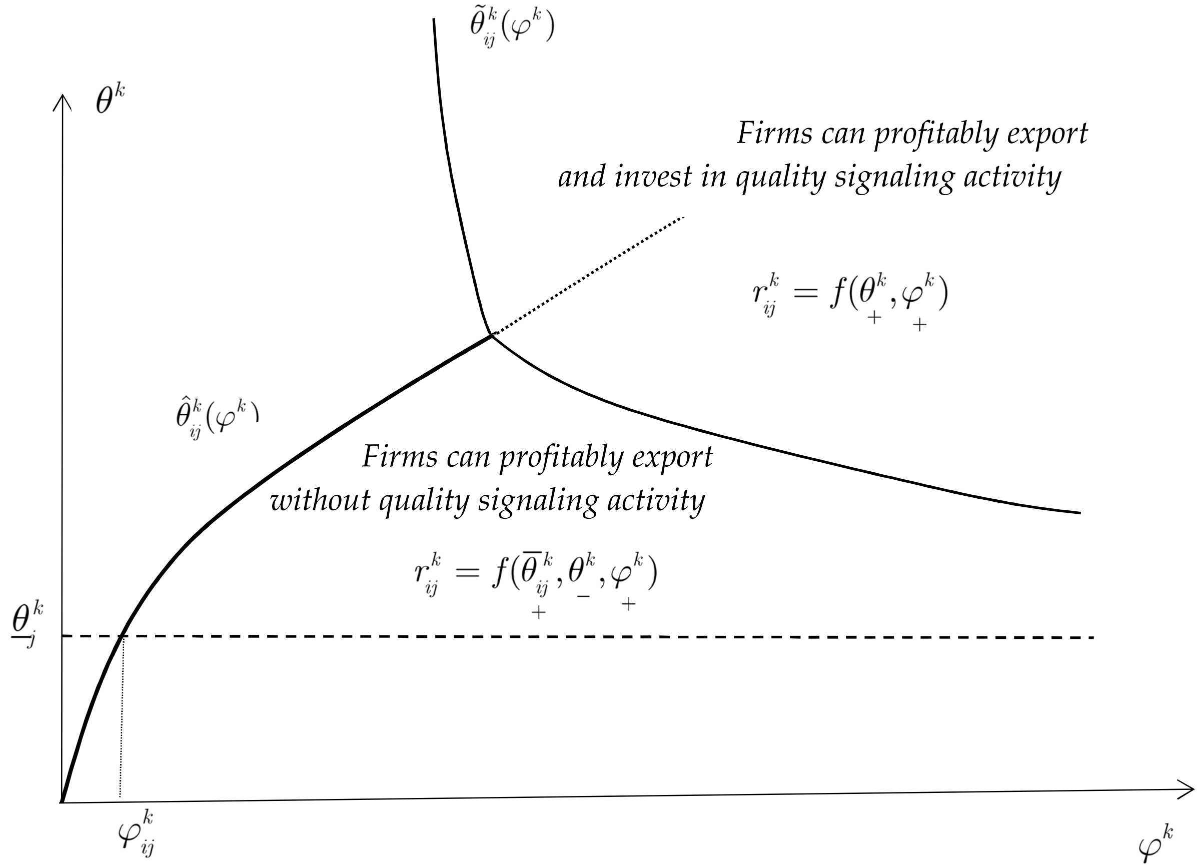

Table 1: Extensive margin: Export participation

Productivity measure	Export participation			
	Sales per employee		Value added per employee	
	(1)	(2)	(3)	(4)
Nb. QSs_j^k	-0.006[a]	-0.007[a]	-0.007[a]	-0.008[a]
	(0.0003)	(0.0004)	(0.0003)	(0.0004)
Nb. QSs_j^k X Ln $productivity_f^k$	0.001[a]	0.001[a]	0.002[a]	0.002[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $quality_f^k$		0.001[a]		0.001[a]
		(0.0001)		(0.0001)
Nb. QSs_j^k X Ln squared $quality_f^k$		-0.0001[a]		-0.0001[a]
		(0.0000)		(0.0001)
Nb. other import-related $NTMs_j^k$	-0.0002	-0.0001	-0.0002	-0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Ln applied $protection_j^k$	-0.005[a]	-0.005[a]	-0.005[a]	-0.005[a]
	(0.001)	(0.001)	(0.001)	(0.002)
Ln $imports_j^k$	0.001[a]	0.001[a]	0.001[a]	0.001[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Firm already present in $t\text{-}1_{fj}^k$	0.425[a]	0.420[a]	0.424[a]	0.420[a]
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	6,912,955	6,487,821	6,752,310	6,336,454
Adjusted R^2	0.462	0.460	0.461	0.458
Fixed effects:				
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	Yes	Yes	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 (columns 1-2) and value-added per employee (columns 3-4). Robust standard errors in parentheses, clustered by HS6 product-destination level, with [a] denoting significance at the 1% level.

Table 2: Extensive margin: Export participation, by types 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%	-0.001^a	-0.001^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ middle range	-0.001^a	-0.001^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ top 25%	-0.001^a	-0.001^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ bottom 25%	0.0003^b	0.0001
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ middle range	0.001^a	0.001^a
	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ top 25%	0.001^a	0.001^a
	(0.0001)	(0.0001)
Nb. other import-related $NTMs_j^k$	-0.0001	-0.0002
	(0.0002)	(0.0002)
Ln applied $protection_j^k$	-0.005^a	-0.005^a
	(0.001)	(0.001)
Ln $imports_j^k$	0.001^a	0.001^a
	(0.0001)	(0.0001)
Firm already present in $t\text{-}1_{fj}^k$	0.420^a	0.419^a
	(0.002)	(0.002)
Observations	6,487,821	6,336,507
Adjusted R^2	0.460	0.458
Fixed effects:		
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	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] and [b] denoting significance at the 1% and 5% level respectively.

Table 3: Intensive margin: Volume and value of exports, by types 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 $quality_f^k$ < median	-0.016[a]	-0.016[a]	-0.017[a]	-0.017[a]
	(0.004)	(0.004)	(0.005)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ > median	-0.024[a]	-0.023[a]	-0.025[a]	-0.024[a]
	(0.005)	(0.005)	(0.006)	(0.006)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ < median	0.001	0.002	0.008	0.008
	(0.005)	(0.005)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ > median	0.013[a]	0.014[a]	0.009[b]	0.009[b]
	(0.004)	(0.004)	(0.004)	(0.004)
Nb. other import-related $NTMs_j^k$	-0.006	-0.004	-0.000	-0.002
	(0.011)	(0.011)	(0.011)	(0.011)
Ln applied $protection_j^k$	-0.433[b]	-0.463[a]	-0.516[a]	-0.551[a]
	(0.186)	(0.177)	(0.183)	(0.175)
Ln $imports_j^k$	0.060[a]	0.064[a]	0.058[a]	0.061[a]
	(0.008)	(0.008)	(0.008)	(0.008)
Firm already present in $t\text{-}1_{fj}^k$	0.663[a]	0.686[a]	0.660[a]	0.680[a]
	(0.019)	(0.018)	(0.019)	(0.018)
Observations	119,571	122,831	115,101	118,023
Adjusted R^2	0.736	0.675	0.738	0.676
Fixed effects:				
$Firm\text{-}Product_{fk}$ & $Firm\text{-}Destination_{fj}$	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] and [b] denoting significance at the 1% and 5% level respectively.

Table 4: 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*. 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). 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. Robust standard errors in parentheses, with ^{a}, ^{b} and ^{c} denoting significance at the 1%, 5% and 10% level respectively.

Appendix

Appendix A.1. Quality and demand

Maximizing (1) subject to the budget constraint $E_j^k = \int_{\Omega_j^k} p(\nu)q(\nu)\mathrm{d}\nu$, where Ω_j^k is the set of varieties available in country j leads to the following demand for a variety produced in country i:

$$q_{ij}^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon_j^k-1)} \left[\sum_\ell \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon_j^k-1}{\varepsilon_j^k}} [q_{\ell j}^k(\nu)]^{\frac{\varepsilon_j^k-1}{\varepsilon_j^k}} \mathrm{d}\nu \right]^{\frac{\varepsilon_j^k}{\varepsilon_j^k-1}} [p_{ij}(v)]^{-\varepsilon_j^k} / \lambda^\varepsilon$$

where λ is the Lagrange multiplier and $\Omega_{\ell j}^k$ is the set of varieties produced in country ℓ that are available in country j. Therefore, the expenditures for a variety are:

$$p_{ij}^k(\nu)q_{ij}^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon_j^k-1)} \left[\sum_\ell \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon_j^k-1}{\varepsilon_j^k}} [q_{\ell j}^k(\nu)]^{\frac{\varepsilon_j^k-1}{\varepsilon_j^k}} \mathrm{d}\nu \right]^{\frac{\varepsilon_j^k}{\varepsilon_j^k-1}} [p_{ij}(v)]^{1-\varepsilon_j^k} / \lambda^\varepsilon \tag{A. 1}$$

Plugging (A.1) in the budget constraint yields:

$$E_j^k = \lambda^{-\varepsilon_j^k} \left[\sum_\ell \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon_j^k-1}{\varepsilon_j^k}} [q_{\ell j}^k(\nu)]^{\frac{\varepsilon_j^k-1}{\varepsilon_j^k}} \mathrm{d}\nu \right]^{\frac{\varepsilon_j^k}{\varepsilon_j^k-1}} \left[\sum_\ell \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon_j^k-1}{\varepsilon_j^k}} [p_{ij}^k(\nu)]^{1-\varepsilon_j^k} \mathrm{d}\nu \right] \tag{A. 2}$$

Using (A.1) and (A.2), we obtain (2):

$$p_{ij}^k(\nu)q_{ij}^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon_j^k-1)} E_j^k (P_j^k)^{\varepsilon_j^k-1} [p_{ij}^k(\nu)]^{-(\varepsilon_j^k-1)}$$

with

$$P_j^k = \left[\sum_\ell \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k(\varepsilon_j^k-1)} [p(\nu)]^{-(\varepsilon_j^k-1)} \mathrm{d}\nu \right]^{\frac{-1}{\varepsilon_j^k-1}}.$$

Appendix A.2. Endogenous product quality

In this appendix, we check whether our main results hold when firms endogenously select their product quality. We consider that only the quality of products supplied by domestic firms is perfectly observed by consumers (information asymmetry still occurs for foreign products). Each producer determines the quality of its variety by considering only the domestic market. For simplicity of notation, we drop the product index k.

As in the industrial organization literature, we assume that quality production is associated with fixed costs (Sutton, 2007). Improving product quality leads to fixed expenses associated with activities such as R-D, advertising, and quality control. The investment cost in the quality of variety is given by $\frac{1}{\xi}\frac{\theta^\gamma}{\gamma}$, where γ is the quality-elasticity of the fixed costs and ξ is the ability to produce quality, as in Hallak and Sivadasan (2013). Hence, fixed costs are increasing in quality and can vary across firms. The domestic demand for a local variety is given by $q_{ii} = [\theta_i]^{\varepsilon-1} E_i P_i^{\varepsilon-1} [p_{ii}]^{-\varepsilon}$ in which we have θ_i instead of the average quality as consumers perfectly observe the quality selected by the domestic producers. The profit associated with domestic sales is $\pi_{ii} = p_{ii}q_{ii} - \frac{[\theta_i]^\alpha}{\varphi} q_{ii} - \frac{1}{\xi}\frac{[\theta_i]^\gamma}{\gamma}$. We assume that, without a loss of generality, the distribution costs in the home country are negligible ($\tau_{ii} = 1$ and $f_{ii} = 0$). Hence, higher product quality shifts out demand (under perfect information) but increases marginal and fixed costs. The profit-maximizing price is $p_{ii} = \frac{\varepsilon}{\varepsilon-1}\frac{[\theta_i]^\alpha}{\varphi}$, while profit-maximizing quality is such that:

$$(\varepsilon-1)(1-\alpha)\frac{r_{ii}}{\varepsilon} = \frac{[\theta_i]^\gamma}{\xi}. \tag{A. 3}$$

Using the equilibrium price and demand, profit-maximizing quality is expressed as follows:

$$\theta_i(\varphi,\xi) = \left[\left(\frac{(\varepsilon-1)(1-\alpha)}{\varepsilon}\right)^{\frac{1}{\varepsilon-1}} \xi^{\frac{1}{\varepsilon-1}} \varphi P_i E_i^{\frac{1}{\varepsilon-1}} \frac{\varepsilon-1}{\varepsilon}\right]^\Gamma \tag{A. 4}$$

with $\Gamma \equiv \frac{\varepsilon-1}{\gamma-(\varepsilon-1)(1-\alpha)}$. The second order condition requires that $\Gamma > 0$. If the last inequality was not satisfied, firms would produce at the minimum quality level. The level of quality adopted by a firm increases with its productivity and its ability to produce quality. Plugging (A.1) into the profit equation yields:

$$\pi_{ii}(\xi,\varphi) = \frac{1}{\xi}\frac{[\theta(\xi,\varphi)]^\gamma}{\gamma}\frac{\gamma-(\varepsilon-1)(1-\alpha)}{(\varepsilon-1)(1-\alpha)} \tag{A. 5}$$

Using (A.2), it follows that π_{ii} increases with $\xi^{\frac{1-\alpha}{\gamma}}\varphi \equiv \Phi$. It follows that, in our model, the relevant index is Φ, which is equivalent to a competitiveness index. This index decreases with the quality-elasticity of fixed and variable costs as the advantage in terms of ability to produce quality declines. Hence, there exists a minimum competitiveness index (Φ_i such that $\pi_{ii}(\Phi_i) = 0$), above which quality $\pi_{ii}(\Phi) > 0$. Using $\pi_{ii}(\Phi_i) = 0$, profit-maximizing quality can be rewritten as follows:

$$\theta_i(\varphi,\xi) = \theta_i^{min}\left(\frac{\xi^{\frac{1-\alpha}{\gamma}}\varphi}{\Phi_i}\right)^\Gamma \tag{A. 6}$$

where θ_i^{min} is such that $\pi_{ii}(\theta_i^{min}) = 0$. Because product quality is increasing with firm productivity, the effect of productivity on prices is ambiguous. Some standard calculations show that the price is decreasing with productivity if $\gamma > \varepsilon - 1$. It follows that a firm producing in country i serves country j if and only if $\theta_i(\varphi,\xi) < \widehat{\theta}_{ij}$, or equivalently:

$$\varphi > \left(\frac{\theta_i^{min}}{\underline{\theta}_j}\frac{\phi_{ij}^\rho}{\Phi_i^\Gamma}\xi^{\frac{\Gamma(1-\alpha)}{\gamma}}\right)^{\frac{1}{\rho-\Gamma}} \tag{A. 7}$$

provided that $\gamma > \eta + \varepsilon - 1$. Under these circumstances, firms with high levels of productivity and a low ability to produce quality (and thus supplying a low quality product) gain market share when the QSs are enforced under information asymmetry.

Appendix A.3. The marginal firm

We show that:

$$\left(\bar{\theta}_{ij}^k\right)^{\beta(\varepsilon_j^k-1)} A_j^k = \varepsilon_j^k f_{ij}^k \left(\underline{\theta}_j^k\right)^{\eta^k} \left(\widehat{p}_{ij}^k\right)^{\varepsilon_j^k-1} \tag{A. 8}$$

where $\widehat{p}_{ij}^k$ is the highest price set by an exporter located in country i and serving country j. The marginal firm selling a variety with a quality $\underline{\theta}_j^k$ and with a productivity φ_{ij}^k is the firm with the highest price and the lowest export sales. We know that moving along the quality cutoff curve ($\widehat{\theta}_{ij}(\varphi)$), the profit is null. However, we do not know how price reacts along this curve as it depends negatively on productivity and positively on quality. The iso-price and iso-revenue curves (for serving a country) are given by $(\partial p_{ij}/\partial\varphi)\mathrm{d}\varphi + (\partial p_{ij}/\partial\theta)\mathrm{d}\theta = 0$ and $(\partial r_{ij}/\partial\varphi)\mathrm{d}\varphi + (\partial r_{ij}/\partial\theta)\mathrm{d}\theta = 0$, which implies:

$$\left.\frac{\mathrm{d}\theta}{\mathrm{d}\varphi}\right|_{\mathrm{d}p=0} = \left.\frac{\mathrm{d}\theta}{\mathrm{d}\varphi}\right|_{\mathrm{d}r=0} = \frac{1}{\alpha}\frac{\theta}{\varphi}$$

while we have $\partial\widehat{\theta}_{ij}/\partial\varphi = \rho\widehat{\theta}_{ij}/\varphi$. As $\rho < 1/\alpha$, prices decrease and export sales increase moving up along the quality cutoff curve $(\widehat{\theta}_{ij}(\varphi))$. Thus, there exists a maximum price $\widehat{p}^k_{ij}$ (or a minimum cost competitiveness index $\widehat{\Phi}^k_i$) such that $\pi^k_{ij}(\widehat{p}^k_{ij}, \underline{\theta}^k_j) = 0$, implying $\left(\bar{\theta}^k_{ij}\right)^{\beta(\varepsilon^k_j-1)} \left(P^k_j\right)^{\varepsilon^k_j-1} E^k_j = \varepsilon^k_j f^k_{ij} \left(\underline{\theta}^k_j\right)^{\eta^k} \left(\widehat{p}^k_{ij}\right)^{\varepsilon^k_j-1}$.

Appendix A.4. QS and average quality

In this Appendix, we show that a stricter QS induces a lower quality cutoff (equation (10)) and makes competition tougher among the non-signaling incumbents. We rewrite the export sales of firms that do not disclose as follows:

$$r^k_{ij}(\varphi^k, \theta^k, \underline{\theta}^k_j) = \varepsilon^k_j f^k_{ij}(\underline{\theta}^k_j)^{1/\rho^k} \left[\frac{\varphi^k/(\theta^k)^{\alpha_k}}{\varphi^k_{ij}}\right]^{\varepsilon^k_j-1} = f^k_{ij}\left(\underline{\theta}^k_j\right)^{\eta^k} \varepsilon^k_j \left(\frac{\Phi^k}{\Phi^k_{ij}}\right)^{\varepsilon^k_j-1}.$$

For a given productivity cutoff, a QS increases the sales of incumbent firms (due to the exit of low-quality firms not complying and the increase in the average quality). However, among these incumbents, the rise in sales is higher for those with a high productivity. Indeed, we have:

$$\frac{\partial r^k_{ij}(\varphi^k, \theta^k)}{\partial\varphi^k\partial\theta^k} < 0,\ \frac{\partial r^k_{ij}(\varphi^k, \theta^k)}{\partial\varphi^k\partial\underline{\theta}^k_j} > 0, \text{ and } \frac{\partial r^k_{ij}(\varphi^k, \theta^k)}{\partial\theta^k\partial\underline{\theta}^k_j} < 0.$$

As the market size E^k_j for product k in destination j is fixed, the sales of firms with no signaling activity and with quality just below the quality cutoff decrease when the market share of high-productivity medium-quality firms increases whereas the fixed costs of distribution are unchanged. Therefore, following the enforcement of the QS, the productivity cutoff φ^k_{ij} increases and the quality cutoff curve $\widehat{\theta}^k_{ij}(\varphi^k)$ rotates in a clockwise direction about the point $(\varphi^k = 0; \theta^k = 0)$ so that the quality ladder $\hat{\theta}^k_{ij}/\bar{\theta}^k_j$ shrinks (this effect is captured through a lower price index). This stronger competition induces the exit of high-price firms (i.e. low-productivity high-quality firms) that do not disclose, as the consumers make their choice based on price.

The effect of a QS on signaling cutoff curve is also unclear. Indeed, using (16) and (18), it is straightforward to check that:

$$\left.\frac{\partial\tilde{\theta}^{b,k}_{ij}}{\partial\underline{\theta}^k}\right|_{\tilde{\pi}^k_{ij}=0} = \left.\frac{-\partial\tilde{\pi}^k_{ij}/\partial\underline{\theta}^k}{\partial\tilde{\pi}^k_{ij}/\partial\tilde{\theta}^{b,k}_{ij}}\right|_{\tilde{\pi}^k_{ij}=0} < 0 < \left.\frac{\partial\tilde{\theta}^{b,k}_{ij}}{\partial\varphi^k_{ij}}\right|_{\tilde{\pi}^k_{ij}=0} = \left.\frac{-\partial\tilde{\pi}^k_{ij}/\partial\varphi^k_{ij}}{\partial\tilde{\pi}^k_{ij}/\partial\tilde{\theta}^{b,k}_{ij}}\right|_{\tilde{\pi}^k_{ij}=0} \tag{A. 9}$$

as long as $\beta^k > 1/\rho^k$. Thus, a stricter QS has two different effects on the signaling cutoff curve (a direct effect and an indirect effect through productivity cutoff φ^k_{ij}). For a given productivity cutoff, the curve shifts downward, as we assume $\beta^k_j > 1/\rho^k$. However, by raising the productivity cutoff, a stricter QS may rise the signaling cutoff curve. In this case, less firms disclose and the average quality of varieties may decrease. Hence, the effect of a stricter QS on signaling cutoff curve is unclear.

Appendix B. Additional tables

Table B1: 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 B2: 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 B3: Share (%) of HS6 products subject to QSs and average number of measures per HS6 product, by country

Country	Nb. of HS6 products exported by France	Share (%) of HS6 products with at least one QS		Avge. number of QS per HS6 product		Share (%) of French exports impacted by a QS
		All products	Products exported by France	All products	Products exported by France	
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 B4: 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 B5: Intensive margin: Volume and value of exports

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	-0.242[a]	-0.245[a]	-0.146[a]	-0.133[a]
	(0.050)	(0.051)	(0.022)	(0.020)
Nb. QSs_j^k X Ln $productivity_f^k$	0.046[a]	0.046[a]	0.036[a]	0.033[a]
	(0.010)	(0.010)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $quality_f^k$	0.020[b]	0.023[b]	0.005	0.003
	(0.010)	(0.010)	(0.011)	(0.011)
Nb. QSs_j^k X Ln $productivity_f^k$ X Ln $quality_f^k$	-0.004[b]	-0.004[b]	-0.002	-0.001
	(0.002)	(0.002)	(0.003)	(0.003)
Nb. other import-related $NTMs_j^k$	-0.009	-0.006	-0.001	-0.002
	(0.011)	(0.011)	(0.011)	(0.011)
Ln applied $protection_j^k$	-0.435[b]	-0.465[a]	-0.519[a]	-0.553[a]
	(0.186)	(0.177)	(0.183)	(0.175)
Ln $imports_j^k$	0.060[a]	0.064[a]	0.057[a]	0.061[a]
	(0.008)	(0.008)	(0.008)	(0.008)
Firm already present in $t\text{-}1_{fj}^k$	0.663[a]	0.687[a]	0.660[a]	0.680[a]
	(0.019)	(0.018)	(0.019)	(0.018)
Observations	119,571	122,831	115,099	118,021
Adjusted R^2	0.736	0.675	0.738	0.676
Fixed effects:				
Firm-Product_{fk} & $\text{Firm-Destination}_{fj}$	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] and [b] denoting significance at the 1% and 5% level respectively.

Table B6: 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%	-0.001[a]	-0.001[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ middle range	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]	-0.001[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ top 25%	-0.001[a]	-0.001[a]	-0.002[a]	-0.001[a]	-0.001[a]	-0.001[a]
	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ bottom 25%	0.0004[a]	0.0003[b]	0.001[a]	0.001[c]	-0.0001	0.0003[b]
	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ middle range	0.001[a]	0.001[a]	0.002[a]	0.001[a]	0.001[a]	0.001[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ top 25%	0.001[a]	0.001[a]	0.001[a]	0.001[a]	0.001[a]	0.001[a]
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Nb. other import-related $NTMs_j^k$	0.0001	-0.0001	-0.0001	-0.0001	0.0001	-0.0001
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Ln applied $protection_j^k$	-0.007[a]	-0.005[a]	-0.005[a]	-0.005[a]	0.001	-0.005[a]
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Ln maximum $price_f^k$	0.003[a]					
	(0.0001)					
Ln $imports_j^k$		0.001[a]	0.001[a]	0.001[a]	0.0001	0.001[a]
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ln number French $exporters_j^k$					0.017[a]	
					(0.0002)	
Firm already present in $t\text{-}1_{fj}^k$	0.401[a]	0.420[a]	0.420[a]	0.421[a]	0.416[a]	0.420[a]
	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	4,184,393	6,487,821	6,487,821	6,487,821	6,487,821	6,466,933
Adjusted R^2	0.466	0.458	0.460	0.460	0.462	0.460
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: Column 1 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 2, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 3, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 4, 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 5 includes the number of French firms exporting to a given product-destination pair. Column 6 controls for markups set by firms. 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 B7: 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 $quality_f^k$ < median	-0.016^a	-0.016^a	-0.032^a	-0.031^a	-0.016^a	-0.017^a
	(0.004)	(0.005)	(0.009)	(0.011)	(0.004)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ > median	-0.024^a	-0.024^a	-0.051^a	-0.052^a	-0.024^a	-0.025^a
	(0.005)	(0.005)	(0.010)	(0.015)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ < median	0.002	0.001	0.001	-0.007	-0.000	0.000
	(0.005)	(0.007)	(0.010)	(0.013)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ > median	0.013^a	0.013^a	0.020^b	0.021^b	0.013^a	0.015^a
	(0.004)	(0.004)	(0.008)	(0.009)	(0.004)	(0.004)
Nb. other import-related $NTMs_j^k$	-0.005	-0.006	0.003	-0.002	-0.004	-0.006
	(0.011)	(0.010)	(0.011)	(0.003)	(0.011)	(0.011)
Ln applied $protection_j^k$	-0.522^a	-0.433^a	-0.437^b	-0.423^b	-0.403^b	-0.434^b
	(0.188)	(0.160)	(0.186)	(0.186)	(0.187)	(0.186)
Ln maximum $price_f^k$	-0.090^a					
	(0.008)					
Ln $imports_j^k$		0.060^a	0.060^a	0.060^a	0.050^a	0.060^a
		(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
Ln number French $exporters_j^k$					0.116^a	
					(0.016)	
Firm already present in $t\text{-}1_{fj}^k$	0.668^a	0.663^a	0.663^a	0.662^a	0.658^a	0.663^a
	(0.019)	(0.030)	(0.019)	(0.019)	(0.019)	(0.019)
Observations	120,296	119,571	119,571	119,571	119,571	119,561
Adjusted R^2	0.736	0.718	0.736	0.736	0.736	0.736
Fixed effects:						
Firm-$Product_{fk}$ & 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: Column 1 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 2, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 3, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 4, 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 5 includes the number of French firms exporting to a given product-destination pair. Column 6 controls for markups set by firms. 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 ^{b} denoting significance at the 1% and 5% level respectively .

Table B8: 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 $quality_f^k$ < median	-0.017^a	-0.016^a	-0.034^a	-0.039^a	-0.017^a	-0.017^a
	(0.004)	(0.004)	(0.008)	(0.011)	(0.004)	(0.004)
Nb. QSs_j^k X Ln $productivity_f^k$ < median X Ln $quality_f^k$ > median	-0.023^a	-0.023^a	-0.044^a	-0.048^a	-0.023^a	-0.023^a
	(0.005)	(0.005)	(0.010)	(0.014)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ < median	0.001	0.002	0.004	-0.007	0.001	0.002
	(0.005)	(0.006)	(0.010)	(0.013)	(0.005)	(0.005)
Nb. QSs_j^k X Ln $productivity_f^k$ > median X Ln $quality_f^k$ > median	0.014^a	0.014^a	0.023^a	0.014	0.014^a	0.015^a
	(0.004)	(0.004)	(0.008)	(0.009)	(0.004)	(0.004)
Nb. other import-related $NTMs_j^k$	-0.001	-0.004	0.004	-0.000	-0.002	-0.004
	(0.011)	(0.010)	(0.010)	(0.003)	(0.011)	(0.011)
Ln applied $protection_j^k$	-0.493^a	-0.463^a	-0.467^a	-0.449^b	-0.427^b	-0.464^b
	(0.178)	(0.163)	(0.177)	(0.177)	(0.177)	(0.177)
Ln maximum $price_f^k$	0.046^a					
	(0.007)					
Ln $imports_j^k$		0.064^a	0.064^a	0.064^a	0.053^a	0.064^a
		(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Ln number French $exporters_j^k$					0.127^a	
					(0.016)	
Firm already present in $t\text{-}1_{fj}^k$	0.685^a	0.686^a	0.686^a	0.686^a	0.682^a	0.686^a
	(0.018)	(0.029)	(0.018)	(0.018)	(0.018)	(0.018)
Observations	123,133	122,831	122,831	122,831	122,831	122,821
Adjusted R^2	0.673	0.655	0.675	0.675	0.676	0.675
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: Column 1 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 2, standard errors are clustered at the firm level (instead of HS6 product-destination level). In column 3, an alternative count for QSs and other import-related NTMs based on measures computed at the one-digit level is used. In column 4, 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 5 includes the number of French firms exporting to a given product-destination pair. Column 6 controls for markups set by firms. 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} and ^{b} denoting significance at the 1% and 5% level respectively .