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Do Standards Improve the Quality of Traded Products?

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Abstract: Quality-focused non-tariff measures are increasingly adopted by policy makers to address market failures. This paper tests for their selection and quality effects in a context of information asymmetry regarding product attributes. Our theory reveals that the enforcement of quality standards (Qs) induces the exit of low-quality firms but also that of some high-quality ones. The overall quality effect is therefore ambiguous. Using French firm data, we find that the Qs imposed by destination countries increase the probability, volume and value of exports of high-productivity medium-quality firms at the expense of low-productivity high-quality firms. Qs improve the average quality of exported consumption goods.

Keywords: Firm exports, Quality standards, Information asymmetry.

Les normes améliorent-elles la qualité des produits échangés ?

Abstract : Les décideurs publics adoptent de plus en plus de mesures non tarifaires axées sur la qualité pour remédier aux défaillances du marché. Cet article teste leurs effets en termes de sélection et de qualité dans un contexte d'asymétrie informationnelle sur les attributs des produits. La partie théorique révèle que la mise en œuvre de standards de qualité exclut du marché des entreprises fabriquant des produits de mauvaise qualité, mais aussi de certaines entreprises de haute qualité. L'effet global sur la qualité est donc ambigu. A l'aide de données d'entreprises françaises, nous constatons que les standards de qualité imposés par les pays de destination augmentent la probabilité, le volume et la valeur des exportations des entreprises de qualité moyenne à productivité élevée au détriment d'entreprises de qualité élevée à faible productivité. Les standards de qualité améliorent la qualité moyenne des biens de consommation exportés.

Mots-clefs : Exportations des entreprises, Standards de qualité, Asymétrie informationnelle.

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1 Introduction

The use of quality standards (Qs), such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBTs), by national governments has become increasingly common in several industries and has induced many trade disputes among countries (WTO, 2012).¹ Even though Qs 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 they are trade reducing and, potentially, welfare decreasing (see, for example, Andriamananjara et al., 2004; Disdier et al., 2008; Hoekman and Nicita, 2011). Indeed, fewer varieties are traded as fewer foreign firms can export to the domestic market due to additional production and distribution costs (compliance costs).² In addition, Qs have usually been treated as pure trade barriers, equivalent to *ad valorem* taxes, implying that more standards lead to higher prices.³ As a result, consumers may be worse off following the introduction of Qs not only because their favorite varieties are excluded from the market but also because the prices of the remaining varieties increase.

Nevertheless, the trade literature has disregarded the fact that standards may be welfare-improving tools, addressing market failures such as information asymmetry between consumers and producers with respect to quality, safety and other product characteristics (Leland, 1979; Shapiro, 1983; Ronnen, 1991; Crampes and Hollander, 1995). In an information asymmetry context, quality is underprovided. 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). Therefore, under asymmetric information, the introduction of Qs should increase the quality of prod-

¹For example, national policy makers set minimum energy efficiency standards for many household appliances or a maximum amount of pesticide residues that is acceptable 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/>).

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

³One exception is Beghin et al. (2015) who extend the trade restrictiveness index approach to the case of market imperfections and domestic regulations. In their analysis, the authors start from an agnostic prior on the impact of regulatory policies on trade and welfare.

ucts that are actually consumed.

As we lack empirical evidence regarding the quality effects of standards, this paper aims to address this aspect. We test whether non-tariff measures (NTMs), such as SPS and TBT measures, enhance the quality of traded products. More precisely, we check whether the enforcement of Qs 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) raises the average quality of foreign products perceived by domestic consumers.

To study the effects of Qs on the selection of firms and the market share of exporters according to the quality of their products, we build a new firm-based trade model identifying the mechanisms at work in the presence of uncertainty about product quality. We assume that foreign producers know exactly the quality of their products, while domestic consumers only observe the average quality of products available in their market. Firms are characterized by the productivity and quality of their products, which are horizontally and vertically differentiated. The variable costs of production increase with quality for a given productivity and decrease with productivity for a given quality. Hence, for a given price, there might be various combinations of productivity and quality. It follows that export sales decrease with a firm's product quality (cost effect) as consumers observe only the average quality and increase with a firm's product productivity (efficiency effect). Due to fixed costs associated with serving a foreign market, there exists a quality cutoff above which a firm cannot export its product. In other words, because of uncertainty about product quality, high-quality goods offered by low-productivity firms may be withdrawn from the market. By contrast, high-productivity firms may export products with a quality below the average quality of products available on the market, as long as their price is not too high.

To correct for market failures associated with information asymmetry, policy makers may impose Qs that have to be met by all products marketed in the domestic market, regardless of whether they are manufactured domestically or abroad. As expected, the enforcement of a Qs by a policy maker forces some low-quality firms to

exit, regardless of their productivity, because they are not able to keep up with the new regulation. However, we show that some high-quality firms also cease to serve a country with a QS. The intuition is the following. By excluding low-quality firms from the domestic market, a QS makes competition tougher among incumbent firms. This stronger competition induces the exit of high-price firms (i.e. low-productivity high-quality firms), as consumers make their choice based on price and the average quality. Competition intensifies as the disparity in heterogeneity between the qualities declines. Hence, the revenue of high-quality sellers declines.⁴ This effect is more pronounced for low-productivity high-quality firms. In addition, this effect yields a reallocation of market shares from low-productivity high-quality incumbents towards high-productivity medium-quality incumbents (as the latter have lower prices than the former).⁵ Because both low-quality and high-quality firms exit the market, a QS has an ambiguous effect on the average quality of exported products.

We empirically assess the main predictions derived from our model. We match a dataset on public QSs, such as SPS and TBT measures, with French firm-product-destination export data. We estimate the effect of SPS and TBT measures on both the extensive and intensive margins of trade for individual French exporters, as well as on the average quality of exported products. The estimation of product quality using trade data at the firm level 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. Therefore, we rely on our theoretical model and information on price and productivity to infer quality at the firm-product (i.e., variety) level. Higher quality is assigned to varieties that have a higher price conditional on productivity. As predicted by the model, we find that the larger the number of QSs is, the higher the

⁴Ronnen (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 obtain a similar result by considering firms that differ in efficiency.

⁵Similar to the findings of 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.

participation in a certain product-destination market for a pair of high-productivity medium-quality incumbents at the expense of low-productivity high-quality incumbents. As for the intensive margin, we show that the export volumes and values of the high-productivity medium-quality incumbents increase with the number of Qs, at the expense of low-productivity high-quality incumbents. When it comes to the average quality of exported products perceived by foreign consumers, the effect of Qs is dependent on the classes of goods and sectors considered. Qs increase the average quality of consumption goods such as food and beverages as well as textile products.

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 Qs in trade has been investigated in few papers. On the theoretical side, [Das and Donnenfeld \(1989\)](#) and [Gagné 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 Qs increase 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., 2015](#)). 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 body of the empirical literature, we go one step further. We theoretically and empirically study how both the productivity and quality characteristics of firms shape their export decisions in the presence of Qs in a context of information asymmetry between consumers and producers with respect to product quality. Moreover, we also investigate the role of

Qs on the average quality of exported products.

This paper also adds to works on the relationship 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. Our paper is conceptually close to the work of Hallak and Sivadasan (2013), who build a firm-based trade model, exploiting two sources of heterogeneity: *process productivity* (i.e., the classical concept of productivity) and *product productivity* (i.e., the capacity of firms to produce high-quality goods with low fixed costs). Their results show that, conditional on size, exporting firms sell high quality goods at high prices. Furthermore, it has also been shown that the competitiveness of 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, while all these papers assume perfect information, we consider information asymmetry between buyers and sellers with respect to product quality, as in Akerlof (1970). In our approach, we consider that consumers can neither correlate product quality with price nor perfectly judge it even after consumption (credence goods).⁶ 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 production processes such as the environmental cost of production, the use of child labor, and animal welfare standards (Dulleck et al., 2011).

Finally, this paper also contributes to the literature on adverse selection. While the theoretical literature on adverse selection and the under-provision of quality has increased dramatically since the seventies, empirical tests using data on *tangible* goods are rather scarce compared to those focusing on insurance markets. Some studies have tested for adverse selection in durable goods markets (Bond, 1982; Genesove, 1993; Hendel et al., 2005; Engers et al., 2009; Peterson and Schneider, 2014, 2017). Our data allows us to exploit the differences across countries to identify adverse selection. As the presence of Qs reduces the information asymmetry problem, the differences in the

⁶Our 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).

number of Qs 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 presents the theoretical model. Section 3 describes the data and the empirical strategy. Section 4 reports and discusses the results regarding the trade effects of Qs. Section 5 investigates the impact of Qs on the average quality of products. Section 6 concludes.

2 Theory

We develop a trade model that considers heterogeneous firms and information asymmetry on product quality.⁷ We provide the microeconomic foundations of the impact of Qs on trade and the average quality of products delivered by firms under this setting. Hence, similar to the classical asymmetric-information framework (Akerlof (1970)'s market for lemons), we study the properties of market outcomes in the presence of adverse selection in a global economy.

2.1 General assumptions and results

We consider an imperfectly competitive sector producing (horizontally and vertically) differentiated products under increasing returns. In our setting, 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 considering the quality of goods as uncertain. Consumers are assumed to be risk-neutral and only their perceptions about the average quality are considered. As a result, the goods with above average quality may be driven out of the market. In our framework, there is no potential for screening or signaling. Despite information asymmetry, a trade

⁷We 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).

equilibrium is reached as products are also horizontally differentiated and firms differ in terms of productivity.

Demand. Let $q_{ij}^k(\bar{\theta}_{ij}^k, p_{ij}^k, \cdot)$ represent the demand in country j for a variety of product k produced in country i . The variable $\bar{\theta}_{ij}^k$ is the average quality for the set of varieties of product k available in country j and imported from country i . p_{ij}^k is the price of a variety of product k . Product quality captures all attributes of a product other than price, which consumers value. The consumer's behavior is such that:

$$\varepsilon_{q,p}^k \equiv -\frac{\partial q_{ij}^k}{\partial p_{ij}^k} \frac{p_{ij}^k}{q_{ij}^k} > 0 \quad \text{and} \quad \zeta_{q,\bar{\theta}}^k \equiv \frac{\partial q_{ij}^k}{\partial \bar{\theta}_{ij}^k} \frac{\bar{\theta}_{ij}^k}{q_{ij}^k} > 0$$

where $\varepsilon_{q,p}^k$ is the price-elasticity of demand and $\zeta_{q,\bar{\theta}}^k$ is the quality-elasticity of demand. Both are perfectly observed by the producers.

Technology and profit. In our framework, each variety is produced by a single firm, but a firm can produce more than one differentiated product (firms can produce multiple products). Consistently, in the empirical section, we use the firm-product pair (i.e., variety) as the basic unit of our analysis. Each firm-product pair is characterized by a level of productivity (φ^k) and a level of quality (θ^k). We assume that the quality characteristics of the different varieties cannot be easily customized for each foreign market.⁸ Therefore, the quality of the varieties is not adjusted by firms as often as prices are. 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 assume 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. In Appendix A.1,

⁸Therefore, the quality supplied by a multiproduct 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.

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.

As in firm-based trade theory, we consider that the distribution of products includes both fixed costs (ϕ_{ij}^k) and variable costs (τ_{ij}^k), which are specific to each product-origin-destination triplet. The variable production cost increases with quality for a given productivity and decreases with productivity for a given quality. Furthermore, fixed distribution costs are increasing with product quality ($\phi_{ij}^k(\theta^k)$). 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 such as fresh fruits and vegetables may have to invest in better storage facilities to meet a QS over an extended period.

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

$$\pi_{ij}^k \equiv p_{ij}^k q_{ij}^k[\bar{\theta}_{ij}^k, p_{ij}^k] - c_{ij}^k[\theta^k, \varphi^k, \tau_{ij}^k] q_{ij}^k[\bar{\theta}_{ij}^k, p_{ij}^k] - \phi_{ij}^k[\theta^k] \quad (1)$$

where $c_{ij}^k[\theta^k, \varphi^k, \tau_{ij}^k]$ is the *marginal* cost of production. This cost is independent from quantity, but it increases with quality and variable trade costs and decreases with productivity. Higher marginal costs can be caused by producing products with high quality because there is a more thorough selection of ingredients and/or additional production tasks. Product markets are internationally segmented, meaning that the price of a variety varies across destination countries.

Firms select prices to maximize their profit (1), where demand is given by $q_{ij}^k(\bar{\theta}_{ij}^k, p_{ij}^k, \cdot)$. The profit-maximizing price is given by:

$$p_{ij}^k = (1 - [\varepsilon_{q,p}^k]^{-1})^{-1} c_{ij}^k \quad (2)$$

where $\varepsilon_{q,p}^k > 1$ ensures that the equilibrium price is higher than the marginal cost. The price is equal to a mark-up times the marginal cost, which depends not only on the firm's productivity but also on the quality of its products (through c_{ij}). The price set

by a firm for a variety is increasing with quality and trade costs but decreasing with productivity. Hence, the profit of a firm producing a variety of product k in country i and serving market j is (evaluated at equilibrium prices):

$$\pi_{ij}^k = \frac{p_{ij}^k[\varphi^k, \theta^k, \tau_{ij}^k] q_{ij}^k[\varphi^k, \tau_{ij}^k, \theta^k, \bar{\theta}_{ij}^k]}{\varepsilon_{q,p}^k} - \phi_{ij}^k[\theta^k] \quad (3)$$

where $p_{ij}^k[\varphi^k, \theta^k, \tau_{ij}^k] q_{ij}^k[\varphi^k, \tau_{ij}^k, \theta^k, \bar{\theta}_{ij}^k] \equiv r_{ij}^k$ is the export sales of the firm (associated with a specific destination). It follows that:

$$\frac{\partial r_{ij}^k}{\partial \varphi^k} = q_{ij}^k (\varepsilon_{q,p}^k - 1) \left(-\frac{\partial p_{ij}^k}{\partial \varphi^k} \right) > 0, \quad \frac{\partial r_{ij}^k}{\partial \theta^k} > 0 \quad \text{and} \quad \frac{\partial r_{ij}^k}{\partial \bar{\theta}_{ij}^k \partial \varphi^k} > 0 \quad (4)$$

In the remainder of the text, we use the terms firm and firm-product pair interchangeably. As expected, profit and income 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 an exporter provides a relatively high-quality product, the average quality in the destination market increases. Since consumers are now willing to pay more for all goods imported from country i , high-quality producers share their benefits with low-quality producers. In addition, the sales of high-productivity firms increase more with average quality than the sales of low-productivity firms. In other words, when consumption expenditures are held constant, a higher average product quality reallocates market shares to more productive firms.

As consumers do not know the quality of products and given that distribution/production costs increase with product quality, the profits and sales associated with destination market j are lower for firms selling a product with higher quality. Formally, we have:

$$\frac{\partial r_{ij}^k}{\partial \theta^k} = -\frac{r_{ij}^k (\varepsilon_{q,p}^k - 1) \zeta_{p,\theta}^k}{\theta^k} < 0 \quad \text{and} \quad \frac{\partial \pi_{ij}^k}{\partial \theta^k} = \frac{1}{\varepsilon_{q,p}^k} \frac{\partial r_{ij}^k}{\partial \theta^k} - \frac{\phi_{ij}^k}{\theta^k} \zeta_{\phi,\theta}^k < 0 \quad (5)$$

with

$$\zeta_{p,\theta}^k \equiv \frac{\partial p_{ij}^k}{\partial \theta^k} \frac{\theta^k}{p_{ij}^k} > 0 \quad \text{and} \quad \zeta_{\phi,\theta}^k \equiv \frac{\partial \phi_{ij}^k}{\partial \theta^k} \frac{\theta^k}{\phi_{ij}^k} > 0. \quad (6)$$

where $\zeta_{p,\theta}^k$ and $\zeta_{\phi,\theta}^k$ are the quality-elasticity of price and distribution cost, respectively. 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. The producers of top-quality goods tend to withhold their products from sale. As indicated by Akerlof's Lemons Principle ("The bad drives out the good until no market is left"), high-quality products are driven out of the market by low-quality products. Therefore, information asymmetry may lead to the under-provision of high-quality products, although such products are preferred by the consumers (market failure). However, in our configuration, products with a quality that is better than the lowest quality product can be sold. 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.

Furthermore, since production and distribution costs are assumed to be non-negative with product quality and $\partial r_{ij}^k / \partial \theta^k < 0$ for a given productivity, there exists a maximum quality for a given productivity $\hat{\theta}_{ij}^k(\varphi^k)$ above which it is not profitable to serve the destination market j . Formally, $\hat{\theta}_{ij}^k(\varphi^k)$ (called the *quality cutoff curve*) is such that $\pi_{ij}^k(\varphi^k, \hat{\theta}_{ij}^k) = 0$. Using the implicit function theorem, it is straightforward to check that:

$$\frac{\partial \hat{\theta}_{ij}^k}{\partial \varphi^k} = \frac{-\partial \pi_{ij}^k(\varphi^k, \hat{\theta}_{ij}^k) / \partial \varphi^k}{\partial \pi_{ij}^k / \partial \hat{\theta}_{ij}^k} > 0. \quad (7)$$

Hence, market failure associated with information asymmetry hurts high-quality low-productivity firms as they charge high prices to consumers. *In other words, under information asymmetry, only high-productivity firms are able to profitably export high-quality products.* Figure 1 displays the curve $\hat{\theta}_{ij}^k(\varphi^k)$ in which each firm-product pair is represented by a single point, e.g., a (φ^k, θ^k) combination. Firms below this threshold $\hat{\theta}_{ij}^k(\varphi^k)$ earn non-negative profits, while firms above the curve $\hat{\theta}_{ij}^k(\varphi^k)$ exit the market. The firms along the curve have equal revenue and profits. The positive slope of the curve $\hat{\theta}_{ij}^k(\varphi^k)$ indicates that firms with high productivity are more likely to export.

Insert Figure 1 here

Firms supplying a high-quality product can profitably export provided that their productivity is high enough. Under perfect information and endogenous product quality, more productive firms specialize in higher quality products (Baldwin and Harrigan, 2011; Kugler and Verhoogen, 2012; Gagné and Larue, 2016). Because there are different mechanisms at work, we show that high-quality firms are more likely to be high-productivity firms. This results from a mechanism of *adverse selection*, which varies according to the firm’s productivity.

Qs. We now assume that each destination country j introduces a standard setting for minimum quality ($\underline{\theta}_j^k$). By enforcing public standards, policy makers specify requirements with which the characteristics of the production process (‘process standard’) and the final product (‘product standard’) must comply. When policy makers choose a standard, it is applied to all products marketed in the domestic market regardless of whether they are manufactured by foreign or domestic firms. Hence, public standards, unlike tariffs, do not directly discriminate. Qs 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 more complex mostly because of the assumptions about firm heterogeneity (for a given price, there are various combinations of productivity and quality) and the preference for variety (horizontally differentiated products). We capture two competing effects. On the one hand, the introduction of Qs increases the average quality of the products delivered by producers for an unchanged quality cutoff curve ($\widehat{\theta}_{ij}^k(\varphi)$), as it forces low-quality firms – which are not able to comply with the requirements – to exit, regardless of their productivity. On the other hand, a higher average product quality reduces export sales of high-quality incumbents as

$$\frac{\partial r_{ij}^k}{\partial \theta^k \partial \bar{\theta}_{ij}^k} = \frac{\zeta_{q,\bar{\theta}}^k}{\bar{\theta}_{ij}^k} \frac{1}{\epsilon_{q,p}^k} \frac{\partial r_{ij}^k}{\partial \theta^k} < 0. \quad (8)$$

Hence, the quality cutoff curve may shift downwards because of the reallocation of market shares among incumbents.

2.2 From theory to the empirics

We now define the preferences, technology and market structure to deliver clear predictions regarding the impact of Qs enforced by a destination country on export decisions (extensive margin), export sales (intensive margin), and the average quality of products delivered by firms. Our specifications are also useful for inferring product quality.

Preferences, market structure and technology. The 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:

$$U_j^k = \left[\sum_i \int_{\Omega_{ij}^k} \left[(\bar{\theta}_{ij}^k)^{\beta_j^k} q_{ij}^k(\nu) \right]^{\frac{\varepsilon^k - 1}{\varepsilon^k}} d\nu \right]^{\frac{\varepsilon^k}{\varepsilon^k - 1}} \quad (9)$$

where Ω_{ij}^k is the set of varieties ν available in country j and produced in country i . $\varepsilon^k > 1$ 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.

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 fixed distribution costs are equal to $\phi_{ij}^k = f_{ij}^k [\theta^k]^{\eta^k}$, 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 exported. The marginal cost of production is assumed to be equal to $c_{ij}^k = (\theta^k)^{a^k} \omega_i^k \tau_{ij}^k / \varphi^k$, where τ_{ij}^k represents an iceberg trade cost, ω_i^k is the price of the

production factors, and α^k is the quality-elasticity of the variable costs (with $\alpha^k \geq 0$).

Import demand and price. In Appendix A.2, we show that the equilibrium demand for a variety produced in country i and exported to country j is such that:

$$p_{ij}^k q_{ij}^k = \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon^k-1)} A_j^k \left(p_{ij}^k\right)^{1-\varepsilon^k} \quad (10)$$

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

$$P_j^k = \left[\sum_i \int_{\Omega_{ij}} \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon^k-1)} [p_{ij}^k(\nu)]^{1-\varepsilon^k} d\nu \right]^{\frac{-1}{\varepsilon^k-1}}. \quad (11)$$

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 is unchanged.

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

$$p_{ij}^k = \frac{\varepsilon^k}{\varepsilon^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k \frac{(\theta^k)^{\alpha^k}}{\varphi^k}. \quad (12)$$

with $T_{ij}^k \equiv 1 + t_{ij}^k$, where t_{ij}^k is the ad valorem tariff applied by country j to product k imported from country i . 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).

Extensive margin. We now determine the quality cutoff curve ($\widehat{\theta}_{ij}^k$) and the productivity cutoff (φ_{ij}^k) to meet the Qs prevailing in the foreign country. The latter variable is defined such that $\pi_{ij}^k(\varphi_{ij}^k, \underline{\theta}_j^k) = 0$. Given our assumptions regarding technologies (production and transportation) and preferences, we have:

$$\varphi_{ij}^k = \left(\frac{\varepsilon^k f_{ij}^k}{A_j^k} \right)^{\frac{1}{\varepsilon^k - 1}} \frac{(\underline{\theta}_j^k)^{\frac{1}{\rho}}}{(\widehat{\theta}_{ij}^k)^{\beta_j^k}} \frac{\varepsilon^k}{\varepsilon^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k \quad \text{with } \rho^k \equiv \frac{\varepsilon^k - 1}{\eta^k + \alpha^k(\varepsilon^k - 1)}. \quad (13)$$

We further define the highest quality $\widehat{\theta}_{ij}^k$ that can be exported for a given productivity (the profit becomes negative above this threshold). Remember that the relationship between maximum quality and productivity is positive. The marginal firm, which is indifferent between exporting and exiting – i.e., with a profit equal to zero in market j ($\pi_{ij}^k(\varphi^k, \widehat{\theta}_{ij}^k) = 0$) – offers the following quality (implicitly given):

$$\widehat{\theta}_{ij}^k(\varphi^k) = \underline{\theta}_j^k \left(\frac{\varphi^k}{\varphi_{ij}^k} \right)^{\rho^k} \quad (14)$$

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 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, under information asymmetry, the relationship between product quality and the probability of exporting is nonmonotonic 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 when consumers cannot perfectly identify the quality of each variety.

In addition, inserting (13) in (14) 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 in [Amiti and Khandelwal](#)

(2013), which uses a different mechanism. Furthermore, $\widehat{\theta}_{ij}^k / \theta_j^k$ can be interpreted as the market's quality ladder, which is defined by 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.

Intensive margin. By plugging (12) into (10), we obtain the export sales, which are defined as a function of the firms' characteristics and average quality. However, to evaluate the impact of a QS on the intensive margin, the export sales have to be expressed as a function of the QS. We show in Appendix A.3 that $(\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon^k-1)} A_j^k = \varepsilon^k f_{ij}^k (\theta_j^k)^{\eta^k} (\widehat{p}_{ij}^k)^{\varepsilon^k-1}$ where \widehat{p}_{ij}^k is the highest price of product k imported by country j from country i . By inserting this expression in (10) and using (12), it follows that the export sales of a firm-product pair (characterized by φ^k and θ^k) conditional on exporting are given by:

$$r_{ij}^k = \varepsilon^k f_{ij}^k (\theta_j^k)^{\eta^k} (\widehat{p}_{ij}^k)^{\varepsilon^k-1} \left(\frac{\varepsilon^k}{\varepsilon^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k \right)^{-(\varepsilon^k-1)} (\varphi^k)^{\varepsilon^k-1} (\theta^k)^{-\alpha^k(\varepsilon^k-1)}. \quad (15)$$

Equation (15) can be used to estimate the impact of QSs on exports. Conditional on exporting, sales are decreasing with the firm's product quality and trade costs due to higher prices but increasing with market size and the firm's product productivity. The sales equation also captures the role of QSs. 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.

QSs and average quality. This subsection analyzes the impact of a QS on the average quality of traded products. It is worth noting that, 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). We now determine the impact of a QS on both the productivity and quality cutoffs. The effect of a QS on the quality cutoff is unclear *a priori*. On the one hand, the quality cutoff increases when the productivity cutoff is unchanged (direct effect). On the other hand, and according to (13), low-

productivity firms may exit the market when the enforced QS induces a lower quality cutoff. To justify this result, we can rewrite the export sales as $\widehat{p}_{ij}^k = \frac{\varepsilon^k}{\varepsilon^k - 1} \omega_i^k \tau_{ij}^k T_{ij}^k \frac{(\theta_j^k)^{\alpha_k}}{\varphi_{ij}^k}$; the export sales (15) can be expressed as follows:

$$r_{ij}^k(\varphi^k, \theta^k, \underline{\theta}_j^k) = f_{ij}^k \left(\underline{\theta}_j^k \right)^{\eta^k} \varepsilon^k \left[\frac{\varphi^k / (\theta^k)^{\alpha_k}}{\varphi_{ij}^k / (\underline{\theta}_j^k)^{\alpha_k}} \right]^{\varepsilon^k - 1} = f_{ij}^k \left(\underline{\theta}_j^k \right)^{\eta^k} \varepsilon^k \left(\frac{\Phi^k}{\Phi_{ij}^k} \right)^{\varepsilon^k - 1}.$$

For a given productivity cutoff, a QS increases the sales of incumbent firms because the average quality delivered by firms tends to be higher (due to the exit of low-quality firms that are not able to comply with the quality requirements). However, in the presence of a QS, the rise in sales is higher for incumbents with high productivity that also supply a medium-quality product. Indeed, we have:

$$\frac{\partial r_{ij}^k(\varphi^k, \theta^k)}{\partial \varphi^k \partial \theta^k} < 0, \quad \frac{\partial r_{ij}^k(\varphi^k, \theta^k)}{\partial \varphi^k \partial \underline{\theta}_j^k} > 0, \quad \text{and} \quad \frac{\partial r_{ij}^k(\varphi^k, \theta^k)}{\partial \theta^k \partial \underline{\theta}_j^k} < 0.$$

As the market size E_j^k for product k in destination j is fixed, the sales of firms with either productivity just above the productivity cutoff or quality just below the quality cutoff decrease when the market share of high-productivity medium-quality firms increases. Therefore, following the enforcement of the QS, the productivity cutoff φ_{ij}^k increases and the quality cutoff $\widehat{\theta}_{ij}^k(\varphi^k)$ shifts downward. The intuition is the following. By excluding low-quality firms from the market, a QS makes competition tougher among the incumbents as the heterogeneity of the different levels of quality shrinks (this effect is captured through a lower price index). This stronger competition induces the exit of high-price firms, i.e., low-productivity firms and high-quality firms, as the consumers make their choice based on price. In addition, this competition results in the reallocation of market shares from high-quality low-productivity incumbents to medium-quality high-productivity incumbents as the latter sell their products for lower prices than the former.

Clearly, there are winners and losers among firms following the introduction of the QS. A QS does not help small domestic firms but rather makes high-productivity firms

supplying a quality product at a level just above the QS more profitable. In addition, a QS drives low-quality and high-quality products away from the market. Hence, *the impact of a QS on average quality is ambiguous under information asymmetry since both very low- and high-quality products exit the market.*⁹

3 Empirical analysis

We first present the data used in the empirical analysis. We then describe how product quality is measured and display the estimated equations for the extensive and intensive margins.

3.1 Data

Our analysis combines trade policy data (Qs and tariffs) with French export data computed at the firm-level.

Qs. Our empirical study relies on the TRAINS NTM database released by the UNCTAD and made publicly available through the I-TIP portal.¹⁰ 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).

The information available in the TRAINS NTM database covers a broad range of policy instruments. This database encompasses not only measures of well-identified

⁹Similarly, the effect of a QS on welfare is ambiguous. On the one hand, public standards can be viewed as welfare-improving tools because they reduce information asymmetries (e.g. Ronnen, 1991). On the other hand, public standards create distortions in entry decisions (Gaigné and Larue, 2016). Indeed, the adoption of a QS causes there to be fewer varieties in the country (as φ_{ij}^k increases and $\hat{\theta}_{ij}^k$ decreases). As a result, consumers may be worse off because either their favorite varieties are excluded from the market or the prices of the remaining varieties go up.

¹⁰TRAINS 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 B1 in the Appendix B for the list of countries).

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 dataset are broken up into 16 chapters (from A to P), depending on their scope and/or design (see Table 1). The decomposition follows the International Classification of NTMs. Each chapter is further differentiated into subgroups to allow for a finer classification of the measures.¹¹ For our analysis, we retain the first 15 chapters (from A to O), which deal with countries' requirements regarding their imports and exclude the last chapter (P) 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.

Insert Table 1 here

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

¹¹See UNCTAD (2016) for a detailed description of the classification. For example, chapter A on SPS measures is decomposed into nine two-digit codes (from A1 to A9). Two-digit codes are then differentiated into three-digit codes. Some groupings are then further decomposed; however, most of the groupings stop at three digits. In our analysis, we focus on the two-digit codes and if more than one measure belongs to the same subgroup and affects the same product in the same country, we group them (for example, two A11 measures on product k in country j are aggregated into a single measure). These measures usually have the same purpose and are strongly connected and cannot be seen as two different measures. The robustness checks using measures defined at the one-digit level (e.g., aggregated at the chapter level) provide similar results.

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.¹² 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.

Table 2 reports the share of HS6 products in our sample that are subject to at least one QS (SPS or TBT measure) as well as the average number of standards in force on each product by country. 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 also reported for other import-related NTM measures. On average, 53.0% of the HS6 products are subject to at least one QS. For other NTMs, the share is slightly higher (e.g., 57.2%). In addition, each HS6 product faces on average 5.1 QSs and 2.7 other import-related NTMs.

Insert Table 2 here

¹²We 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.

French firm-level data. In addition to the QS data, we use French firm-level data. French customs provide export data by firm, HS6 product and destination country. As mentioned above, the TRAINS NTM database provides information on all NTMs in force in each destination country at the time of data collection (between 2012 and 2016). Working on the annual flows of newly adopted measures does not make much sense. The time-variation in the notification of measures by countries is rather small and most of the variation in standards occurs across countries and products.¹³ We therefore use data on French firms' exports in 2011 and perform a cross-section analysis using the stock of Qs 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.¹⁴ 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.¹⁵

Table 3 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 Qs for each product. For comparison, these statistics are also provided for other import-related NTMs. The last column of the table reports the share of French exports (in value) not subject to Qs in the destination country. These results highlight four main facts. First, the number of products exported by French firms

¹³Furthermore, in the TRAINS NTM database, a start date is associated with each measure. However, this date is subject to inconsistencies.

¹⁴Our results are the same if we consider 2012 exports. In addition, new Qs often update and therefore replace existing measures, meaning that the stock of Qs remains unchanged even if new measures are adopted after 2012.

¹⁵Unfortunately, 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 are strongly correlated. We prefer not to use the value-added per employee measure because this productivity measure also captures the quality effect. Our conclusions are however robust to its use (see the online Appendix).

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, a comparison of Tables 2 and 3 suggests that on average the share of French products effectively affected by at least one NTM in the destination market is 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% for Qs and 56.9% vs. 57.2% for other import-related NTMs). 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 NTMs (and especially by a small number of Qs). Indeed, the average number of measures per product is smaller in Table 3 compared to that reported in Table 2 (3.7 vs. 5.1 for Qs and 2.2 vs. 2.7 for other NTMs). Fourth, on average, 35.5% of French exports are subject to Qs. However, strong differences are observed across destination countries.

Insert Table 3 here

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 Qs 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.¹⁶ 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.¹⁷ Tariff data are not available for Liberia and Thailand, which are dropped from our analysis.

¹⁶CEPII stands for Centre d'Etudes Prospectives et d'Informations Internationales. <http://www.cepii.fr/anglaisgraph/bdd/macmap.htm>.

¹⁷As for Qs and other import-related NTMs, most of the variation in tariffs is observed across products and countries rather than over time.

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).

3.2 Econometric approach

This section first displays the computation of the quality cost measure and then presents the equations to be estimated to test for the theoretical predictions on the impact of Qs on firms' exports derived from our model. The estimations are performed at the extensive and intensive margins of trade.

Evaluating quality cost. A major challenge is determining how to measure product quality at the firm level θ_f^k . We cannot directly use unit values (the ratio of the value to the quantity sold) as a proxy for quality 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^k), by lower productivity (φ^k), or by a higher unit cost (ω_i^k), even though product quality is lower. In addition, we cannot directly use the approach developed in [Khandelwal \(2010\)](#) to measure quality. This methodology assigns a higher quality to varieties with higher market shares, conditional on prices. In this case, the author assumes that consumers identify the quality of each product. Under information asymmetry, consumers consider only average quality.

To evaluate the additional cost associated with quality θ_f^k , we use the price equation (12) 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 (12), we first regress prices as follows

$$\ln p_{ij,f}^k = FE_i^k + FE_j^k + FE_f^k + \epsilon_{ij,f}^k. \quad (16)$$

where f indexes individual firms, 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 are not needed (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 (12), the estimated (denoted with a hat) fixed effects \widehat{FE}_f^k from (16) 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 production marginal cost up to a constant). Hence, using the definition of $\Phi_f^k = \varphi_f^k(\theta_f^k)^{-\alpha^k}$, we have

$$FE_f^k = -\ln \varphi_f^k + \alpha^k \ln \theta_f^k. \quad (17)$$

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).¹⁸ Expanding the product lines and moving away from the core competence of the firm decreases efficiency. The within-firm ranking of each product is computed as follows. The firm exports of a product 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.¹⁹ 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 (17), we use the following OLS regression to infer quality:

$$\widehat{FE}_f^k + \ln \varphi_f = \kappa \ln \text{rank}_f^k + \lambda^k + \lambda_f^k \quad (18)$$

¹⁸This assumption does not necessarily imply that the rank 1 is characterized by the lowest marginal cost because the firm's core product can be the variety with the highest quality and, in turn, have the highest marginal cost.

¹⁹This product is not necessarily the product with the lowest marginal cost (or price) in the firm, as in Eckel et al. (2016) and Manova and Yu (2017).

where the term λ^k represents a product fixed effect that represents 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

$$\hat{\zeta}_f^k \equiv \hat{\lambda}^k + \hat{\lambda}_f^k = \ln(\theta_f^k)^{\alpha^k}. \quad (19)$$

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 (18), we can also infer the productivity of each product-firm pair, given by

$$\hat{\varphi}_f^k = \varphi_f (\text{rank}_f^k)^{-\hat{\kappa}}. \quad (20)$$

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

Extensive margin. We explore the impact of Qs on the presence²⁰ of a firm in a given product-destination market. Our dependent variable (y_{fj}^k) is the probability that firm f exports product k to destination j . Our counterfactual scenario considers that the firms that do not export in the same product-destination pair kj . This choice model can be written using a latent variable representation, with y_{fj}^{*k} representing the latent variable that determines whether a strictly positive export flow is observed for firm f in the product-destination pair kj . Our estimated equation is therefore as follows:

$$Pr(y_{fj}^k) = \begin{cases} 1 & \text{if } y_{fj}^{*k} > 0, \\ 0 & \text{if } y_{fj}^{*k} \leq 0, \end{cases} \quad (21)$$

²⁰When using cross-section data, one cannot test for the entry/exit of firms.

with

$$y_{fj}^{*k} = \alpha_1 QS_j^k + \alpha_2 QS_j^k \times \varphi_f^k + \alpha_3 QS_j^k \times \zeta_f^k + \alpha_4 QS_j^k \times (\zeta_f^k)^2 + \alpha_5 QS_j^k \times \varphi_f^k \times \zeta_f^k \\ + \text{controls}_j^k + \text{controls}_{fj}^k + FE_f^k + FE_{fj} + \varepsilon_{fj}^k,$$

where QS_j^k is the number of Qs (SPS and TBT measures) applied to product k by destination country j . Among the explanatory variables, the estimated equation first includes four interaction terms. The interaction term between the number of Qs and the exporting firm-product's productivity in logs (φ_f^k) aims to capture a possible reallocation effect across low- and high-productivity exporters. In addition, the effect of Qs 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_f^k), computed as described in the previous paragraph. Furthermore, as shown in the theoretical discussion, above a certain quality for a given productivity, it is not profitable for firms to serve the destination market j . The third interaction term between the number of Qs and the squared firm-product quality in logs ($(\zeta_f^k)^2$) accounts for this effect. Remember that the introduction of Qs under information asymmetry makes the relationship between product quality and the probability of exporting nonmonotonic and bell-shaped. Finally, the last interaction term for the number of Qs, the productivity and the quality aims to capture the reallocation effects between high/low productivity and quality firms.

Our equation includes additional explanatory variables. The product-destination controls (controls_j^k) consist of 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).²¹

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.

We estimate the export equation using a linear probability model. The inclusion of fixed effects in a probit model would give rise to the incidental parameter problem. The linear probability model avoids this issue. 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.²²

Intensive margin. We also investigate the effect of QSs on the export volumes and values of a firm for a given product-destination market by estimating the following specification:

²¹The cross-section analysis is affected by the restriction on QS and other import-related NTM data (see Section 3.1). However, French customs data are available for several years. Therefore, we can easily identify whether a firm was already serving a product-destination in previous years.

²²The 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).

$$\begin{aligned} \ln X_{fj}^k = & \beta_1 QS_j^k + \beta_2 QS_j^k \times \varphi_f^k + \beta_3 QS_j^k \times \zeta_f^k + \beta_4 QS_j^k \times \varphi_f^k \times \zeta_f^k \quad (22) \\ & + \text{controls}_j^k + \text{controls}_{fj}^k + FE_f^k + FE_{fj} + \varepsilon_{fj}^k, \end{aligned}$$

where X_{fj}^k denotes exports either in volume or in value of product k by firm f to destination country j . As previously described, QS_j^k is the number of standards applied by destination country j on product k . The interaction term between the number of Qs and the exporting firm's productivity in logs (φ_f^k) aims to capture the reallocation effects across high- and low-productivity exporters, while the interaction term between the number of Qs and firm-product quality in logs (ζ_f^k) aims to account for the reallocation effects across high- and low- product quality firms. Hence, we expect that $\beta_2 > 0$ and $\beta_3 < 0$. Finally, the third interaction for the number of Qs, firm-product productivity and firm-product quality accounts for possible reallocation effects between high/low productivity and quality firms.

The controls are the same as those used for the estimation of the extensive trade margin. At the product-destination level, we consider the number of other import-related NTMs (in logs) set for product k by destination j , as well as the maximum price observed for product k in market j (proxied by the imports computed at the product-destination level). The controls are also defined at the firm-product-destination level (the presence of the firm f in product-destination market kj in the previous year). Our estimations include firm-product and firm-destination fixed effects (FE_f^k and FE_{fj}). Finally, ε_{fj}^k is the error term, and errors are clustered at the product-destination level.

4 Results

4.1 Extensive margin

This section investigates the effect of Qs on the export participation of a firm in a product-destination pair (equation (21)). The results are presented in Table 4. The

estimations include firm-product and firm-destination fixed effects (FE_f^k and FE_{fj}). We compare firms exporting a given product k and entering destination j with those that are not. Column 1 introduces an interaction term between the number of QSs and firm-product productivity, while column 2 shows how the QS variable is interacted with the firm-product quality and squared quality. Finally, column 3 incorporates a three-way interaction term for the number of QSs, firm-product productivity and firm-product quality. In the different estimations, productivity, quality and squared quality alone are captured by the firm-product fixed effects.

In line with our theoretical predictions, we show that QSs increase the export participation of high-productivity and medium-quality firms at the expense of low-productivity and high-quality firms. Indeed, in columns 1-3, we obtain a negative and significant coefficient for the number of QSs and a positive and significant coefficient for the interaction term between the number of QSs and the productivity of a firm. Furthermore, in columns 2 and 3, the coefficient for the interaction term between the number of standards and the quality of a firm for a given product is positive (and significant in column 3), while the one estimated for the interaction term between the number of QSs and the squared firm-product quality is negative and significant. This result suggests that there are diminishing returns to quality after a certain point, as predicted by the theoretical model. Finally, in column 3, the triple interaction term is negative and significant, highlighting a reallocation effect towards high-productivity medium-quality firms.

Overall, we show that QSs decrease the likelihood that a firm will participate in the export market. According to the results shown in column 3, a 10% increase in the number of QSs reduces the probability that a firm exports product k to market j by 5 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. A 10% increase in the number of measures raises the probability of exporting for the most productive firms by 1 percentage point and reduces the export probability of high-quality firms by 0.1 percentage point (column 3). These findings support

the predictions derived from our theoretical model. Moreover, our empirical findings point to reallocation effects across both destinations and products in terms of export decisions.

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. Furthermore, the higher the demand is for a product in a given destination (proxied through imports), the higher the presence of French exporters. The past presence of a firm in a product-destination pair also significantly and drastically increases export participation.

Insert Table 4 here

4.2 Intensive margin

We now analyze the effect of Qs on the intensive trade margin of a firm in a product-destination pair by estimating equation (22). The results are presented in Table 5. This table includes firm-product and firm-destination fixed effects (FE_f^k and FE_{fj}). Columns 1-3 describe the effect of Qs on firms' export volume, while columns 4-6 show the impact on the export value. The specifications follow the same logic as that in Table 4. We first interact the number of Qs with firm-product productivity (columns 1 and 4). We then add an interaction term between the number of Qs and the measure of firm-product quality (columns 2 and 5). Finally, columns 3 and 6 also include an interaction for the number of Qs, the measure of firm-product productivity and the measure of firm-product quality.

As previously shown for the extensive margin, we highlight an overall negative effect of Qs on the trade intensive margin. A 1% increase in the number of Qs leads to a decrease in the firm exports (in volume and value) by approximately 14 percentage points (columns 3 and 6). Furthermore, the results suggest a reallocation effect in terms of export sales (volume and value) from the least productive firms to the most productive firms. The estimated coefficients for the interaction term between

the number of Qs and firm-product productivity are indeed positive and significant ($p < 0.01$) in all estimations. Some reallocation in export volumes also takes place across firms with different levels of product quality; the coefficient for the interaction term between the number of Qs and the quality of a firm for a given product is significant (columns 3 and 6). However the average effect is not significant.²³ More interestingly, the three-way interaction term for the number of Qs, firm-product productivity and firm-product quality is negative and significant. This last result suggests that for a given productivity, firm exports increase up to a certain quality and then tend to decrease.

Overall, our findings depict reallocation in terms of export volume and value across products and destinations. In addition, when we control for firm heterogeneity, we show that demand shifts towards the most productive and medium-quality firms, at the expense of the least productive and high-quality ones.

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 influences its current exports in terms of both volume and value.

Insert Table 5 here

Finally, we conduct some simulations to quantify the economic effects of Qs on French firms. More precisely, we set the number of Qs for product k to the maximum number observed across all destinations j . The motivation for this exercise is as follows. If the number of Qs affecting product k increases to the highest level observed across all destinations, firms will have to comply with additional and potentially different standards when exporting. Their compliance costs will increase, and their exports will be affected. With our simulation exercise, we derive order of magnitude predictions regarding firms' exports. We focus on the intensive margin measured using the

²³Using equation (22), this average effect can be computed as follows: $\beta_3 + \beta_4 * \text{Ln productivity}$. In both columns 3 and 6, the average effect is not significantly different from 0.

value of exports. Since we are interested in studying the variation across destinations, we rely on the following set of fixed effects: firm-product and firm-destination.

According to our results, if all export destinations served by French firms adopted the maximum number of Qs observed for a product, 41% of the French firms would benefit from this change and their export value would increase by 22%. However, the overall effect on French exports would be much more limited (+ 2% of exports, i.e., 1.6 billion euros). As shown by Figure 2, highly productive firms are the main winners (panel (a)) and the effect is lower once we control for quality (panel (b)). This result validates our theoretical predictions that high productivity medium quality firms gain market share at the expense of other firms. Since the winning firms are more productive, the price tends to decrease and the demand for French products increases, generating a positive effect on French exports at the intensive margin. However, this calculation does not account for the extensive margin, and the overall effect of Qs on French exports is uncertain.

Insert Figure 2 here

4.3 Robustness checks

We proceed to a series of sensitivity tests to confirm the robustness of our results. We present the results in Table B2 (extensive margin), Table B3 (intensive margin, export volume), and Table B4 (intensive margin, export value). 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 Qs and other import-related NTMs based

on measures computed at the one-digit level (see footnote 11 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.

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 B3), 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). Finally, clustering at the firm level (column 2) and controlling for the number of French exporters (column 5) do not affect our results.

5 Average quality

We now investigate the impact of QSs on the average quality of the products exported by French firms to the different countries. In the theoretical discussion, we showed that the impact of a QS on the average quality is ambiguous under information asymmetry since both low- and high-quality products exit the market. 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.

5.1 Empirical approach

Evaluating average quality. 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. More precisely, to evaluate the origin-destination specific average quality perceived by the consumers $((\bar{\theta}_{ij}^k)^{\beta_j^k})$, 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 entrants (firm-product pairs) in country i and product k . We use a specific parameterization 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 . Using (12) and the fact that Φ^k follows a Pareto distribution, we obtain:

$$R_{ij}^k = \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon^k-1)} A_j^k \left(\frac{\varepsilon^k}{\varepsilon^k-1} \omega_i^k \tau_{ij}^k T_{ij}^k\right)^{-(\varepsilon^k-1)} \frac{h_i^k}{h_i^k - (\varepsilon^k - 1)} N_{ij}^k \left(\Phi_{ij}^k\right)^{\varepsilon^k-1} \quad (23)$$

with $N_{ij}^k = N_i^k \left(\underline{\Phi}_i^k / \Phi_{ij}^k\right)^{h_i^k}$, the total number of firms producing in country i and selling product k in country j . Bilateral country-level trade and unit value data provide information on the volume Q_{ij}^k and import unit values \bar{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 $\bar{P}_{ij}^k T_{ij}^k = R_{ij}^k / Q_{ij}^k$ with $Q_{ij}^k = N_i^k \int_{\Phi_{ij}^k}^{\infty} q_{ij}^k dG_i(\Phi^k)$. Standard calculations reveal that:

$$\bar{P}_{ij}^k = \frac{\int_{\Phi_{ij}^k}^{\infty} \left(p_{ij}^k\right)^{-(\varepsilon^k-1)} dG_i(\Phi^k)}{\int_{\Phi_{ij}^k}^{\infty} \left(p_{ij}^k\right)^{-\varepsilon^k} dG_i(\Phi^k)} = \frac{\varepsilon^k}{\varepsilon^k-1} \omega_i^k \tau_{ij}^k \frac{h_i^k - \varepsilon^k}{h_i^k - (\varepsilon^k - 1)} \left(\Phi_{ij}^k\right)^{-1}. \quad (24)$$

Using $Q_{ij}^k = R_{ij}^k / (\bar{P}_{ij}^k T_{ij}^k)$, (23) and (24) yield:

$$Q_{ij}^k = N_{ij}^k \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon^k-1)} A_j^k \frac{h_i^k}{h_i^k - \varepsilon^k} \left(\bar{P}_{ij}^k T_{ij}^k\right)^{-\varepsilon^k}. \quad (25)$$

Equation (25) 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 $N_{ij}^k \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\varepsilon^k-1)}$ can be estimated as the residual of the following regression:

$$\ln Q_{ij}^k + \varepsilon^k \ln \left(\bar{P}_{ij}^k T_{ij}^k\right) = FE_i^k + FE_j^k + \lambda_1 CL_{ij} + \lambda_2 CB_{ij} + \lambda_3 CT_{ij} + \lambda_{ij}^k, \quad (26)$$

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

Equation (26) is estimated by merging five different data sources. First, \bar{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^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.²⁴ FE_i^k and FE_j^k stands

²⁴Data on import unit values rely on importers' declarations and include all trade costs (except tariffs and domestic taxes after the border); Source: http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=2. Baci database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=1. MacMap database: see section 3.1. Trade elasticities: <http://www.columbia.edu/~dew35/TradeElasticities/TradeElasticities.html>; These elasticities are computed at the 3-digit level using HS 6-digit import data from the COMTRADE database for the years 1994-2003. GeoDist

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).²⁵

We then compute the average quality of each HS6 product exported by France to each destination. To do so, we keep from the estimation of equation (26), 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 $\lambda_{ij}^k = \ln N_{ij}^k + (\epsilon^k - 1) \ln(\bar{\theta}_{ij}^k)^{\beta_j^k}$, 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 .

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

$$\ln(\widehat{\bar{\theta}_{ij}^k})^{\beta_j^k} = \gamma_1 QS_j^k + \text{controls}_j^k + FE^k + FE_j + \epsilon_j^k, \quad (27)$$

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 Qs 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.

5.2 Results

Table 6 presents the empirical results. According to the theoretical model, Qs 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.

database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6.

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

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 done using 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 nonsignificant effect is obtained for capital/intermediate goods and manufacturedv(without textiles) products (columns 2-3). 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 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.²⁶

Furthermore, we obtain positive and significant estimated coefficients for the other import-related measures. The mechanism at play is however different from the one previously highlighted for QSs. Other NTMs do not reduce information asymmetries with respect to the quality of the incumbent firms staying in the market. The NTMs increase variable trade costs and therefore induce some selection effects among French

²⁶For comparison, the elasticity of the average quality of exported products to a change in the number of the other NTMs is $1.37 \cdot 0.193 = 0.26$.

exporters. As a result, the average quality of exported products is expected to increase with respect to this variable.

Insert Table 6 here

6 Conclusion

This paper studies the effects of QSs instituted by destination countries on the exports of firms (extensive and intensive margins) 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. Producers know the quality of their product, while consumers observe only the average quality available on the market. Under this setting, the introduction of a QS by a policy maker to address negative externalities leads to the exit of low-quality firms that are not able to satisfy the requirements, regardless of their productivity. However, some high-quality firms are also excluded from the market, following a reallocation of demand from high-quality low-productivity firms to medium-quality high-productivity firms. Therefore, the overall effect of a QS on the average quality of exported products is ambiguous. Second, we test for the predictions of our model, relying on French firm export data. In line with our theoretical model, we show that the presence of QSs in the destination country increases the export participation of medium-quality high-productivity French firms, at the expense of high-quality low-productivity ones. The same pattern is observed for export volumes and values. As for the effect of QSs on the average quality of exported products, we document a nonsignificant effect. However, the impact varies significantly across classes of goods and sectors. QSs 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 ensures a minimum quality but does not necessarily lead to an improvement in the average quality of the products available on the market.

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Figure 1: Cutoff-quality curve

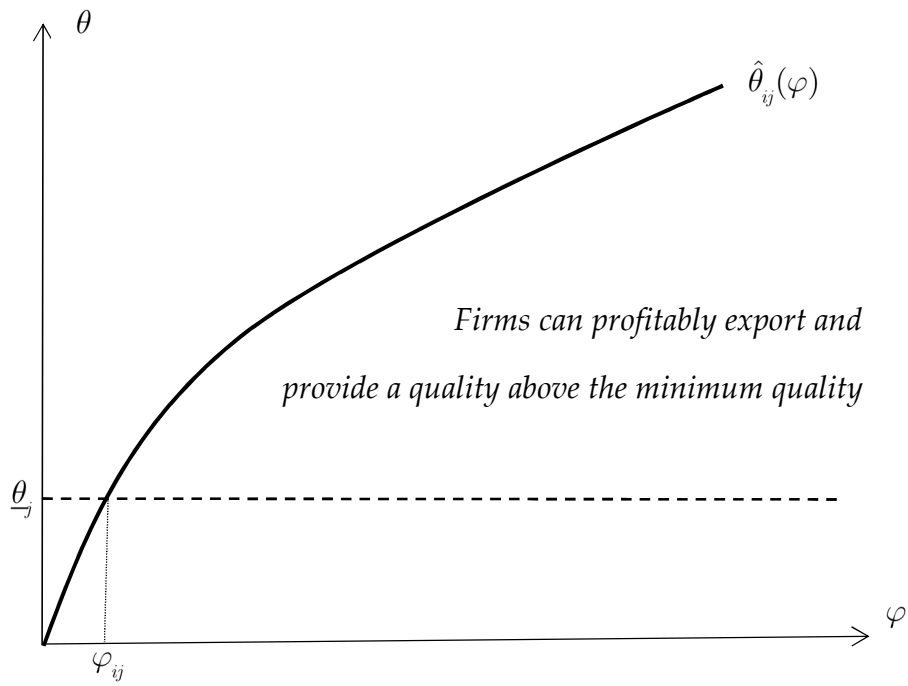


Figure 2: Distribution of losing and winning firms

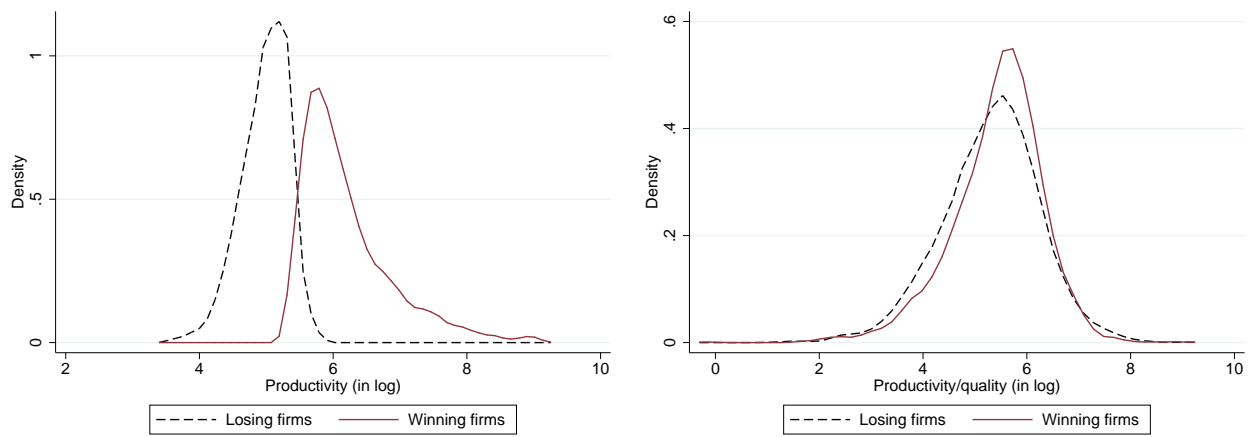


Table 1: NTMs classification, by chapter

Chapter	Description
A	Sanitary and phytosanitary measures
B	Technical barriers to trade
C	Pre-shipment inspection and other formalities
D	Contingent 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 2: Share (%) of HS6 products subject to Qs and other import-related NTMs and average number of measures per HS6 product, by country

Country	Share (%) of HS6 products with at least		Avge. number per HS6 product of	
	one QS	one other NTM	Qs	other NTMs
<i>Mean</i>	53.0	57.2	5.1	2.7
Afghanistan	12.8	11.1	3.6	1.5
Argentina	91.1	100.0	5.0	3.2
Australia	100.0	100.0	8.4	3.2
Benin	37.9	100.0	4.6	5.2
Bolivia	35.4	1.9	6.4	1.5
Brazil	81.1	38.3	8.8	2.9
Brunei	43.0	20.9	4.3	1.4
Burkina Faso	26.2	100.0	2.3	2.1
Cambodia	71.1	100.0	5.3	1.5
Canada	100.0	99.5	7.5	2.2
Cape Verde	28.6	100.0	5.1	7.1
Chile	66.1	4.9	3.4	1.1
China	65.5	22.3	6.5	1.5
Colombia	46.5	71.1	6.3	2.1
Costa Rica	32.1	5.8	3.7	1.0
Cote d'Ivoire	9.7	100.0	1.3	1.1
Cuba	97.1	96.2	1.3	1.0
Ecuador	33.4	10.6	5.2	1.6
El Salvador	34.0	0.04	2.9	2.0
Ethiopia	43.9	100.0	4.7	9.9
Gambia	13.4	99.9	14.2	2.1
Ghana	41.3	100.0	6.8	4.1
Guatemala	20.2	1.0	10.0	1.1
Guinea	97.5	97.4	3.3	9.1
Honduras	33.6	0.3	4.8	1.0
India	99.8	100.0	3.3	3.3
Indonesia	56.5	37.7	4.5	1.5
Japan	99.8	31.3	5.4	2.2
Kazakhstan	42.2	24.0	2.9	1.2
Lao	28.5	100.0	4.8	2.5
Liberia	100.0	20.7	4.7	1.9
Malaysia	38.3	19.7	4.9	1.5
Mali	28.4	100.0	2.8	8.0
Mexico	38.8	11.8	5.2	1.2
Myanmar	27.2	38.3	6.3	1.5
Nepal	100.0	100.0	2.5	6.1
New Zealand	62.7	100.0	6.8	3.0
Nicaragua	20.9	13.7	7.9	1.1
Niger	34.8	100.0	1.9	6.1
Nigeria	31.6	76.0	5.7	1.1
Pakistan	37.0	100.0	1.1	2.4
Panama	22.6	15.2	5.3	1.1
Paraguay	29.7	10.5	4.2	1.1
Peru	39.1	8.0	6.5	1.1
Philippines	74.8	100.0	7.1	7.3
Senegal	15.3	21.0	3.0	1.1
Singapore	100.0	39.4	3.0	1.2
Sri Lanka	54.0	100.0	3.9	4.3
Tajikistan	62.9	2.9	2.1	1.0
Thailand	33.2	16.5	7.1	1.2
Togo	17.5	100.0	3.8	4.0
United States	100.0	64.2	11.1	1.3
Uruguay	57.1	11.6	3.7	1.1
Venezuela	99.7	99.9	7.9	2.8
Vietnam	100.0	100.0	5.9	3.1

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

Table 3: HS6 products exported by France and subject to Qs and other import-related NTMs, by destination country

Country	Nb. of HS6 products exported by France	Share (%) of HS6 products with at least		Avge. number per HS6 product of		Share (%) of French exports not subject to Qs
		one QS	one other NTM	Qs	other NTMs	
<i>Mean</i>	1294.1	52.9	56.9	3.7	2.2	35.5
Afghanistan	435	16.3	14.0	3.3	0.9	62.1
Argentina	1733	92.7	99.5	4.4	3.2	2.7
Australia	2482	99.5	99.5	7.8	3.3	0.1
Benin	1659	42.5	99.6	2.3	5.3	9.1
Bolivia	358	25.1	3.4	6.3	0.3	54.2
Brazil	2484	81.7	42.6	8.3	1.7	10.6
Brunei	272	50.0	15.1	2.4	0.3	39.3
Burkina Faso	1561	24.1	99.6	0.6	2.1	53.0
Cambodia	556	79.0	99.8	4.1	1.4	7.5
Canada	2713	99.4	98.7	7.1	2.1	0.1
Cape Verde	379	42.7	99.7	1.7	7.1	45.1
Chile	1734	65.9	6.4	2.8	0.1	40.1
China	3098	63.3	19.9	6.1	0.4	16.9
Colombia	1575	43.9	70.7	3.2	1.8	68.6
Costa Rica	695	24.2	11.9	2.4	0.4	52.6
Cote d'Ivoire	2224	8.7	99.5	0.1	1.2	78.6
Cuba	600	96.7	96.5	1.3	1.0	69.6
Ecuador	791	31.4	6.3	4.8	0.3	65.6
El Salvador	406	26.1	0.0	2.8	0.0	91.0
Ethiopia	585	51.6	99.8	1.7	10.0	17.6
Gambia	300	9.7	100.0	1.1	2.2	42.2
Ghana	1056	41.3	99.9	2.9	4.1	38.3
Guatemala	604	18.9	1.7	9.8	0.1	55.6
Guinea	1299	96.8	96.7	3.3	9.1	2.8
Honduras	376	18.9	1.9	3.9	0.1	54.4
India	2547	99.3	99.3	2.4	3.3	0.2
Indonesia	1662	55.1	33.0	4.1	1.0	25.2
Japan	2928	99.3	28.4	5.1	0.6	0.1
Kazakhstan	1269	45.6	23.2	2.4	0.6	37.0
Lao	204	42.2	100.0	2.2	2.7	96.7
Liberia	346	99.7	41.9	5.0	0.8	0.0
Malaysia	1824	36.6	15.1	4.1	0.5	65.8
Mali	1559	26.0	99.6	0.7	8.0	48.7
Mexico	2237	35.9	9.0	3.9	0.3	35.6
Myanmar	222	27.0	23.0	3.6	0.9	43.7
Nepal	229	100.0	100.0	2.5	6.2	0.0
New Zealand	1535	64.2	99.4	3.5	3.1	9.9
Nicaragua	282	14.2	17.0	2.7	0.7	67.0
Niger	1233	42.6	99.8	0.7	6.1	29.9
Nigeria	1489	39.7	84.0	2.3	1.0	49.1
Pakistan	1061	27.7	99.5	0.3	2.5	78.7
Panama	901	17.5	9.8	4.0	0.5	51.2
Paraguay	515	23.7	12.4	3.6	0.6	26.7
Peru	1151	28.4	8.5	4.8	0.3	55.8
Philippines	1391	83.0	99.8	5.5	7.0	7.5
Senegal	2412	15.2	15.5	1.5	0.6	80.4
Singapore	2432	99.7	41.4	3.1	0.5	0.1
Sri Lanka	758	58.6	99.6	1.9	4.3	17.0
Tajikistan	216	79.2	4.6	2.4	0.1	3.6
Thailand	2185	30.4	13.5	7.0	0.5	66.7
Togo	1510	21.0	99.8	0.8	4.0	44.9
United States	3555	99.2	60.0	10.7	0.7	0.1
Uruguay	943	47.7	12.5	3.2	0.3	30.7
Venezuela	987	99.0	99.4	7.4	2.6	0.05
Vietnam	1620	99.6	99.6	5.7	3.1	0.1

Note: The shares of HS6 products with at least one QS and one other import-related NTM are computed by dividing the number of HS6 products subject to at least one of these measures and the total number of HS6 products exported by France to each destination. The average numbers of Qs and other import-related NTMs per HS6 product are computed only on HS6 products subject to at least one of these measures. Products without measures are not included in the calculation. In the last column, the exports in value are used for the computation of the share.

Table 4: Extensive margin: Export participation

	Export participation ($Prob(y_{fj}^k) > 0$)		
	(1)	(2)	(3)
Nb. of QSs _{<i>j</i>} ^{<i>k</i>}	-0.005 ^{<i>a</i>} (0.0001)	-0.004 ^{<i>a</i>} (0.0001)	-0.005 ^{<i>a</i>} (0.0001)
Nb. of QSs _{<i>j</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>}	0.001 ^{<i>a</i>} (0.0001)	0.001 ^{<i>a</i>} (0.0001)	0.001 ^{<i>a</i>} (0.0001)
Nb. of QSs _{<i>j</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}		0.0001 (0.0001)	0.001 ^{<i>a</i>} (0.0001)
Nb. of QSs _{<i>j</i>} ^{<i>k</i>} X Ln squared quality _{<i>f</i>} ^{<i>k</i>}		-0.0001 ^{<i>a</i>} (0.0001)	-0.0001 ^{<i>a</i>} (0.0001)
Nb. of QSs _{<i>j</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}			-0.0001 ^{<i>a</i>} (0.0001)
Nb. of other import-related NTMs _{<i>j</i>} ^{<i>k</i>}	-0.0002 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)
Ln applied protection _{<i>j</i>} ^{<i>k</i>}	-0.005 ^{<i>a</i>} (0.001)	-0.005 ^{<i>a</i>} (0.001)	-0.005 ^{<i>a</i>} (0.001)
Ln imports _{<i>j</i>} ^{<i>k</i>}	0.001 ^{<i>a</i>} (0.0001)	0.001 ^{<i>a</i>} (0.0001)	0.001 ^{<i>a</i>} (0.0001)
Firm already present in $t - 1$ _{<i>fj</i>} ^{<i>k</i>}	0.425 ^{<i>a</i>} (0.002)	0.420 ^{<i>a</i>} (0.002)	0.420 ^{<i>a</i>} (0.002)
Observations	6,987,228	6,609,716	6,609,716
Adjusted R ²	0.463	0.459	0.459
Fixed effects:			
Firm-Product _{<i>f</i>} ^{<i>k</i>} & Firm-Destination _{<i>fj</i>}	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. Robust standard errors in parentheses, clustered by HS6 product-destination level, with ^{*a*} denoting significance at the 1% level.

Table 5: Intensive margin: Volume and value of exports

	Volume (logs) of exports ($\ln q_{fj}^k$)			Value (logs) of exports ($\ln v_{fj}^k$)		
	(1)	(2)	(3)	(4)	(5)	(6)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>}	-0.120 ^{<i>a</i>} (0.020)	-0.123 ^{<i>a</i>} (0.023)	-0.139 ^{<i>a</i>} (0.024)	-0.123 ^{<i>a</i>} (0.019)	-0.118 ^{<i>a</i>} (0.022)	-0.138 ^{<i>a</i>} (0.023)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>}	0.022 ^{<i>a</i>} (0.004)	0.023 ^{<i>a</i>} (0.004)	0.026 ^{<i>a</i>} (0.004)	0.023 ^{<i>a</i>} (0.004)	0.022 ^{<i>a</i>} (0.004)	0.026 ^{<i>a</i>} (0.004)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}		-0.001 (0.002)	0.019 ^{<i>b</i>} (0.009)		0.0004 (0.002)	0.025 ^{<i>a</i>} (0.009)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}			-0.004 ^{<i>b</i>} (0.002)			-0.005 ^{<i>a</i>} (0.002)
Nb. of other import-related NTMs _{<i>f</i>} ^{<i>k</i>}	-0.008 (0.011)	-0.007 (0.011)	-0.006 (0.011)	-0.004 (0.010)	-0.002 (0.010)	-0.002 (0.010)
Ln applied protection _{<i>f</i>} ^{<i>k</i>}	-0.466 ^{<i>a</i>} (0.178)	-0.403 ^{<i>b</i>} (0.178)	-0.404 ^{<i>b</i>} (0.178)	-0.526 ^{<i>a</i>} (0.158)	-0.364 ^{<i>b</i>} (0.170)	-0.366 ^{<i>b</i>} (0.170)
Ln imports _{<i>f</i>} ^{<i>k</i>}	0.059 ^{<i>a</i>} (0.008)	0.062 ^{<i>a</i>} (0.008)	0.062 ^{<i>a</i>} (0.008)	0.069 ^{<i>a</i>} (0.007)	0.063 ^{<i>a</i>} (0.008)	0.063 ^{<i>a</i>} (0.008)
Firm already present in $t - 1$ _{<i>fj</i>} ^{<i>k</i>}	0.665 ^{<i>a</i>} (0.018)	0.667 ^{<i>a</i>} (0.019)	0.667 ^{<i>a</i>} (0.019)	0.694 ^{<i>a</i>} (0.018)	0.673 ^{<i>a</i>} (0.018)	0.673 ^{<i>a</i>} (0.018)
Observations	121,877	119,250	119,250	130,287	119,250	119,250
Adjusted R ²	0.740	0.737	0.737	0.682	0.675	0.675
Fixed effects:						
Firm-Product _{<i>f</i>} ^{<i>k</i>} & Firm-Destination _{<i>fj</i>}	Yes	Yes	Yes	Yes	Yes	Yes

Note: In columns (1)-(3) (respectively in columns (4)-(6)), the dependent variable is the export volume in logs (respectively 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. 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 6: Average quality

	Average Quality ($\ln(\bar{\theta}_{ij}^k)^{\beta_j^k}$)			
	(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 (0.032)	0.181 ^a (0.032)	0.192 ^a (0.033)	0.193 ^a (0.033)
Observations	26,672	26,672	26,672	26,672
Adjusted R ²	0.338	0.338	0.338	0.338
Fixed effects:				
Product ^k & Destination _j	Yes	Yes	Yes	Yes

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

Appendix

Appendix A.1. Endogenous product quality

In this appendix, we check whether our main results hold when firms endogenously select their product quality. We consider that the consumers observe perfectly only the quality of products supplied by domestic firms (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:

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

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

$$\theta_i(\varphi, \xi) = \left[\left(\frac{(\varepsilon - 1)(1 - \alpha)}{\varepsilon} \right)^{\frac{1}{\varepsilon-1}} \xi^{\frac{1}{\varepsilon-1}} \varphi P_i E_i^{\frac{1}{\varepsilon-1}} \frac{\varepsilon - 1}{\varepsilon} \right]^\Gamma \quad (\text{A. 2})$$

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:

$$\pi_{ii}(\xi, \varphi) = \frac{1}{\xi} \frac{[\theta(\xi, \varphi)]^\gamma}{\gamma} \frac{\gamma - (\varepsilon - 1)(1 - \alpha)}{(\varepsilon - 1)(1 - \alpha)} \quad (\text{A. 3})$$

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:

$$\theta_i(\varphi, \xi) = \theta_i^{min} \left(\frac{\xi^{\frac{1-\alpha}{\gamma}} \varphi}{\Phi_i} \right)^\Gamma \quad (\text{A. 4})$$

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:

$$\varphi > \left(\frac{\theta_i^{\min} \phi_{ij}^{\rho}}{\underline{\theta}_j \Phi_i^{\Gamma} \xi^{\frac{\Gamma(1-\alpha)}{\gamma}}} \right)^{\frac{1}{\rho-\Gamma}} \quad (\text{A. 5})$$

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 Qs are enforced under information asymmetry.

Appendix A.2. Quality and demand

Maximizing (9) subject to the budget constraint $E_j^k = \int_{\Omega_j^k} p(v)q(v)dv$, 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 :

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

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:

$$p_{ij}^k(v)q_{ij}^k(v) = (\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon^k-1)} \left[\sum_{\ell} \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon^k-1}{\varepsilon^k}} [q_{\ell j}^k(v)]^{\frac{\varepsilon^k-1}{\varepsilon^k}} dv \right]^{\frac{\varepsilon^k}{\varepsilon^k-1}} [p_{ij}(v)]^{1-\varepsilon^k} / \lambda^{\varepsilon} \quad (\text{A. 6})$$

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

$$E_j^k = \lambda^{-\varepsilon^k} \left[\sum_{\ell} \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon^k-1}{\varepsilon^k}} [q_{\ell j}^k(v)]^{\frac{\varepsilon^k-1}{\varepsilon^k}} dv \right]^{\frac{\varepsilon^k}{\varepsilon^k-1}} \left[\sum_{\ell} \int_{\Omega_{\ell j}^k} (\bar{\theta}_{\ell j}^k)^{\beta_j^k \frac{\varepsilon^k-1}{\varepsilon^k}} [p_{ij}^k(v)]^{1-\varepsilon^k} dv \right] \quad (\text{A. 7})$$

Using (A.1) and (A.2), we obtain (10):

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

with

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

Appendix A.3. The marginal firm

We show that:

$$(\bar{\theta}_{ij}^k)^{\beta_j^k(\varepsilon^k-1)} A_j^k = \varepsilon^k f_{ij}^k (\underline{\theta}_j^k)^{\eta^k} (\widehat{p}_{ij}^k)^{\varepsilon^k-1} \quad (\text{A. 8})$$

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 $(\hat{\theta}_{ij}(\varphi))$, 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 $(\partial p_{ij}/\partial \varphi)d\varphi + (\partial p_{ij}/\partial \theta)d\theta = 0$ and $(\partial r_{ij}/\partial \varphi)d\varphi + (\partial r_{ij}/\partial \theta)d\theta = 0$, which implies:

$$\left. \frac{d\theta}{d\varphi} \right|_{dp=0} = \left. \frac{d\theta}{d\varphi} \right|_{dr=0} = \frac{1}{\alpha} \frac{\theta}{\varphi}$$

while we have $\partial \hat{\theta}_{ij}/\partial \varphi = \rho \hat{\theta}_{ij}/\varphi$. As $\rho < 1/\alpha$, prices decrease and export sales increase moving up along the quality cutoff curve $(\hat{\theta}_{ij}(\varphi))$. Thus, there exists a maximum price \hat{p}_{ij}^k (or a minimum cost competitiveness index $\hat{\Phi}_i^k$) such that $\pi_{ij}^k(\hat{p}_{ij}^k, \theta_j^k) = 0$, implying $(\hat{\theta}_{ij}^k)^{\beta(\varepsilon^k-1)} (P_j^k)^{\varepsilon^k-1} E_j^k = \varepsilon^k f_{ij}^k (\theta_j^k)^{\eta^k} (\hat{p}_{ij}^k)^{\varepsilon^k-1}$.

Appendix B. Additional tables

Table B1: 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 B2: Extensive margin: Export participation - Robustness checks

	Export participation ($Prob(y_{fj}^k) > 0$)				
	(1) Max. price	(2) Cluster firm	(3) Altern. count of QSSs	(4) SPS only	(5) Nb. French exporters
Nb. of QSSs _j ^k	-0.005 ^a (0.0005)	-0.005 ^a (0.0005)	-0.009 ^a (0.001)	-0.003 ^a (0.001)	-0.004 ^a (0.0004)
Nb. of QSSs _j ^k X Ln productivity _f	0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)
Nb. of QSSs _j ^k X Ln quality _f ^k	0.001 ^a (0.0002)	0.001 ^a (0.0002)	0.001 ^a (0.0002)	0.001 ^a (0.0002)	0.001 ^a (0.0002)
Nb. of QSSs _j ^k X Ln squared quality _f ^k	-0.0001 ^b (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)
Nb. of QSSs _j ^k X Ln productivity _f X Ln quality _f ^k	-0.0002 ^a (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)
Nb. of other import-related NTMs _j ^k	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)	-0.0001 ^c (0.0001)	0.0002 (0.0002)
Ln applied protection _j ^k	-0.007 ^a (0.002)	-0.005 ^a (0.001)	-0.005 ^a (0.001)	-0.005 ^a (0.001)	-0.001 (0.002)
Ln maximum price _j ^k	0.003 ^a (0.0001)				
Ln imports _j ^k		0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)	-0.0003 ^a (0.0001)
Ln number of French exporters _j ^k					0.017 ^a (0.0003)
Firm already present in $t - 1$ _{fj} ^k	0.401 ^a (0.002)	0.420 ^a (0.004)	0.420 ^a (0.002)	0.421 ^a (0.002)	0.398 ^a (0.002)
Observations	4,258,917	6,609,716	6,609,716	6,609,716	4,312, 100
Adjusted R ²	0.464	0.457	0.459	0.459	0.466
Fixed effects:					
Firm-Product _f ^k & Firm-Destination _{fj}	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the probability that firm f exports product k to destination j in 2011. QSSs 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, clustered by HS6 product-destination level, with ^a, ^b and ^c denoting significance at the 1%, 5% and 10% level respectively.

Table B3: Intensive margin: Volume of exports - Robustness checks

	Volume (logs) of exports ($\ln q_{fj}^k$)				
	(1) Max. price	(2) Cluster firm	(3) Altern. count of QSs	(4) SPS only	(5) Nb. French exporters
Nb. of QSs _j ^k	-0.140 ^a (0.024)	-0.139 ^a (0.023)	-0.266 ^a (0.043)	-0.226 ^a (0.050)	-0.137 ^a (0.024)
Nb. of QSs _j ^k X Ln productivity _f	0.026 ^a (0.005)	0.026 ^a (0.005)	0.049 ^a (0.008)	0.042 ^a (0.009)	0.026 ^a (0.005)
Nb. of QSs _j ^k X Ln quality _f ^k	0.016 ^c (0.009)	0.019 ^c (0.010)	0.037 ^b (0.017)	0.062 ^a (0.021)	0.020 ^b (0.009)
Nb. of QSs _j ^k X Ln productivity _f X Ln quality _f ^k	-0.003 ^c (0.002)	-0.004 ^c (0.002)	-0.007 ^b (0.003)	-0.012 ^a (0.004)	-0.004 ^b (0.002)
Nb. of other import-related NTMs _j ^k	-0.006 (0.011)	-0.006 (0.010)	-0.003 (0.011)	-0.002 (0.003)	-0.005 (0.011)
Ln applied protection _j ^k	-0.499 ^a (0.180)	-0.404 ^a (0.156)	-0.409 ^b (0.178)	-0.396 ^b (0.178)	-0.375 ^b (0.179)
Ln maximum price _j ^k	-0.098 ^a (0.008)				
Ln imports _j ^k		0.062 ^a (0.009)	0.063 ^a (0.008)	0.063 ^a (0.008)	0.053 ^a (0.008)
Ln number of French exporters _j ^k					0.112 ^a (0.016)
Firm already present in $t - 1$ _{fj} ^k	0.672 ^a (0.019)	0.667 ^a (0.030)	0.667 ^a (0.019)	0.666 ^a (0.019)	0.662 ^a (0.019)
Observations	120,149	119,250	119,250	119,250	119,250
Adjusted R ²	0.738	0.720	0.737	0.737	0.737
Fixed effects:					
Firm-Product _f ^k & Firm-Destination _{fj}	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 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, clustered by HS6 product-destination level, with ^a, ^b and ^c denoting significance at the 1%, 5% and 10% level respectively.

Table B4: Intensive margin: Value of exports - Robustness checks

	Value (logs) of exports ($\ln v_{fj}^k$)				
	(1) Max. price	(2) Cluster firm	(3) Altern. count of QSs	(4) SPS only	(5) Nb. French exporters
Nb. of QSs _j ^k	-0.132 ^a (0.022)	-0.138 ^a (0.023)	-0.263 ^a (0.041)	-0.209 ^a (0.050)	-0.136 ^a (0.023)
Nb. of QSs _j ^k X Ln productivity _f	0.025 ^a (0.004)	0.026 ^a (0.004)	0.049 ^a (0.008)	0.038 ^a (0.009)	0.025 ^a (0.004)
Nb. of QSs _j ^k X Ln quality _f ^k	0.024 ^a (0.009)	0.025 ^b (0.010)	0.049 ^a (0.017)	0.058 ^a (0.021)	0.026 ^a (0.009)
Nb. of QSs _j ^k X Ln productivity _f X Ln quality _f ^k	-0.004 ^a (0.002)	-0.005 ^b (0.002)	-0.009 ^a (0.003)	-0.011 ^a (0.004)	-0.005 ^a (0.002)
Nb. of other import-related NTMs _j ^k	-0.002 (0.010)	-0.002 (0.010)	0.002 (0.010)	-0.001 (0.003)	-0.0002 (0.010)
Ln applied protection _j ^k	-0.393 ^b (0.170)	-0.366 ^b (0.154)	-0.370 ^b (0.170)	-0.354 ^b (0.169)	-0.334 ^b (0.170)
Ln maximum price _j ^k	0.045 ^a (0.007)				
Ln imports _j ^k		0.063 ^a (0.008)	0.063 ^a (0.008)	0.063 ^a (0.008)	0.052 ^a (0.008)
Ln number of French exporters _j ^k					0.123 ^a (0.015)
Firm already present in $t - 1$ _{fj} ^k	0.675 ^a (0.018)	0.673 ^a (0.029)	0.673 ^a (0.018)	0.672 ^a (0.018)	0.668 ^a (0.018)
Observations	120,149	119,250	119,250	119,250	119,250
Adjusted R ²	0.676	0.654	0.675	0.675	0.676
Fixed effects:					
Firm-Product _f ^k & Firm-Destination _{fj}	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 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, clustered by HS6 product-destination level, with ^a and ^b denoting significance at the 1% and 5% level respectively.

Online appendix (not for publication) Estimations with productivity in value added terms

Table OA1: Extensive margin: Export participation

	Export participation ($Prob(y_{fj}^k) > 0$)		
	(1)	(2)	(3)
Nb. of QSs _j ^k	-0.005 ^a (0.0003)	-0.004 ^a (0.0003)	-0.004 ^a (0.0003)
Nb. of QSs _j ^k X Ln productivity _f ^k	0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)
Nb. of QSs _j ^k X Ln quality _f ^k		0.0001 (0.0001)	0.001 ^a (0.0001)
Nb. of QSs _j ^k X Ln squared quality _f ^k		-0.0001 ^a (0.0001)	-0.0001 ^a (0.0001)
Nb. of QSs _j ^k X Ln productivity _f ^k X Ln quality _f ^k			-0.0002 ^a (0.0001)
Nb. of other import-related NTMs _j ^k	-0.0002 (0.0002)	-0.0001 (0.0002)	-0.0001 (0.0002)
Ln applied protection _j ^k	-0.005 ^a (0.001)	-0.005 ^a (0.001)	-0.005 ^a (0.001)
Ln imports _j ^k	0.001 ^a (0.0001)	0.001 ^a (0.0001)	0.001 ^a (0.0001)
Firm already present in $t - 1$ _{fj} ^k	0.424 ^a (0.002)	0.420 ^a (0.002)	0.420 ^a (0.002)
Observations	6,849,042	6,479,781	6,479,781
Adjusted R ²	0.461	0.457	0.457
Fixed effects:			
Firm-Product _f ^k & Firm-Destination _{fj}	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 the value added per employee. Robust standard errors in parentheses, clustered by HS6 product-destination level, with ^a denoting significance at the 1% level.

Table OA2: Intensive margin: Volume and value of exports

	Volume (logs) of exports ($\ln q_{fj}^k$)			Value (logs) of exports ($\ln v_{fj}^k$)		
	(1)	(2)	(3)	(4)	(5)	(6)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>}	-0.087 ^{<i>a</i>} (0.020)	-0.096 ^{<i>a</i>} (0.022)	-0.099 ^{<i>a</i>} (0.022)	-0.089 ^{<i>a</i>} (0.019)	-0.079 ^{<i>a</i>} (0.020)	-0.081 ^{<i>a</i>} (0.020)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>}	0.020 ^{<i>a</i>} (0.005)	0.023 ^{<i>a</i>} (0.005)	0.024 ^{<i>a</i>} (0.005)	0.021 ^{<i>a</i>} (0.004)	0.019 ^{<i>a</i>} (0.005)	0.019 ^{<i>a</i>} (0.005)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}		-0.002 (0.002)	0.006 (0.009)		-0.001 (0.002)	0.005 (0.008)
Nb. of QSs _{<i>f</i>} ^{<i>k</i>} X Ln productivity _{<i>f</i>} ^{<i>k</i>} X Ln quality _{<i>f</i>} ^{<i>k</i>}			-0.002 (0.002)			-0.001 (0.002)
Nb. of other import-related NTMs _{<i>f</i>} ^{<i>k</i>}	-0.004 (0.011)	-0.003 (0.011)	-0.003 (0.011)	-0.001 (0.011)	0.0002 (0.011)	0.0002 (0.011)
Ln applied protection _{<i>f</i>} ^{<i>k</i>}	-0.485 ^{<i>a</i>} (0.180)	-0.426 ^{<i>b</i>} (0.180)	-0.427 ^{<i>b</i>} (0.180)	-0.543 ^{<i>a</i>} (0.160)	-0.391 ^{<i>b</i>} (0.172)	-0.393 ^{<i>b</i>} (0.172)
Ln imports _{<i>f</i>} ^{<i>k</i>}	0.060 ^{<i>a</i>} (0.008)	0.063 ^{<i>a</i>} (0.008)	0.063 ^{<i>a</i>} (0.008)	0.070 ^{<i>a</i>} (0.008)	0.063 ^{<i>a</i>} (0.008)	0.063 ^{<i>a</i>} (0.008)
Firm already present in $t - 1$ _{<i>fj</i>} ^{<i>k</i>}	0.663 ^{<i>a</i>} (0.019)	0.664 ^{<i>a</i>} (0.019)	0.664 ^{<i>a</i>} (0.019)	0.688 ^{<i>a</i>} (0.018)	0.668 ^{<i>a</i>} (0.018)	0.668 ^{<i>a</i>} (0.018)
Observations	117,832	115,236	115,236	125,814	115,236	115,236
Adjusted R ²	0.847	0.846	0.846	0.812	0.810	0.810
Fixed effects:						
Firm-Product _{<i>f</i>} ^{<i>k</i>} & Firm-Destination _{<i>fj</i>}	Yes	Yes	Yes	Yes	Yes	Yes

Note: In columns (1)-(3) (respectively in columns (4)-(6)), the dependent variable is the export volume in logs (respectively 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 the value added per employee. Robust standard errors in parentheses, clustered by HS6 product-destination level, with ^{*a*} and ^{*b*} denoting significance at the 1% and 5% level respectively.