Do Standards Improve the Quality of Traded Products?

Carl Gaigne, Anne-Célia Disdier, Cristina Herghelegiu

Do Standards Improve the Quality of Traded Products?

Anne-Célia DISDIER, Carl GAIGNÉ, Cristina HERGHELEGIU

Working Paper SMART – LERECO N°21-11

December 2021

UMR INRAE-L'institut Agro **SMART - LERECO**

(Laboratoires d'Etudes et de Recherches en Economie sur les Structures et Marchés Agricoles, Ressources et Territoires)

Les Working Papers SMART-LERECO ont pour vocation de diffuser les recherches conduites au sein de l'UMR SMART- LERECO dans une forme préliminaire permettant la discussion et avant publication définitive. Selon les cas, il s'agit de travaux qui ont été acceptés ou ont déjà fait l'objet d'une présentation lors d'une conférence scientifique nationale ou internationale, qui ont été soumis pour publication dans une revue académique à comité de lecture, ou encore qui constituent un chapitre d'ouvrage académique. Bien que non revus par les pairs, chaque working paper a fait l'objet d'une relecture interne par un des scientifiques de l'UMR SMART-LERECO et par l'un des éditeurs de la série. Les Working Papers SMART-LERECO n'engagent cependant que leurs auteurs.

The SMART-LERECO Working Papers are meant to promote discussion by disseminating the research of the SMART-LERECO members in a preliminary form and before their final publication. They may be papers which have been accepted or already presented in a national or international scientific conference, articles which have been submitted to a peer-reviewed academic journal, or chapters of an academic book. While not peer-reviewed, each of them has been read over by one of the scientists of SMART-LERECO and by one of the two editors of the series. However, the views expressed in the SMART-LERECO Working Papers are solely those of their authors.

Do Standards Improve the Quality of Traded Products?

Carl Gaigné
INRAE, UMR 1302 SMART-LERECO, 35011 Rennes, France and CREATE, Laval University, Quebec, Canada

Anne-Célia Disdier
Paris School of Economics-INRAE, 48 bd Jourdan, 75014 Paris, France

Cristina Herghelegiu
Economist Team, DG Internal Market, Industry, Entrepreneurship and SMEs, European Commission, 1049 Brussels, Belgium

Acknowledgments

We would like to thank David Atkin, John Beghin, Angela Cheptea, Arnaud Costinot, Lionel Fontagné, Beata Javorcik, Chantal Le Mouël, Kalina Manova, Florian Mayneris, Marcelo Olarreaga, Ariell Reshef, John Romalis, Vincent Vicard and the participants at the ETSG 2016 (Helsinki, Finland), the 149th EAAE Seminar (Rennes, France), the PRONTO Workshop 2017 (Paris, France), the Brownbag Seminar (Geneva, Switzerland), the 17th Doctoral Meetings in International Trade and International Finance 2017 (Lille, France), the 4th ERMAS Conference (Cluj-Napoca, Romania), the XV EAAE Congress (Parma, Italy), the DEGIT XXII Conference (Paris, France), the Food Economics and Policy Seminar (Toulouse, France), the IfW seminar (Kiel, Germany), the ETH KOF seminar (Zurich, Switzerland), and the INRA-ALISS seminar (Paris, France) for their helpful comments. This work is supported by the CEPREMAP and the European Commission (PRONTO Project, grant agreement 613504). The project leading to this paper also received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 770680 (RESPECT). This work is also supported by the French National Research Agency (ANR-17-EURE-0001 and ANR-10-EQPX-17 – Centre d'accès sécurisé aux données – CASD).

Corresponding author Carl Gaigné

INRAE, UMR SMART-LERECO
4 allée Adolphe Bobierre, CS 61103
35011 Rennes cedex, FRANCE
Email: carl.gaigne@inrae.fr
Téléphone / Phone: +33 (0)2 23 48 56 08
Fax: +33 (0)2 23 48 53 80

Do Standards Improve the Quality of Traded Products?

Abstract

We examine whether standards raise the quality of traded products by correcting market failures associated with information asymmetry on product attributes. Matching a panel of French firm-product-destination export data with a dataset on sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBTs), we find that such quality standards enforced on products by destination countries: (i) favor the export probability of high-quality firms provided that their productivity is high enough; (ii) raise the export sales of high-productivity high-quality firms at the expense of low-productivity and low-quality firms; (iii) improve the average quality of consumption goods exported by France. We then develop a simple new trade model under uncertainty about product quality, in which heterogeneous firms can strategically invest in quality signaling, to rationalize these empirical results on quality and selection effects.

Keywords: firm exports, quality standards, information asymmetry, product quality, heterogeneity.

JEL Classification: D21, D22, F12, F14.

Les normes améliorent-elles la qualité des produits importés ?

Résumé Nous examinons si les normes améliorent la qualité des produits échangés en corrigeant les défaillances du marché associées à l'asymétrie d'information sur les attributs des produits. A partir de données sur les exportations françaises au niveau entreprise-produit-destination et sur les mesures sanitaires et phytosanitaires (SPS) et les obstacles techniques au commerce (OTC) appliquées par les pays étrangers, nous constatons que ces normes de qualité a (i) favorisent la probabilité d'exportation des entreprises françaises offrant des produits de haute qualité, à condition que leur productivité soit suffisamment élevée, (ii) augmentent les ventes à l'exportation des entreprises à forte productivité au détriment des entreprises à faible productivité, et (iii) améliorent la qualité moyenne des biens de consommation exportés par la France. Afin de rationaliser ces résultats empiriques sur les effets de qualité et de sélection, nous développons ensuite un nouveau modèle de commerce internationale avec incertitude sur la qualité des produits et des entreprises hétérogènes pouvant investir stratégiquement dans le signalement de la qualité.

Mots-clés: exportation, normes de qualité, asymétrie d'information, qualité des produits, hétérogénéité.

Classification JEL: D21, D22, F12, F14.

Do Standards Improve the Quality of Traded Products?

1. Introduction

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

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

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

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

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

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

We first assess empirically the effects of QSs on individual firms' export decisions. We estimate the impact of QSs on both the export participation (extensive trade margin) and export sales (intensive trade margin) of individual French exporters with respect to their productivity and the quality of their products. For this purpose, we match a dataset on public QSs (SPS and TBT measures) enforced in 88 non-European countries with a panel of French firm-product-destination export data over the period 1996-2007. With our data, we uncover two main empirical regularities regarding the role of QSs on the export performance of firms. First, a large number of QSs in a product-destination-year market increases the presence of high-quality French exporters if their productivity is high enough. In other words, the introduction of QSs addresses information asymmetry problems only for the more efficient foreign firms. Second, more QSs induce a reallocation of market shares from low-productivity low-quality firms to high-productivity high-quality firms. Hence, stricter QSs increase the market share of high-quality firms, provided that their productivity is sufficiently high.

We then simulate the impact of QSs on aggregate exports and study their effect on the average quality of exported products. For simulations, we proceed as follows. First, we classify in quartiles the current number of QSs imposed by various destinations j on product k in year t, to account for the heterogeneity in imposing standards across destinations. Then, we set the number of QSs on product k to the maximum number observed across all destinations j in a given quartile in year t. Our simulation exercise suggests that the number of French exporters per product-destination pair would decrease on average by 0.07% (extensive margin effect) over the period 1996-2007. At the intensive margin, 86.5% of surviving firms would experience a fall in their export sales to non-EU countries. Their export sales to non-EU countries would decrease on average by 0.4%. By contrast, 14.5% of surviving firms would benefit from this rise in the number of QSs. The winners are high-productivity high-quality firms. Their export sales to non-EU countries would increase on average by 1.3%. The overall effect on French exports to non-EU markets would be negative (-0.04%). When it comes to the average quality of exported products perceived by foreign consumers, the effect of QSs is dependent on the considered class of goods and sectors. QSs increase the average quality of consumption goods, such as food and beverages, as well as textile products, but have no significant impact on capital and intermediate goods.

We finally rationalize our empirical results on QS-induced changes in trade and quality. We build a new firm-based trade model identifying the mechanisms at work in the presence of QSs and uncertainty about product quality. The main ingredients are the following. Firms can strategically undertake investment in quality signaling (Dranove and Jin, 2010). They can truthfully and credibly disclose information about the quality of their varieties. In the model, firms are characterized by the productivity and quality of their products, which are horizontally and vertically differentiated. Product quality is endogenously set by firms and tailored to each market. The marginal cost of production increases with quality for a given productivity, and decreases with productivity for a given quality. We show that information asymmetry and signaling activity may explain why high-quality firms gain from stricter QSs, provided that their productivity is high enough.[4]

First, we find that the enforcement of QSs forces low-quality firms to improve the quality of their products or to exit the market if they are not able to keep up with the regulations. Second, low-productivity exporters cannot profitably undertake investments in quality signaling. Foreign consumers therefore do not know the true quality of their products whereas their prices are relatively high. Thus, the low-productivity (non-signaling) exporters operate under quality uncertainty and their export sales increase with productivity, but decrease with product quality (cost effect). As a consequence, these exporters have an incentive to supply a quality that just meets the QSs and may reduce their quality after QSs' enforcement because the market competition becomes tougher. Note that, even though there are no fixed costs associated with information disclosure, low-productivity exporters producing low-quality products prefer to hide in the pool of firms selling varieties with a higher quality.[5] Third, signaling activity, which may imply fixed costs, is only profitable for high-productivity firms selling high-quality products. The export sales of these signaling firms increase with their productivity, the quality of their products, and the restrictiveness of QSs (due to a reallocation of market shares). All in all, the introduction of QSs has an ambiguous effect on the average quality of products available on the market. QSs may exclude low-quality firms from the market (increase in average quality), but may also force low-productivity exporters to reduce the quality of their varieties (decrease in average quality).

Literature Review

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

The role of QSs on firms' exports has been explored in few papers. On the theoretical side, Das and Donnenfeld (1989), Gaigné and Larue (2016) and Bastos *et al.* (2018a) develop international trade models with vertical differentiation but assume perfect information. While these theoretical papers take into account both the quality and productivity characteristics of

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

[5] This result is in line with the industrial organization literature (Dranove and Jin, 2010).

firms, the existing empirical studies solely consider productivity features. Their results show that QSs raise the export probability and export value of high-productivity firms at the expense of low-productivity firms (Fontagné *et al.*, 2015; Fugazza *et al.*, 2018; Fernandes *et al.*, 2019). In addition, the export probability is reduced in TBT-imposing destinations, especially for multi-destination firms, which can choose TBT-free destinations (Fontagné and Orefice, 2018). Compared to this strand of the empirical literature, we go one step further. We theoretically and empirically study how both the productivity and quality characteristics of firms shape their export decisions in the presence of QSs and in a context of information asymmetry between consumers and producers with respect to product quality. Moreover, we also analyze the role of QSs on aggregate exports and on the average quality of exported products.

This paper also investigates the link between product quality and trade at firm level. Building on Melitz (2003)'s framework, several papers consider vertical differentiation to explain the quality sorting found in international trade. Conditional on size, exporting firms sell high quality goods at high prices (Hallak and Sivadasan, 2013). Besides, the competitiveness of firms is determined by their quality-adjusted prices (Kugler and Verhoogen, 2012), with high quality products being able to enter more distant markets (Baldwin and Harrigan, 2011). Bastos *et al.* (2018a) analyze in a dynamic setting how learning about demand and quality choices shapes the evolution of firm performance and prices over the life cycle. However, all these papers assume perfect information. By contrast, we account for information asymmetry between buyers and sellers with respect to product quality, as in Akerlof (1970). We consider that consumers can neither correlate product quality with price, nor perfectly judge it even after consumption (credence goods).[6] Credence attributes are of very different nature: (i) attributes that have health/safety consequences and (ii) consumer demand (willingness to pay) for attributes that are related to human health and production processes, such as the environmental cost of production, the use of child labor, and animal welfare standards (Dulleck *et al.*, 2011). Given the type of products, our model considers that firms rely on a costly certification process to credibly signal quality (see Dranove and Jin, 2010, for a survey on the theoretical and empirical literature on quality disclosure and certification).

Finally, this paper complements the literature on adverse selection. While the theoretical contributions on adverse selection and the under-provision of quality have increased significantly since the 1970s, empirical tests using data on *tangible* goods remain rather scarce compared to those focusing on insurance markets. Some studies have tested for adverse selection in durable goods markets (Bond, 1982; Genesove, 1993; Hendel *et al.*, 2005; Engers *et al.*, 2009; Peterson and Schneider, 2014, 2017). Our data allows us to exploit the differences across countries to identify adverse selection. As the presence of QSs reduces the information asymmetry problem, the differences in the number of QSs across countries should drive the probability of serving

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

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 describes the data and the computation of quality and presents the trade effects of QSs at the firm level. Section 3 investigates the impact of QSs on aggregate exports and on the average quality of products. Section 4 exposes the theoretical model that rationalizes our results on QS-induced changes in trade and quality. Section 5 concludes.

2. Trade and selection effects of QSs at the firm level

This section empirically investigates the impact of QSs on the extensive and intensive export margins according to the characteristics of the firms. Our study combines trade policy data (QSs and tariffs) defined at the product-destination-year triplet with French export data computed at the firm-product-destination-year level.

2.1. Underlying mechanisms of the role of QSs

Let us consider the demand in country j for a variety of product k produced by firm f

$$q_{fj}^{k}(\lambda_{fj}^{k}, p_{fj}^{k}, \mathcal{A}_{j}^{k}) \tag{1}$$

where λ_{fj}^{k} represents the quality of the variety provided by firm f from country i *perceived* by consumers in j (it captures all attributes of the product other than price, which consumers value), p_{fj}^{k} is the price of the variety of product k produced by firm f in country i prevailing in country j, and $\mathcal{A}_{j}^{k}$ is a scalar (aggregator) function of all quality-adjusted prices and the amount of income allocated to the differentiated product sector. This aggregator $\mathcal{A}_{j}^{k}$ can be interpreted as an index of the toughness of competition across firms in country j for product k. It shifts downward demand curves as the quality-adjusted prices of varieties available in a country decrease, while it shifts upward demand curves when income increases.

Because λ_{fj}^{k} depends on the information available to consumers, the introduction of QSs can facilitate trade when consumers can neither correlate product quality with price, nor perfectly judge it even after consumption. The demand for foreign products increases due to a better quality of products perceived by consumers. However, QSs may induce additional variable and fixed costs of production (compliance costs) and hamper trade. By raising prices p_{fj}^{k}, the demand for foreign products decreases for a given product quality. As a consequence, the introduction of QSs leads to the exit of low-quality varieties and less productive firms due to fixed export costs. In addition, the introduction of QSs modifies the distribution of quality-adjusted prices and, in turn, the demand for each variety through $\mathcal{A}_{j}^{k}$. By inducing the exit of less productive firms and increasing the quality perceived by consumers, QSs make competition across rivals more intense. Hence, the effect of QSs on trade is ambiguous and depends on the characteristics of sellers (productivity and product quality).

Our estimations aim to study the impact of QSs on exports and whether these effects vary with respect to the type of decision (export participation or export sales) and the type of firms. We postulate a simple specification:

$$\begin{aligned} Y_{fjt}^{k} &= \beta_1 QS_{jt}^{k} + \beta_2 \ln \varphi_{ft}^{k} + \beta_3 \ln \lambda_{fjt}^{k} + \beta_4 QS_{jt}^{k} \times \ln \varphi_{ft}^{k} + \beta_5 QS_{jt}^{k} \times \ln \lambda_{fjt}^{k} \\ &+ \beta_6 QS_{jt}^{k} \times \ln \varphi_{ft}^{k} \times \ln \lambda_{fjt}^{k} + \mu_{fjt}^{k}, \end{aligned} \quad (2)$$

where Y_{fj}^{k} is the strategic variable – export participation ($q_{fjt}^{k} > 0$) or level of exports ($p_{fjt}^{k} q_{fjt}^{k}$, respectively q_{fjt}^{k}) – of firm f associated with destination j and product k in year t, φ_{ft}^{k} is the productivity of firm f producing a variety of product k in year t, and λ_{fjt}^{k} is the quality of the variety of product k exported by firm f to destination j in year t. Among explanatory variables, the estimated equation also includes three interaction terms. The interaction term between the number of QSs and the firm-product's productivity aims to capture a possible reallocation effect across low- and high-productivity firms. In addition, a possible reallocation effect across low- and high-quality firms is accounted for by the interaction term between the number of QSs and the firm-product-destination quality identified for a certain year. Finally, the last interaction term between the number of QSs, the productivity and the quality aims to capture the reallocation effects between high/low productivity and quality firms. μ_{fjt}^{k} represents the usual error term, and $\beta_1, ..., \beta_6$ are the parameters to be estimated.

2.2. Datasets

We build a panel dataset for the period 1996-2007. We start in 1996 because of constraints on data availability and stop in 2007, just before the 2008 crisis, which is likely to have impacted French firms exports.

QSs. Data on QSs come from the TRAINS NTM database released by the UNCTAD.[7] It is currently the most comprehensive NTMs database, providing all the measures in force by country, product and type of instrument at the time of data collection (between 2012 and 2018, depending on the country). For each measure, the database provides the implementation and repeal (if any) dates. Relying on this information, one can build a panel dataset.

[7] TRAINS stands for TRade Analysis Information System and UNCTAD for United Nations Conference on Trade and Development. TRAINS NTMs data are available at: https://trains.unctad.org/. We downloaded the database from the TRAINS website in February 2021. This database includes 91 countries, with European Union (EU) countries aggregated into a single entry.

The TRAINS NTM database encompasses not only measures of well-identified trade objectives (*e.g.* quotas and price controls), but also regulatory and technical instruments aimed at protecting human health and the environment by improving the production process and/or the product quality (*e.g.* SPS and TBTs). Even without trade objectives, these regulatory and technical standards may impact international flows.

The measures included in the TRAINS NTM database are broken up into 16 chapters, depending on their scope and/or design. Each chapter is further differentiated into subgroups to allow for a finer classification of measures.[8] For our analysis, we retain the first 15 chapters, which deal with countries' requirements regarding their imports, and exclude the last chapter covering countries' requirements regarding their exports. Furthermore, we classify NTMs into two categories: i) QSs defined as SPS and TBT measures and ii) all other import-related NTMs. As previously mentioned, our study focuses on the impact of QSs on French firms' exports. However, as other NTMs may also affect export flows, we include them as control variables in our estimations.

For each country, the products targeted by NTM measures are identified at the 6-digit level of the Harmonized System (HS) classification, and thus can be easily matched with French firm export and tariff data, which are also defined at that level of aggregation (see below). Finally, we count the number of SPS and TBTs (*e.g.* QSs), as well as other import-related NTMs imposed by each importing country on a given HS6 product and a given year.[9] This simple count of measures is the common approach in the literature on NTMs (UNCTAD, 2018). Indeed, the databases on NTMS – and among others the TRAINS NTM database – list the existing NTMs, but unfortunately do not provide information on their restrictiveness. However, the number of measures imposed by an importing country on a given HS6 product can be seen as a proxy for their restrictiveness. It is likely to be more costly and therefore more difficult for an exporter to enter a product-destination market with a high number of QSs and other import-related NTMs.

French firm-product level data. In addition to the QS data, we use French firm-product level data. French customs provide export data – in value (thousand euros) and volume (tons) – by

[8]Table A.1 in the Appendix A lists the 16 chapters. See UNCTAD (2016) for a more refined decomposition of the classification. For example, chapter A on SPS measures is decomposed into nine two-digit codes (from A1 to A9). Two-digit codes are then differentiated into three-digit codes. Some groupings are then further decomposed; however, most of the groupings stop at three digits. In our analysis, we focus on the two-digit codes and if more than one measure belongs to the same subgroup and affects the same product in the same country and year, we group them (for example, two A11 measures on product k in country j and year t 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.

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

firm, HS6 product, destination country and year. Using official firm identifiers, we merge the customs data with the BRN (Bénéfices réels normaux) dataset compiled by the French Statistical Institute, which provides annual firm balance-sheet data (*e.g.* value added, total sales, and employment) needed for the computation of productivity.

As previously mentioned, we focus on the period 1996-2007 and perform a panel analysis using the number of QSs and other import-related NTMs in force in a given year in each destination country on each product and potentially affecting French firms' export decisions. To keep the dataset manageable, we restrict our sample to firms exporting a given product to a given destination for at least three years within our time period. This strategy also addresses potential bias due to occasional exporters (Fontagné *et al.*, 2015). Furthermore, taking into account the core principle of mutual recognition of QSs 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.

Productivity. In our dataset, proxies for annual physical productivity (computed as the value added per worker)[10] are available only at the firm level. In the absence of information on productivity at the firm-product pair level, we have to control for the heterogeneity in productivity for each firm across its varieties. In accordance with the industrial organization literature (Prahalad and Hamel, 1990; Eckel and Neary, 2010; Eckel *et al.*, 2016), multi-product firms have a core competence product that is produced with the highest productivity φ^k_{ft} (its rank 1).[11] Expanding the product lines and moving away from the core competence of the firm decreases productivity. The within-firm ranking of each product for a given year is computed as follows. The annual exports of a product by a firm are summed across all destinations. The annual export values for each product are then sorted in descending order. The first rank is assigned to the product with the highest export value. The product with the lowest export value is ranked last. The productivity of each product-firm-year triplet is then simply computed by dividing the productivity of the firm by the rank of the product: $\varphi^k_{ft} = \varphi_{ft}/\text{rank}^k_{ft}$.

Quality. The measurement of product quality using firm-level trade data when information asymmetry prevails is challenging. Various approaches are available but some of them cannot be implemented here. We cannot directly use unit values (the ratio of the value to the quantity sold) as a higher price does not necessarily reflect higher product quality. In our case, higher

[10]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 value added per worker are strongly correlated. Our main conclusions are robust to the use of sales per worker as a measure of firm productivity.

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

prices can be induced by a higher horizontal product differentiation, a lower productivity (φ^k), or a higher unit cost, even though product quality is lower. Furthermore, we cannot rely on input prices at the firm level as in Bastos *et al.* (2018b). Verhoogen (2008) and Kugler and Verhoogen (2012) show that firms use high-quality inputs to produce high-quality products. Thus, assuming that input markets are competitive, higher input prices should reflect higher quality inputs and, in turn, higher quality output. Unfortunately, many firms in our sample are multi-product firms and our dataset does not report input prices for each product separately. As information on both price and quantity is available, we therefore rely on the approach usually used in the literature and consider demand equations (Khandelwal, 2010; Khandelwal *et al.*, 2013).[12] For a given price in a firm-product-destination-year quadruplet, a variety with higher sales is assigned a higher quality.

Assuming that (1) is given by a CES (constant elasticity of substitution) demand system, we have $q^k_{fjt} = \mathcal{A}^k_{jt}(\lambda^k_{fjt})^{\sigma^k-1}(p^k_{fjt})^{-\sigma^k}$, where σ^k is the elasticity of substitution and $\mathcal{A}^k_{jt} = E^k_{jt}(P^k_{jt})^{\varepsilon^k-1}$, with E^k_{jt} the total income allocated to varieties of product k in country j in year t, and P^k_{jt} the (product-specific) exact price index prevailing in country j in year t. Quality at the firm-product-destination-year level can be estimated relying on the following OLS regression:

$$\ln q^k_{fjt} + \sigma^k \ln p^k_{fjt} = \text{FE}^k + \text{FE}_{jt} + \varepsilon^k_{fjt} \tag{3}$$

where q^k_{fjt} represents the volume of exports of product k by firm f to destination j in year t and p^k_{fjt} the price of exports (proxied by the unit values). For the elasticity of substitution σ^k, we rely on the elasticities reported by Broda *et al.* (2006). Imposing these elasticities of substitution across products allows us to avoid estimating the demand for each good before inferring quality. Fixed effects FE_{jt} capture destination j's expenditures and price index, and are common to all exporters serving the same destination country in year t. Since prices and quantities are not necessarily comparable across product categories, a product fixed effect (FE^k) is also added.

Hence, we define the estimated quality as $\ln \widehat{\lambda}^k_{fjt} = \widehat{\varepsilon}^k_{fjt}/(\sigma^k-1)$. Conditional on price, a variety with a higher quantity is assigned higher quality. This quality measure defined at the firm-product-destination-year level will be further used in our empirical analysis for the intensive trade margin (volume and value of exports to a certain product-destination market).

Unfortunately, the methodology proposed by Khandelwal (2010) and Khandelwal *et al.* (2013) does not allow us to infer the latent quality of products that are not exported (because we do not know the latent demand). However, we need this information to evaluate the role of quality at the extensive margin (the probability of serving a foreign country). We therefore adopt the following strategy. We track firms after their first entry in a product-destination market over the

[12] Quality measures based on supply side appear to be highly correlated with those inferred using demand equations (Disdier *et al.*, 2018).

period 1996-2007, and if a firm does not export to that market in a subsequent year, we assign to this zero-export observation the previous quality measure observed for that firm in that market.

Overall, our final sample includes 56,080 French firms exporting 4,625 HS6 products to 88 destination countries (EU excluded).[13] On average, over the period 1996-2007, a firm exports 2.8 HS6 products per destination (median = 1) and serves 2.3 destinations per HS6 product (median = 1). The data show that 48.9% of firms serve only one destination (mono-destination firms) and 38.5% export only one product (mono-product firms).

In our sample, on average 14.6% of French firms' exports in value are impacted by at least one QS between 1996 and 2007. This percentage is continuously increasing over time, from 2.7% in 1996 to 28.0% in 2007. The average share of HS6 products exported by French firms and impacted by at least one QS is equal to 11.3% over the period. This share is raising from 2.0% in 1996 to 21.7% in 2007. Besides, the average number of QSs per HS6 product exported by French firms is equal to 2.9, with a minimum of 1.3 in 1996 and a maximum of 3.8 in 2007.[14] Strong differences are also observed between markets. Across the 88 destinations included in our sample, the share of French exports affected by at least one QS ranges from a minimum of 0% to a maximum of 72.1%, the share of French products impacted by at least one QS shifts between 0% and 64.9%, and the number of QSs per product exported by French firms varies between 0 and 7.7.

2.3. Identification strategy

Extensive margin. We explore the impact of QSs on the presence of a firm in a given product-destination-year market. Our dependent variable (y^k_{fjt}) is the probability that firm f exports product k to destination j in year t. Our counterfactual scenario considers the firms that do not export in the same product-destination-year triplet kjt. This choice model can be written using a latent variable representation, with y^{*k}_{fjt} representing the latent variable that determines whether a strictly positive export flow is observed for firm f in the product-destination-year triplet kjt. We estimate this export equation using a linear probability model and control for unobservable characteristics at firm, product, destination and year levels using different sets of fixed effects. The linear probability model avoids the incidental parameter problem affecting the probit model. The estimated equation is as follows:

$$Pr(y^k_{fjt}) = \begin{cases} 1 & \text{if} \quad y^{*k}_{fjt} > 0, \\ 0 & \text{if} \quad y^{*k}_{fjt} \leq 0, \end{cases} \tag{4}$$

[13] Table A.2 in the Appendix A reports the list of countries. Besides, different versions of the HS classification are used in the data sources. We converted all HS6 codes into the HS1992 version.

[14] 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.

with

$$\begin{aligned} y^{*k}_{fjt} \;=\; & \beta_1^{EM} QS^k_{jt} + \beta_2^{EM} \ln \hat{\varphi}^k_{f,t-1} + \beta_3^{EM} \ln \widehat{\lambda}^k_{fj,t-1} + \beta_4^{EM} QS^k_{jt} \times \ln \hat{\varphi}^k_{f,t-1} \\ & + \beta_5^{EM} QS^k_{jt} \times \ln \widehat{\lambda}^k_{fj,t-1} + \beta_6^{EM} QS^k_{jt} \times \ln \hat{\varphi}^k_{f,t-1} \times \ln \widehat{\lambda}^k_{fj,t-1} \\ & + \text{controls}^k_{jt} + \text{FE}_f + \text{FE}^{HS4}_{jt} + \mu^k_{fjt}, \end{aligned}$$

where QS^k_{jt} is the number of QSs (SPS and TBT measures) applied to product k by destination country j in year t, $\hat{\varphi}^k_{f,t-1}$ is a measure of the productivity for a given firm-product pair in year $t-1$, while $\hat{\lambda}^k_{fj,t-1}$ is the quality measure computed at the firm-product-destination-year level. We consider lagged terms for both productivity and quality to reduce the potential endogeneity bias.

Equation (4) includes additional explanatory variables. The product-destination-year controls (controls^k_{jt}) include the number of other import-related NTMs and the tariff bilateral protection (in logs) applied on product k by destination j in year t. Tariff barriers may indeed impact French firms' exports. In their absence, one cannot distinguish the effects of QSs and other import-related NTMs on exports from those of tariffs.[15] To capture the role of the index of toughness of competition across firms in a foreign market $\mathcal{A}^k_{jt}$ (which is also equivalent to the index of market demand from a country), we include the highest price observed for product k in destination j in year t. This maximum price is expected to be positively correlated with $\mathcal{A}^k_j$. However, this maximum price is likely to be endogenous. In estimations, we therefore rely on lagged imports defined at the product-destination-year level to proxy the demand in a market (excluding imports originating from France).

Fixed effects are incorporated in the estimation to capture unobservable characteristics. As in Fontagné *et al.* (2015), we first include a set of firm fixed effects (FE_f). With this specification, we absorb any firm-specific (time-invariant) characteristics that may affect export performance. Second, we also consider a set of three-way fixed effects (HS4-destination-year), FE^{HS4}_{jt}, to control for HS4-destination-time varying factors that may impact trade flows (*e.g.* business cycles, import-demand shocks, or multilateral trade resistance). These three-way fixed effects also control for the geographic and sector orientation of French exports, as well as for any characteristic specific to each destination, and, for instance, for the fact that the demand for quality is, on average, higher in developed countries. They therefore capture a significant part of the potential correlation between the QSs imposed by destination countries and other aspects of these destination markets. μ^k_{fj} is the error term.[16] Finally, our estimations retain only groups with more than one observation. As shown by Correia (2015), the inclusion of single groups in linear

[15]Tariff data were obtained from the TRAINS database and can be accessed through the World Bank Integrated Trade Solution (WITS): https://wits.worldbank.org/.

[16]The interaction between QSs, productivity and quality varies at the firm-product-destination-year level. Therefore, we do not need to cluster standard errors. However, as a robustness check, we cluster standard errors at the destination–product-year level and our results remain valid (*cf. infra*).

regressions where fixed effects are nested within clusters might lead to incorrect inferences.[17]

Intensive margin. We now consider the intensive margin of trade and investigate the effect of QSs on the export value and volume of a firm for a given product-destination-year market. We estimate the following specification:

$$\begin{aligned}\ln r^k_{fjt} \;=\;& \beta_1^{IM} QS^k_{jt} + \beta_2^{IM} \ln \hat{\varphi}^k_{f,t-1} + \beta_3^{IM} \ln \widehat{\lambda}^k_{fj,t-1} + \beta_4^{IM} QS^k_{jt} \times \ln \hat{\varphi}^k_{f,t-1} \\ &+ \beta_5^{IM} QS^k_{jt} \times \ln \widehat{\lambda}^k_{fj,t-1} + \beta_6^{IM} QS^k_{jt} \times \ln \hat{\varphi}^k_{f,t-1} \times \ln \widehat{\lambda}^k_{fj,t-1} \\ &+ \text{controls}^k_{jt} + \text{FE}_f + \text{FE}^{HS4}_{jt} + \mu^k_{fjt}, \qquad (5)\end{aligned}$$

where r^k_{fjt} denotes exports in value terms $r^k_{fjt} = p^k_{fjt} q^k_{fjt}$ of product k by firm f to destination country j in year t. We also consider the export volume q^k_{fjt} as a dependent variable. The variables of interest, the controls and sets of fixed effects included in equation (5) are the same as those used for the estimation of the extensive trade margin.

2.4. Results

Extensive margin. Table 1 presents the results. QS variables are introduced step-by-step in estimations. Column 1 considers the number of QSs alone. Column 2 then shows how the QS variable is interacted with firm-product productivity and firm-product-destination quality. Finally, column 3 incorporates the three-way interaction term for the number of QSs, productivity and quality. Productivity and quality measures, as well as controls, are included in the three columns.

First and as expected, the participation of a French firm in a given product-destination-year triplet is, on average, positively correlated with our measures of firm's productivity and quality ($p < 0.01$). This result is observed in all columns. Second, QSs have a negative impact on firm's export participation. This impact is not significant in column 1, where the potential heterogeneous effects of QSs across firms are not controlled for. However, it becomes significant in column 2, when the two interactions terms of QSs with productivity, and of QSs with quality are introduced. Besides, in column 2, the estimates on the two interaction terms are positive and highly significant ($p < 0.01$). These results therefore suggest that QSs reduce the export participation of firms, but this impact is smaller for high-productivity and high-quality levels. Said differently, high efficiency and quality thresholds disqualify less efficient and low quality firms from exporting. Column 3 confirms these findings, by reporting a positive and significant estimate on the triple interaction term ($p < 0.01$). According to column 3, we

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

have $\frac{\partial^2 y^k_{fjt}}{\partial QS^k_{jt} \partial \hat{\varphi}^k_{f,t-1}} = (\hat{\beta}^{EM}_4 + \hat{\beta}^{EM}_6 \ln \hat{\lambda}^k_{fj,t-1})/\hat{\varphi}^k_{f,t-1}$, which is positive for 21.8% of firms, and $\frac{\partial^2 y^k_{fjt}}{\partial QS^k_{jt} \partial \hat{\lambda}^k_{fj,t-1}} = (\hat{\beta}^{EM}_5 + \hat{\beta}^{EM}_6 \ln \hat{\varphi}^k_{f,t-1})/\hat{\lambda}^k_{f,t-1}$, which is positive for 86.3% of firms. Because $\beta^{EM}_4 < 0$, $\beta^{EM}_5 < 0$, and $\beta^{EM}_6 > 0$, high-productivity firms are more likely to serve a foreign country with a stricter QS, provided that the quality of their variety is high enough. Further, firms selling high-quality varieties are more likely to serve a foreign country with a stricter QS, provided that their productivity is high enough. Hence, the impact of QSs on the export participation of firms depends on their productivity *and* the quality of their varieties.

Regarding the other explanatory variables, we document a negative but non significant effect of other import-related measures on the export participation of French firms. As expected, the higher the tariffs for a product in a given destination, the lower the export participation of French firms ($p < 0.01$). Finally, the higher the demand for a product in a given destination (proxied through imports), the higher the presence of French exporters ($p < 0.01$).

Intensive margin. We now analyze the effect of QSs on the intensive trade margin of a firm in a product-destination-year triplet by estimating equation (5). Results are presented in Table 2. Columns 1-3 describe the effect of QSs on firms' export value, while columns 4-6 show the impact on the export volume. The specifications follow the same logic as that in Table 1.

First, the value and volume of exports increase with firm-product productivity. The estimated coefficient on the quality variable is positive ($p < 0.01$) when the value of exports is considered (columns 1-3), but negative ($p < 0.01$) if one focuses on the volume of exports (columns 4-6). This result can be easily explained. A high-quality firm usually sells its products at a higher price, which raises its exports in value, but does not necessarily sell more products, and often less (negative impact on the export volume). Second and as previously shown for the extensive margin, we highlight an overall negative effect of QSs on the intensive trade margin ($p < 0.01$). Third, the results suggest a reallocation effect in terms of export sales (value and volume) from the least productive to the most productive firms, and from the low quality to the high quality firms. The estimated coefficients for the interaction term between the number of QSs and firm-product productivity, as well as between the number of QSs and firm-product-destination quality, are indeed positive in columns 2 and 5 ($p < 0.01$). Moreover, the three-way interaction term of the number of QSs, firm-product productivity and firm-product-destination quality is positive, both in column 3 and 6 ($p < 0.01$). This last result suggests that, for a given productivity, firm exports increase with quality.

Overall, our findings depict reallocation in terms of export value and volume across products and destinations. In addition, when we control for firm heterogeneity, we show that demand shifts towards the most productive and high-quality firms. When the number of QS increases, high-productivity high-quality firms enjoy higher exports at the expense of low-productivity low-quality exporters.

Table 1: Extensive margin: Export participation

	Export participation ($Prob(y^k_{fjt}) > 0$)		
	(1)	(2)	(3)
QSs$^k_{jt}$	-0.0001	-0.002^a	0.005^a
	(0.001)	(0.001)	(0.001)
QSs$^k_{jt}$ $\times$ ln productivity$^k_{f,t-1}$		0.001^a	-0.002^a
		(0.0001)	(0.0002)
QSs$^k_{jt}$ $\times$ ln quality$^k_{fj,t-1}$		0.001^a	-0.001^a
		(0.0001)	(0.0002)
QSs$^k_{jt}$ $\times$ ln productivity$^k_{f,t-1}$ $\times$ ln quality$^k_{fj,t-1}$			0.001^a
			(0.0001)
ln productivity$^k_{f,t-1}$	0.023^a	0.023^a	0.023^a
	(0.0002)	(0.0002)	(0.0002)
ln quality$^k_{fj,t-1}$	0.027^a	0.026^a	0.026^a
	(0.0003)	(0.0003)	(0.0003)
Other import-related NTMs$^k_{jt}$	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
ln applied protection$^k_{jt}$	-0.006^a	-0.006^a	-0.006^a
	(0.001)	(0.001)	(0.001)
ln imports$^k_{j,t-1}$	0.023^a	0.023^a	0.023^a
	(0.0003)	(0.0003)	(0.0003)
Observations	4,707,654	4,707,654	4,707,654
Adjusted R^2	0.179	0.179	0.179
Fixed effects:			
Firm$_f$ & HS4-Destination-Year$_{HS4jt}$	Yes	Yes	Yes

Notes: The dependent variable is the probability that firm f exports product k to destination j in year t. QSs^k_{jt} is the sum of SPS and TBT measures enforced on product k by destination j in year t. See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

Finally, other import-related NTMs have a negative influence on the export value and volume. Tariffs also negatively impact the export sales of firms (both in value and volume), while the past demand for a given product k in market j positively influences its current exports (both in value and volume). All estimated coefficients on controls are significant ($p < 0.01$).

2.5. Robustness checks

We proceed to a series of sensitivity tests to confirm the robustness of our results. We present the results in Table A.3 (extensive margin), Table A.4 (intensive margin, export value), and Table A.5 (intensive margin, export volume) in the Appendix A.

Table 2: Intensive margin: Value and volume of exports

	Value (logs) of exports ($\ln v^k_{fjt}$)			Volume (logs) of exports ($\ln q^k_{fjt}$)		
	(1)	(2)	(3)	(4)	(5)	(6)
QSs^k_{jt}	-0.020^a	-0.063^a	0.029^a	-0.021^a	-0.038^a	0.048^a
	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)
$\text{QSs}^k_{jt} \times \ln \text{productivity}^k_{f,t-1}$		0.005^a	-0.020^a		0.002^a	-0.021^a
		(0.0005)	(0.001)		(0.001)	(0.001)
$\text{QSs}^k_{jt} \times \ln \text{quality}^k_{fj,t-1}$		0.009^a	-0.021^a		0.003^a	-0.025^a
		(0.001)	(0.001)		(0.001)	(0.002)
$\text{QSs}^k_{jt} \times \ln \text{productivity}^k_{f,t-1} \times$			0.008^a			0.008^a
$\times \ln \text{quality}^k_{fj,t-1}$			(0.0004)			(0.0003)
$\ln \text{productivity}^k_{f,t-1}$	0.457^a	0.454^a	0.454^a	0.540^a	0.538^a	0.539^a
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$\ln \text{quality}^k_{fj,t-1}$	0.270^a	0.264^a	0.266^a	-0.089^a	-0.091^a	-0.090^a
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Other import-related NTMs^k_{jt}	-0.021^a	-0.021^a	-0.021^a	-0.049^a	-0.049^a	-0.050^a
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
$\ln \text{applied protection}^k_{jt}$	-0.069^a	-0.069^a	-0.069^a	-0.042^a	-0.042^a	-0.042^a
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
$\ln \text{imports}^k_{j,t-1}$	0.128^a	0.128^a	0.128^a	0.131^a	0.131^a	0.130^a
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Observations	2,211,097	2,211,097	2,211,097	2,197,310	2,197,310	2,197,310
Adjusted R^2	0.388	0.388	0.389	0.587	0.587	0.587
Fixed effects:						
Firm_f & HS4-Destination-Year_{HS4jt}	Yes	Yes	Yes	Yes	Yes	Yes

Notes: In columns 1-3 (respectively columns 4-6), the dependent variable is the export value in logs (respectively export volume in logs) by firm f of product k to destination j in year t. QSs^k_{jt} is the sum of SPS and TBT measures enforced on product k by destination j in year t. See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

First, instead of the number of QSs, we consider a simple dummy for QSs set to 1 if destination j enforces at least one QS on product k in year t (0 otherwise). Second, we use an alternative count for QSs and other import-related NTMs, based on measures computed at the one-digit level (see footnote 8 in the data section). In column 3, we cluster our standard errors at the product-destination-year level. Then, we remove the lagged imports of product k by destination j from the set of explanatory variables (column 4). In column 5, we select the maximum price of a product in a given destination to proxy the demand of a product-destination pair in year t instead of using imports. The use of the maximum price is driven by the theory, but, unfortunately, is likely to be endogenous. Finally, column 6 includes the number of French firms exporting to a given product-destination-year triplet. Some of the differences in results may be explained by the market structure. Theoretical models usually consider a continuum of firms, so that 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.

Results are very much in line with those obtained in baseline estimations, suggesting that previous results are robust. One notable exception should be mentioned. In the estimations for the export volume (Table A.5), the higher the demand (proxied through maximum price) for a product-destination-year triplet, the lower the export volume (column 5). This counterintuitive result confirms the potential endogeneity of the maximum price and validates its replacement by lagged imports (in logs) computed at the product-destination level in all other estimations. Interestingly, the estimated coefficients are stronger when we use a dummy and an alternative count for QSs (columns 1 and 2). Lastly, clustering at the product-destination-year level (column 3), removing lagged imports (column 4), or controlling for the number of French exporters (column 6) do not affect our results.

Finally, we replicate our main estimations with two alternative sub-samples. First, we run our estimations for differentiated products only, relying on the well-established Rauch (1999)'s classification. Second, we select only multi-product and multi-destination firms. Results are reported in Table A.6 in the Appendix appendix. Estimates at the extensive and intensive margins are very similar, both in terms of magnitude and significance, to those previously reported in Tables 1 and 2.

3. Impact of QSs on aggregate exports and average quality

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

3.1. Aggregate exports

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

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

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

Export values. We use the parameters estimated from the export sales equation (5) reported in column 3 of Table 2.

Relying on our estimation results, if all export destinations served by French firms adopted the maximum number of QSs observed for a product with in a quartile ($QS^k_{\text{max Q1-Q4}}$), the expected change in export values for a given firm-product-destination triplet in year t can be computed as follows:

$$\Delta r^k_{fjt} = \left[e^{(\widehat{\gamma}_1+\widehat{\gamma}_2 \ln\hat{\varphi}^k_{f,t-1}+\widehat{\gamma}_3 \ln\hat{\lambda}^k_{fj,t-1}+\widehat{\gamma}_4 \ln\hat{\varphi}^k_{f,t-1}\ln\hat{\lambda}^k_{fj,t-1})(QS^k_{\text{max}}-QS^k_{jt})} - 1\right] r^k_{fjt}. \quad (6)$$

Using (5) and (6), we identify losing (winning) firms as firms encountering a decrease (an increase) in their exports when the number of QSs for product k in year t is set to the maximum number observed across all destinations j in the quartile, compared to their exports under the actual number of QSs, *e.g.* $\sum_j\sum_k \Delta r^k_{fjt} < 0$ (respectively, $\sum_j\sum_k \Delta r^k_{fjt} > 0$).[18] It follows that 86.5% of French exporters would suffer from this change over the period 1996-2007, and the overall exports of a losing firm to non-EU countries would decrease on average by 0.4%. By contrast, 14.5% of firms would benefit from this rise in the number of QSs, and the aggregate exports of a winning firm to non-EU markets would increase on average by 1.3%. Figure 1 draws

[18] The overall exports of a firm (under the actual vs. the maximum number of QSs in the quartile) are computed by summing predicted vs. simulated export values across all product-destination pairs served by the firm in year t.

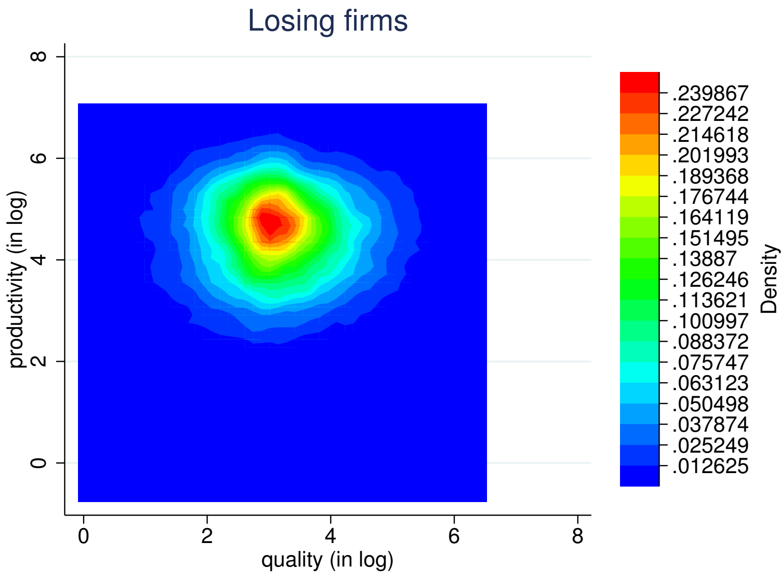


Figure 1: Bivariate distribution of productivity and quality for losing and winning firms

the bivariate distribution of productivity and quality for losing and winning firms.[19] Winning firms are more productive and provide higher quality products, as expected.

Number of exporters. We now estimate the following equation: [20]

$$\ln N^k_{jt} = \gamma QS^k_{jt} + \text{controls}^k_{jt} + \text{FE}_{jt} + \text{FE}^k + \varepsilon^k_{jt}, \tag{7}$$

Results are reported in Table A.7 in the Appendix A and suggest an overall negative effect of QSs on the number of firms. One additional QS involves a decrease in the number of firms in a product-destination-year triplet by 2 percentage points. If all destinations served by French firms adopted the maximum number of QSs observed in year t for a product in a quartile ($QS^k_{\text{max Q1-Q4,t}}$), the expected change in the number of firm-product-destination triplets would equal $\sum_j \sum_k [e^{\widehat{\gamma}(QS^k_{\text{max,t}} - QS^k_{jt})} - 1]N^k_{jt} = -1,314$ (*e.g.* -0.07%).

The expected change in aggregate exports. The expected change in overall French exports over the period 1996-2007 is then given by $\Delta R = \sum_j \sum_k \Delta R^k_{jt}$, and the contribution of the intensive (respectively, extensive) margin is equal to $\sum_j \sum_k \tilde{N}^k_{jt} \Delta \bar{r}^k_{ijt}$ (respectively, $\sum_j \sum_k \bar{r}^k_{ijt} \Delta N^k_{jt}$). According to our estimations, if the number of QSs for product k is set to the

[19] Continuous measures of productivity and quality at the firm level in year t are obtained as follows: for productivity, we compute the mean across all products for a given firm and year; for quality, we compute the mean across all products and destinations for a given firm and year.

[20] Our controls at the product-destination-year level include the number of other import-related NTMs, the applied protection on imports, as well as the average productivity and the average quality. These measures are computed as the mean of *productivity* $^k_{ft}$ and *quality* $^k_{fjt}$ across all firms f within a product-destination-year triplet kjt.

maximum number observed in year t across all destinations j in a quartile ($QS^k_{\text{max Q1-Q4,t}}$), then $\Delta R = -346.3$ millions euros (*e.g.* 0.04% of French exports). Our counterfactual analysis also suggests that QSs yield a negative effect on both the intensive margin (-160.3 millions euros) and the extensive margin (-186.0 millions euros).

3.2. Average quality

We now study the impact of QSs on the average quality of products exported by French firms to different markets. We first present the computation of this average quality and the estimated equation. Results are then reported and discussed.

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

$$\overline{r}^k_{ijt} = \left(\bar{\lambda}^k_{ijt}\right)^{\sigma^k-1} \mathcal{A}^k_{jt} \left(\overline{P}^k_{ijt}T^k_{ijt}\right)^{1-\sigma^k}. \tag{8}$$

where T^k_{ijt} represents the applied protection set by country j on its imports of product k from country i in year t.[21] Equation (8) 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, a 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 consumers in each destination j for product k originating from country i in year t and adjusted by the number of exporters $N^k_{ijt}\left(\bar{\lambda}^k_{ijt}\right)^{\sigma^k-1}$ can be estimated as the residual of the following regression:

$$\ln Q^k_{ijt} + \sigma^k \ln\left(\overline{P}^k_{ijt}T^k_{ijt}\right) = \alpha^k_{it} + \alpha^k_{jt} + \rho_1 CL_{ij} + \rho_2 CB_{ij} + \rho_3 CT_{ij} + \epsilon^k_{ijt}, \tag{9}$$

[21] We implicitly assume that the average value of quality-adjusted prices $p^k_{ijt}/\lambda^k_{ijt}$ is equal to the average price $\overline{P}^k_{ijt}$ divided by the average quality ($\bar{\lambda}^k_{ijt}$).

where $\epsilon^k_{ijt} = (\sigma^k - 1)\ln(\bar{\lambda}^k_{ijt}) + \ln N^k_{ijt}$ and $\alpha^k_{jt} = \ln \mathcal{A}^k_{jt}$. Thus, the average quality perceived by foreign consumers can be expressed as $\ln(\widehat{\lambda}^k_{ijt}) = (\epsilon^k_{ijt} + \ln N^k_{ijt})/(\sigma^k - 1)$.

Equation (9) is estimated by merging five different data sources. First, $\overline{P}^k_{ijt}$ are proxied using the Trade Unit Values database provided by the CEPII. This database is available since 2000. We therefore consider the HS 6-digit import unit values for the period 2000-2007 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 period 2000-2007 (Q^k_{ijt}), which are extracted from the CEPII BACI database. Since we consider all trading partners and not just France, we cannot use French customs data. Data on import-demand elasticities (σ^k) come from Broda *et al.* (2006), while tariff data are extracted from the TRAINS database. Besides, information on common language, contiguity and past colonial ties is obtained from the CEPII GeoDist database.[22] FE^k_{it} and FE^k_{jt} stand for both origin country-product-year and destination country-product-year fixed effects. Some countries are unfortunately missing in the trade elasticities data, and our final sample is restricted to 37 countries (instead of 88).[23]

Finally, we compute the average quality of each HS6 product exported by France to each destination in year t. To do so, we keep from the estimation of equation (9) parameters $\widehat{\lambda}^k_{ijt}$, where France is the exporting country. Relying on French Customs data, we compute the number of French exporters in each product-destination-year triplet $N^k_{FRA,jt}$. Finally, using $\epsilon^k_{FRA,jt} = \ln N^k_{FRA,jt} + (\sigma^k - 1)\ln(\bar{\lambda}^k_{FRA,jt})$, we derive $\ln \widehat{\bar{\lambda}^k_{FRA,jt}}$, *i.e.* the average quality of each product k exported by France to each destination j in year t.

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

$$\ln \widehat{\bar{\lambda}^k_{FRA,jt}} = \gamma QS^k_{jt} + \text{controls}^k_{jt} + \text{FE}^k + \text{FE}_{jt} + \epsilon^k_{jt}, \tag{10}$$

where $\widehat{\bar{\lambda}^k_{FRA,jt}}$ is the average quality perceived by consumers in each destination j for product k originating from France in year t (see above), and ϵ^k_{jt} is the error term. We regress this average quality on the number of QSs enforced by destination j on product k in year t. The estimation also controls for the number of other import-related NTMs and includes product and destination-year fixed effects (FE^k and FE_{jt}).

[22]Data on import unit values rely on importers' declarations and include all trade costs (except tariffs and domestic taxes after the border); source: http://www.cepii.fr/cepii/en/bdd_modele/presentation.asp?id=2. Baci database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=1. TRAINS database: see section 2.2. Trade elasticities: http://www.columbia.edu/ dew35/TradeElasticities; elasticities are computed at the 3-digit level using HS 6-digit import data from the COMTRADE database for the years 1994-2003. GeoDist database: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6.

[23]Note that our previous results at the extensive and intensive margins of trade remain valid when we restrict our sample to these 37 countries.

Table 3: Average quality

	Average quality			
	(1)	(2)	(3)	(4)
No. QSs$^k_{jt}$	0.016^a			
	(0.006)			
No. QSs$^k_{jt}$ × Consumption goods		0.010^b		
		(0.005)		
No. QSs$^k_{jt}$ × Capital/Intermediate goods		0.021^c		
		(0.012)		
No. QSs$^k_{jt}$ × Food & beverages			0.014^b	
			(0.006)	
No. QSs$^k_{jt}$ × Manufacturing (w/o textiles)			0.007	
			(0.012)	
No. QSs$^k_{jt}$ × Textile			0.045^b	
			(0.022)	
No. QSs$^k_{jt}$ × Food & beverages × Consumption goods				0.047^a
				(0.017)
No. QSs$^k_{jt}$ × Food & beverages × Capital/Intermediate goods				0.001
				(0.005)
No. QSs$^k_{jt}$ × Manufacturing (w/o textiles) × Consumption goods				0.038^b
				(0.017)
No. QSs$^k_{jt}$ × Manufacturing (w/o textiles) × Capital/Intermediate goods				-0.010
				(0.014)
No. QSs$^k_{jt}$ × Textile × Consumption goods				0.062^a
				(0.014)
No. QSs$^k_{jt}$ × Textile × Capital/Intermediate goods				0.025
				(0.040)
No. other import-related NTMs$^k_{jt}$	-0.030	-0.032	-0.026	-0.029
	(0.022)	(0.022)	(0.022)	(0.023)
Observations	223,895	223,895	223,895	223,895
Adjusted R^2	0.136	0.136	0.136	0.136
Fixed effects:				
Product$_k$ & Destination-Year$_{jt}$	Yes	Yes	Yes	Yes

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

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

Column 1 includes all products. We then decompose the effects between consumption *versus* capital/intermediate goods (column 2). The identification of different classes of goods is based on the Broad Economic Categories (BEC) classification. In our estimations, we interact the number of QSs with two dummies set to 1 for consumption, and respectively 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 less 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, the higher the average quality of exported products ($p < 0.01$). The other results show that QSs significantly improve the average quality of consumption goods (column 2), food & beverages, and textile products (column 3). Column 4 highlights that the positive effect of QSs on average quality is concentrated in final consumption products (food and beverages, manufacturing other than textile, and textile).[24] In all other cases, the effect is barely or not at all significant. If we quantify the elasticity of the average quality of exported products with respect to the number of QSs by multiplying the estimated coefficient γ (column 4) by the average number of QSs enforced by destination, we obtain an effect of 0.14 for food and beverage products used for consumption, of 0.11 for manufacturing (less textiles) used for consumption, and of 0.18 for textile products used for consumption.

4. A theory of QS-induced changes in trade and quality

Our estimations reveal that the effects of QSs on the presence and performance of firms in foreign markets depend upon their productivity and the quality of their varieties. High-productivity firms gain from stricter QSs provided that the quality of their varieties is high enough. In addition, firms selling high-quality varieties gain from stricter QS provided that their productivity is high enough. We rationalize these empirical results by focusing on the role of uncertainty on export performance. More precisely, we provide in this section the microeconomic foundations of the impact of QSs on the export decisions (extensive margin) and export sales (intensive margin) of firms according to the productivity and quality of their products in a context of information asymmetry between consumers and producers with respect to product quality. The theoretical model is an extension of a standard heterogeneous firm trade model in which firms engage in costly quality-signaling and set strategically the quality of their products for each foreign market.[25]

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

[25] In a working paper version (Disdier *et al.*, 2018), we propose a model in which product quality provided by a firm does not vary across countries as in Bernard *et al.* (2011), Baldwin and Harrigan (2011), and Fajgelbaum

4.1. General framework

We consider an economy with information asymmetry on product quality and heterogeneous firms.[26] If producers know the quality of their products, this quality may not be observed by consumers. In addition, there are n countries that use labor to produce goods in K sectors. We index exporting countries by i and importing countries by j (where each country can buy its own output). One sector produces a homogeneous product (the numeraire) with one unit of labor per unit of output, while $K-1$ sectors produce differentiated products. Within each of these $K-1$ sectors, there is a continuum of horizontally and vertically differentiated varieties.

Preferences and demand. Consumers are assumed to be risk-neutral. For each differentiated product, preferences are assumed to take the CES form:

$$U_j^k = \left[\sum_i \int_{\mathcal{V}_{ij}^k} \left[\lambda_{ij}^k(\nu) q_{ij}^k(\nu)\right]^{\frac{\sigma^k-1}{\sigma^k}} \mathrm{d}\nu\right]^{\frac{\sigma^k}{\sigma^k-1}} \tag{11}$$

where $\mathcal{V}_{ij}^k$ is the set of varieties ν of product k available in country j and produced in country i, q_{ij}^k is the demand expressed in country j for a variety of product k imported from country i, and $\sigma^k > 1$ is the elasticity of substitution between varieties and is assumed to be constant. As in Kugler and Verhoogen (2012) and Hallak and Sivadasan (2013), $\lambda_{ij}^k(\nu)$ represents the quality of variety ν from i *perceived* by consumers in j (it captures all attributes of a product other than price, which consumers value). However, $\lambda_{ij}^k(\nu)$ depends on the information available to consumers. We consider two polar cases. First, if credible and truthful disclosure is feasible, consumers know the exact attributes of any variety and $\lambda_{ij}^k(\nu) = [\theta_{ij}^k(\nu)]^{\beta^k}$, where $\theta_{ij}^k(\nu)$ is the true quality supplied by sellers and β^k signals greater appreciation for vertically differentiated products. Second, if this quality cannot be precisely observed, consumers – who are risk-neutral – do not consider the quality of each variety but rather the average quality $\bar{\theta}_{ij}^k$, as in the standard literature on information asymmetry. Hence, under this configuration, $\lambda_{ij}^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta^k}$.[27]

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

$$r_{ij}^k \equiv p_{ij}^k q_{ij}^k = \left(\lambda_{ij}^k\right)^{\sigma^k-1} \mathcal{A}_j^k \left(p_{ij}^k\right)^{1-\sigma^k} \tag{12}$$

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

et al. (2011). In other words, it is assumed that quality cannot be adjusted by firms as often as prices are.

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

[27]We choose a CES form that abstracts from the impact of income per capita on demand for quality in order to focus on the role of information asymmetry. For the same reason, we treat β^k as an exogenous parameter, while Hallak (2006) considers that β^k increases with income per capita of importing countries.

and P_j^k is the price index in country j, which is defined as:

$$P_j^k = \left[\sum_i \int_{\Omega_{ij}^k} \left(\bar{\theta}_{ij}^k\right)^{\beta_j^k(\sigma^k-1)} [p_{ij}^k(\nu)]^{1-\sigma^k} \mathrm{d}\nu + \int_{\widetilde{\Omega}_{ij}^k} \left(\theta_{ij}^k(\nu)\right)^{\beta_j^k(\sigma^k-1)} [p_{ij}^k(\nu)]^{1-\sigma^k} \mathrm{d}\nu \right]^{\frac{-1}{\sigma^k-1}} \quad (13)$$

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

Technology, market structure, and profit. We consider a continuum of firms producing under monopolistic competition. Each variety is produced by a single firm, but a firm can produce more than one differentiated product (multi-product firms).[28] Each firm-product pair is characterized by a level of productivity φ^k (the ability to produce output using few variable inputs). Firms producing in country i choose the price p_{ij}^k and quality θ_{ij}^k of their product k for each market j. Product markets are internationally segmented, meaning that the price and quality of a variety (a firm-product pair) vary across destination countries.

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

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

$$\pi_{ij}^k \equiv p_{ij}^k q_{ij}^k / T_{ij}^k - c_{ij}^k(\theta_{ij}^k, \varphi^k)\tau_{ij}^k q_{ij}^k - \phi_{ij}^k(\theta_{ij}^k) - \mathbb{I}^k \omega_i F_{ij}^k, \quad (14)$$

where $T_{ij}^k \equiv 1 + t_{ij}^k$, with t_{ij}^k the *ad valorem* tariff applied by country j on product k imported from country i, τ_{ij}^k represents an iceberg trade cost, ϕ_{ij}^k is the fixed cost of distribution,

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

$c_{ij}^k(\theta_{ij}^k, \varphi^k)$ is the *marginal* cost of production, and $\mathbb{I}^k = 1$ if the firm invests in quality signaling and 0 otherwise. The marginal cost increases with quality for a given productivity, and decreases with productivity for a given quality. More specifically, $c_{ij}^k = (\theta_{ij}^k)^{\alpha^k}\omega_i/\varphi^k$, where α^k is the quality-elasticity of the variable costs (with $\alpha^k \geq 0$), and w_i is the wage rate. Fixed distribution costs are given by $\phi_{ij}^k = \omega_i f_{ij}^k(\theta_{ij}^k)^{\eta^k}$, where η^k is common to all firms selling product k. f_{ij}^k is specific to each origin-destination country pair and corresponds to the costs of maintaining a presence in foreign markets (*e.g.*, maintaining a distribution and service network and monitoring foreign customs procedures and product standards). These costs increase with the quality of products to be exported.[29]

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

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

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

$$p_{ij}^k = \frac{\sigma^k}{\sigma^k - 1}\omega_i \tau_{ij}^k T_{ij}^k \frac{(\theta_{ij}^k)^{\alpha^k}}{\varphi^k}, \tag{15}$$

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

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

$$\tilde{\pi}_{ij}^k = \tilde{r}_{ij}^k/\sigma^k - \omega_i f_{ij}^k(\theta_{ij}^k)^{\eta^k} - \omega_i F_{ij}^k \quad \text{and} \quad \tilde{r}_{ij}^k = (\theta_{ij}^k)^{\Lambda^k}(\varphi^k)^{\sigma^k - 1}\mathcal{B}_{ij}^k, \tag{16}$$

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

$$\mathcal{B}_{ij}^k \equiv \mathcal{A}_j^k \left(\frac{\sigma^k}{\sigma^k - 1}\omega_i \tau_{ij}^k T_{ij}^k\right)^{1-\sigma^k}, \tag{17}$$

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

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

When a firm invests in quality signaling, the first-order condition with respect to quality implies that its optimal quality θ_{ij}^k is such that $\eta^k \omega_i f_{ij}^k (\theta_{ij}^k)^{\eta^k} = \Lambda \tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k$, given its profits (16). Hence, the pricing decision of a firm interacts with its vertical differentiation strategy. A firm must improve its quality until the increase in its operating profits is equal to the increase in its fixed costs associated with the quality of its product. To obtain an interior solution, the second order condition requires that $\eta^k > \Lambda^k$. If the last inequality is not satisfied, firms would produce at the minimum quality level. Although each firm operates under monopolistic competition, its quality is related to the quality of its rivals through the price index. In equilibrium, we have:

$$\theta_{ij}^k = \left(\frac{\Lambda^k}{\eta^k} \frac{\mathcal{B}_{ij}^k}{\sigma^k \omega_i f_{ij}^k} \right)^{\frac{1}{\eta^k - \Lambda^k}} \left(\varphi^k\right)^{\frac{\sigma^k - 1}{\eta^k - \Lambda^k}} \quad \text{and} \quad \tilde{r}_{ij}^k = \frac{\eta^k \sigma^k \omega_i f_{ij}^k}{\Lambda^k} (\theta_{ij}^k)^{\eta^k}. \tag{18}$$

The level of quality adopted by a signaling firm and its export sales increase with its productivity, lower trade costs, and income, in line with the empirical evidence. Note also that higher productivity directly lowers prices by reducing the marginal cost of production. However, higher productivity induces the firm to upgrade quality, which increases marginal costs and prices. Whether high-productivity firms charge higher or lower prices than low-productivity firms depends on the strength of incentives to upgrade quality and on product differentiation. Inserting (18) in (15) shows that the price is decreasing (increasing) in productivity if $\beta^k \sigma^k < \eta^k$ (respectively, $\beta^k \sigma^k > \eta^k$), that is, if consumers' appreciation of quality is low (high) enough.

Quality choice and export sales of non-signaling firms. The quality of varieties sold by non-signaling firms is not observed by consumers. The latter only know the average quality of products (for each origin country). Due to information asymmetry, incentives exist for producers to pass off low-quality goods as high-quality. However, consumers account for these incentives by judging the quality of goods as uncertain. Inserting (12), (15), and $\lambda^k(\nu) = (\bar{\theta}_{ij}^k)^{\beta^k}$ in (14), the profit of a non-signaling firm producing a variety of product k in country i and serving market j is:

$$\pi_{ij}^k = r_{ij}^k/\sigma^k - \omega_i f_{ij}^k (\theta_{ij}^k)^{\eta^k} \qquad \text{with} \quad r_{ij}^k = \left(\bar{\theta}_{ij}^k\right)^{\beta_k(\sigma^k-1)} \left(\frac{\varphi^k}{(\theta_{ij}^k)^{\alpha^k}} \right)^{\sigma^k - 1} \mathcal{B}_{ij}^k. \tag{19}$$

A firm serves country j if and only if $\pi_{ij}^k \geq 0$. As expected, exports are increasing with the firm's productivity ($\partial r_{ij}^k/\partial\varphi^k > 0$) and with the average quality ($\partial r_{ij}^k/\partial\bar{\theta}_{ij}^k > 0$). Hence, when the average quality in the destination market increases, consumers are willing to pay more for all goods imported from country i. Under these circumstances, high-quality non-signaling producers share their benefits with low-quality non-signaling producers. In addition, we have $\partial r_{ij}^k/\partial\theta_{ij}^k < 0$ for a given productivity. As a consequence, under information asymmetry, the best strategy for all non-signaling firms, whatever their levels of productivity, is to produce at the minimum quality level ($\theta_{ij}^k = \underline{\theta}_j^k$). The quality supplied by non-signaling firms is lower under information asymmetry than under perfect information.[30] Since consumers only know the average quality of products, their demand for (expensive) top-quality products is lower. Although they are preferred by consumers, high-quality products are therefore driven out of the market by low-quality goods (Akerlof's lemons principle).

Using our assumptions on technology and preferences, we can determine the *productivity cutoff* ($\underline{\varphi}_{ij}^k$) to meet the QS prevailing in the foreign country. The latter variable is defined such that $\pi_{ij}^k(\varphi_{ij}^k, \underline{\theta}_j^k) = 0$ or, equivalently,

$$\underline{\varphi}_{ij}^k = \left(\frac{\sigma^k\omega_i f_{ij}^k}{\mathcal{B}_{ij}^k}\right)^{\frac{1}{\sigma^k-1}} \left(\underline{\theta}_j^k\right)^{\frac{\eta^k-\Lambda^k}{\sigma^k-1}}, \tag{20}$$

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

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

$$\pi_{ij}^k(\varphi^k, \underline{\theta}_j^k) = r_{ij}^k/\sigma^k - \omega_i f_{ij}^k(\underline{\theta}_j^k)^{\eta^k} \qquad \text{with} \quad r_{ij}^k = \sigma^k\omega_i f_{ij}^k \left(\underline{\theta}_j^k\right)^{\eta^k} \left(\frac{\varphi^k}{\underline{\varphi}_{ij}^k}\right)^{\sigma^k-1}, \tag{21}$$

where we have used (20). A QS increases the export sales of incumbent firms with no signaling activity. This response is more pronounced for more productive incumbents.

Disclosure choice and export decision. A firm invests in quality signaling activity if and only if $\tilde{\pi}_{ij}^k = \tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k - \omega_i f_{ij}^k(\theta_{ij}^k)^{\eta^k} - \omega_i F_{ij}^k > \pi_{ij}^k(\varphi^k, \underline{\theta}_j^k)$. It follows that, if a firm chooses to disclose, then this firm can profitably export, *i.e.* $\tilde{r}_{ij}^k(\theta_{ij}^k)/\sigma^k - \omega_i f_{ij}^k(\theta_{ij}^k)^{\eta^k} > 0$. Using (18) implies that $\tilde{\pi}_{ij}^k = (\eta^k - \Lambda^k)\omega_i f_{ij}^k(\theta_{ij}^k)^{\eta^k}/\Lambda^k - \omega_i F_{ij}^k$. Hence, a firm discloses (and exports) if and only if $\theta_{ij}^k > \widehat{\theta}_{ij}^k$, where $\widehat{\theta}_{ij}^k$ (called *signaling cutoff*) is such that $\tilde{\pi}_{ij}^k(\varphi^k, \theta_{ij}^k) = \pi_{ij}^k(\varphi^k, \underline{\theta}_j^k)$

[30] Under perfect information, the quality supplied by non-signaling firms would be given by (18).

or, equivalently,

$$\left(\widehat{\theta}^k_{ij}\right)^{\eta^k} = \left(\tilde{\theta}^k_{ij}\right)^{\eta^k} + \frac{\Lambda^k}{\eta^k - \Lambda^k}\left(\underline{\theta}^k_j\right)^{\eta^k}\left[\left(\frac{\varphi^k}{\underline{\varphi}^k_{ij}}\right)^{\sigma^k-1} - 1\right] \quad \text{with} \quad \tilde{\theta}^k_{ij} \equiv \left(\frac{\Lambda^k}{\eta^k - \Lambda^k}\frac{F^k_{ij}}{f^k_{ij}}\right)^{\frac{1}{\eta^k}}. \tag{22}$$

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

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

$$\breve{\varphi}^k_{ij} \equiv \left(\frac{\eta^k}{\Lambda^k}\right)^{\frac{1}{\sigma^k-1}} \underline{\varphi}^k_{ij}, \tag{23}$$

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

The next proposition and Figure 2 summarize our main results.

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

Hence, information asymmetry and signaling activity may explain why high-quality firms gain from stricter QSs provided that their productivity is high enough. Only the most productive firms have a strong incentive to disclose as they provide high-quality products and can recover the fixed costs associated with information disclosure for serving foreign markets. Even though there are no fixed costs associated with information disclosure, low-productivity incumbents prefer to hide in the pool of firms selling varieties with a higher quality.

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

$$\theta^k_{ij} = \underline{\theta}^k_j \left(\frac{\Lambda^k}{\eta^k}\right)^{\frac{1}{\eta^k-\Lambda^k}} \left(\frac{\varphi^k}{\underline{\varphi}^k_{ij}}\right)^{\frac{\sigma^k-1}{\eta^k-\Lambda^k}} = \underline{\theta}^k_j \left(\frac{\varphi^k}{\breve{\varphi}^k_{ij}}\right)^{\frac{\sigma^k-1}{\eta^k-\Lambda^k}}. \tag{24}$$

Hence, $\theta_{ij}^k = \underline{\theta}_j^k$ when $\varphi^k = \breve{\varphi}_{ij}^k$, so that $\theta_{ij}^k > \underline{\theta}_j^k$ when $\varphi^k > \widehat{\varphi}_{ij}^k$. As a result and as shown in Figure 2, firms with a medium level of productivity ($\varphi^k \in [\breve{\varphi}_{ij}^k, \widehat{\varphi}_{ij}^k]$) would provide a higher quality than the minimum quality imposed by the QS if there is no information asymmetry. By contrast, low-productivity firms ($\varphi^k < \breve{\varphi}_{ij}^k$) supply a higher quality than they would under certainty.

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

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

$$\tilde{\varphi}_{ij}^k = \left(\frac{\tilde{\theta}_j^k}{\underline{\theta}_j^k}\right)^{\frac{\eta^k - \Lambda^k}{\sigma^k - 1}} \breve{\varphi}_{ij}^k. \tag{25}$$

Thus, without QS, firms with a productivity $\varphi^k < \tilde{\varphi}_{ij}^k$ do not enter market j, while firms with a productivity $\varphi^k > \tilde{\varphi}_{ij}^k$ invest in quality signaling and export (Figure 3, panel (a)).

Assume now the enforcement of a QS (Figure 3, panel (b)). The QS is not "too" strict, *i.e.* such that $\underline{\theta}_j^k < \tilde{\theta}_{ij}^k$. Under these circumstances, different forces are at play. First, firms with a productivity $\varphi^k \in [\underline{\varphi}_{ij}^k, \tilde{\varphi}_{ij}^k]$ can now profitably export to country j without signaling activity. Hence, the introduction of a QS tends to increase the number of varieties available in market j. Second, firms with a productivity $\varphi^k \in [\tilde{\varphi}_{ij}^k, \widehat{\varphi}_{ij}^k]$ cease to disclose, reduce the quality of their varieties ($\theta_{ij}^k = \underline{\theta}_j^k$) and continue to export, even if their profits decline. Third, more productive firms ($\varphi^k > \widehat{\varphi}_{ij}^k$) maintain their signaling activity and their exports. Hence, all in all, the introduction of a QS has an ambiguous effect on the average quality. Indeed, the QS forces low-productivity firms to improve the quality of their products, whereas the quality of varieties supplied by medium-productivity firms declines because the market competition becomes tougher. Moreover, the QS allows the entry of new exporters and limits the range in which sellers can differentiate the quality of their products. As a result, medium-productivity firms have to downgrade the quality of their products with the enforcement of a QS.[31] Clearly,

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

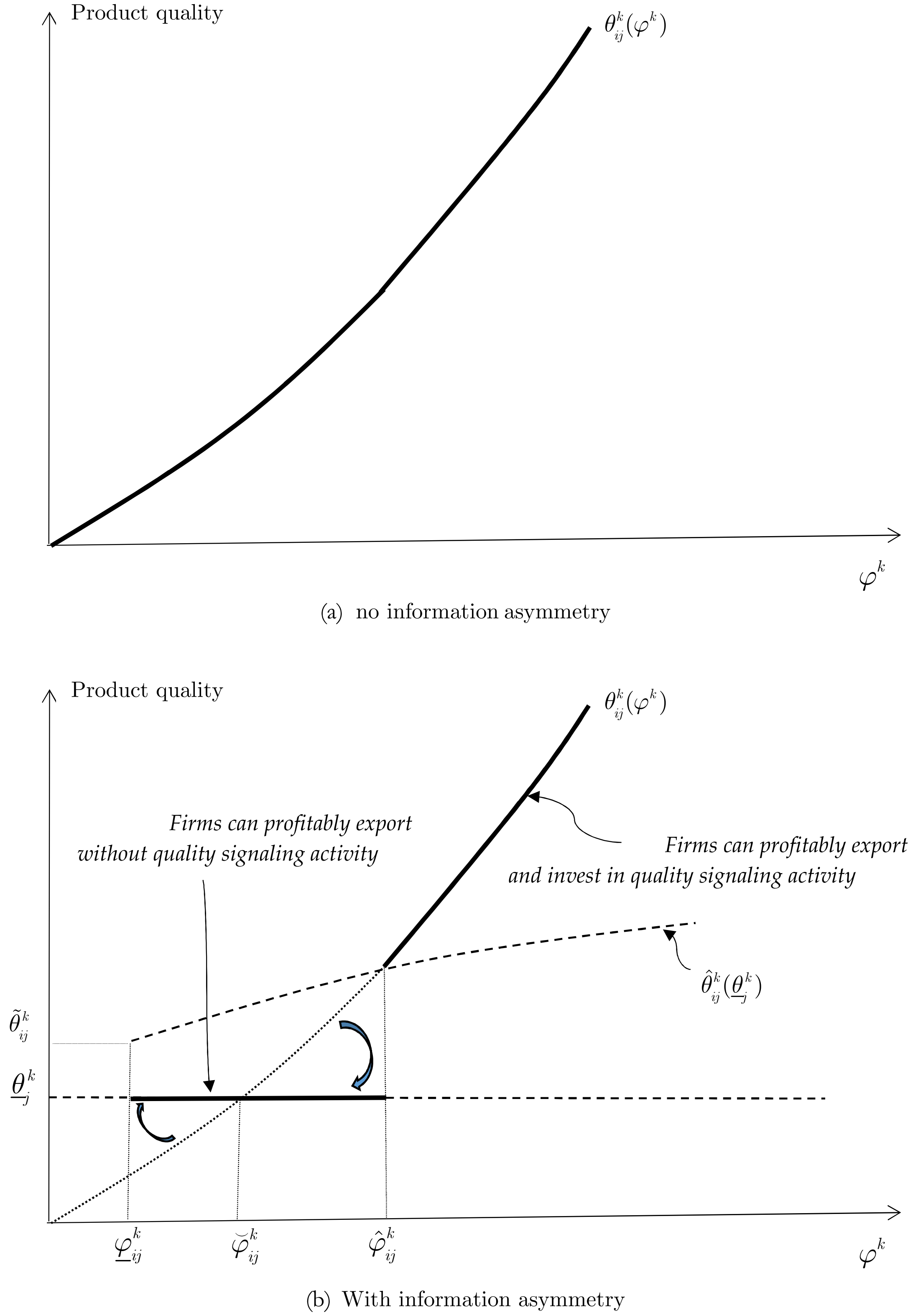
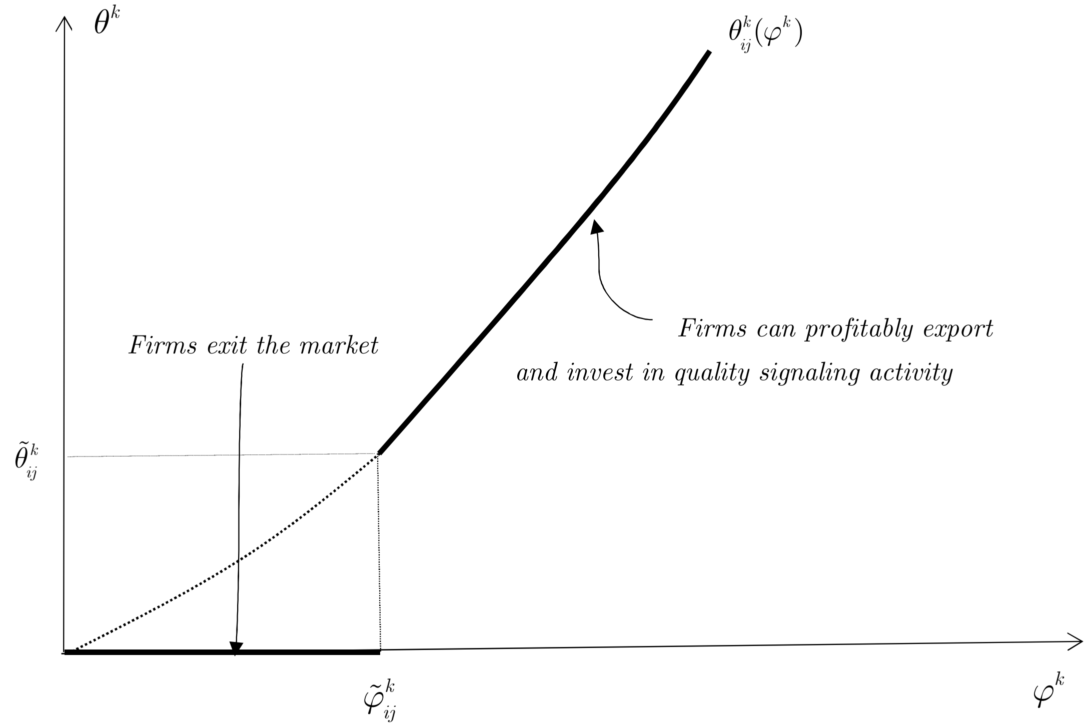
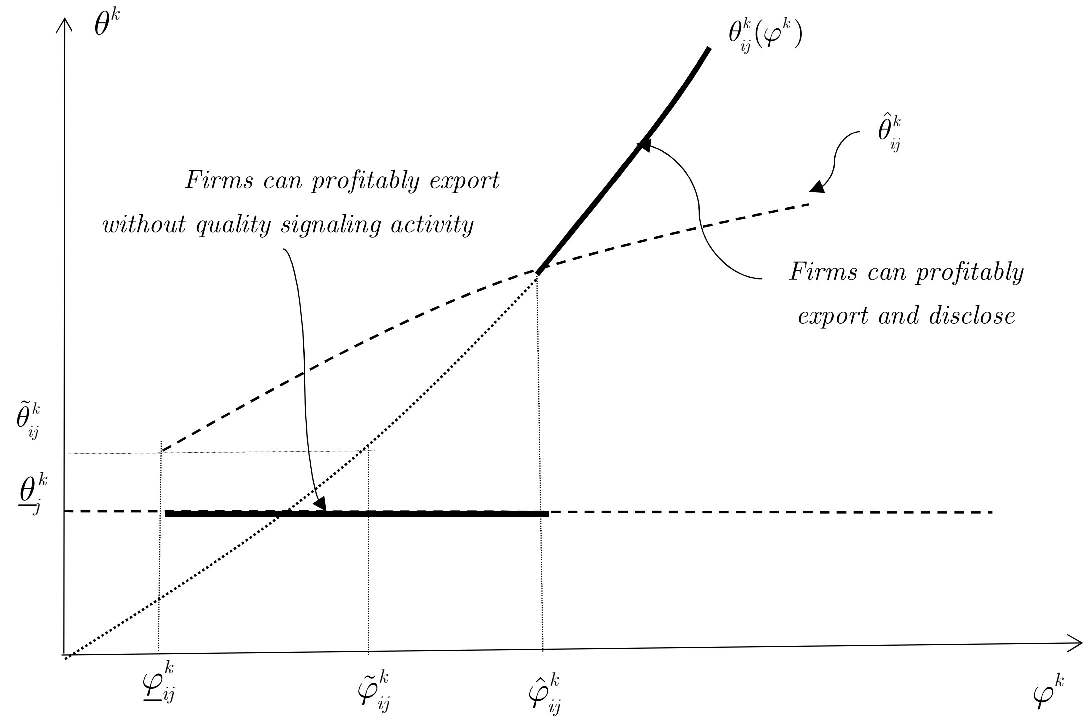


Figure 2: Information asymmetry, QS, and firms' decisions



(a) No standard



(b) Introduction of quality standard

Figure 3: Impact of QS under information asymmetry

there are winners and losers among low-productivity firms ($\varphi^k < \widehat{\varphi}^k_{ij}$), while high-productivity firms ($\varphi^k > \widehat{\varphi}^k_{ij}$) benefit from the QS.

Last, we study the effects of a stricter QS. A marginal increase in $\underline{\theta}^k_j$ forces low-productivity firms to exit (the productivity cutoff φ^k_{ij} increases) because of higher costs to comply with the requirements. In addition, the effect of a QS on the signaling cutoff ($\widehat{\theta}^k_{ij}$) is unclear. A QS has both a direct effect on the signaling cutoff and an indirect effect through the productivity cutoff (φ^k_{ij}). For a given productivity cutoff, the signaling cutoff shifts upward. However, by raising the productivity cutoff, a QS may reduce the signaling cutoff. In this case, more firms disclose and the average quality of varieties may increase. In other words, a QS implies fewer exporters and has an ambiguous effect on the average quality of the products available on the market.[32]

The next proposition and Figure 3 summarize our main results.

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

This proposition rationalizes our empirical results reported in Section 3. Indeed, the ambiguous effect of QSs on average quality may arise from two opposite mechanisms. The introduction of QSs forces low-quality producers to exit the market (increase in average quality), while it also forces low-productivity incumbents to reduce the quality of their varieties (decrease in average quality).

Two final remarks are in order. First, our framework focuses on the effects of QSs on trade and the quality of traded products. We disregard the impact of QSs on domestic labor markets and the mass of local producers. However, we could easily extend our framework to account for these general equilibrium effects. For example, as in most trade models, we could assume that: (i) an exogenous fraction δ^k of income is spent on varieties of product $k \in [1, K]$ with $\sum_{k=1}^{K} \delta^k = 1$ (U^k_j is embodied in a Cobb-Douglas upper-tier utility); (ii) each country i is endowed with L_i units of labor and its wage rate is ω_i so that $E^k_j = \delta^k \omega_j L_j$; (iii) firms produce after paying an entry cost equal to $f^{k,E}_i$ units of labor and do not know a priori their productivity φ, which is drawn from a Pareto productivity distribution. Such additional assumptions would make the formal analysis more heavier while our qualitative results will remain unchanged. Information asymmetry, firm heterogeneity, signaling activity, and fixed export costs play a key role in our analysis.

Second, a stricter QS may increase welfare through a reduction in information asymmetry and a better allocation of resources. However, the introduction of a QS creates a distortion in the distribution of quality-adjusted prices (low-productivity – non-signaling – firms cannot provide

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

their variety with the optimal quality). Under these conditions, a stricter QS improves welfare as long as the varieties that cease to be available in the market are low-volume, low-quality products, and the additional costs associated with higher quality borne by low-productivity firms staying in the market are not too high.

5. Conclusion

This paper studies the effects of QSs enforced by destination countries on the exports of firms (extensive and intensive margins) according to the productivity and quality of their varieties, as well as on aggregate exports and the average quality of exported products.

First, we estimate the trade effects of QSs, relying on a panel of French exporters over the period 1996-2007. We find that QSs in the destination country increase the export probability of high-quality French exporters provided that their productivity is high enough. QSs also raise the export sales of high-productivity high-quality firms at the expense of low-productivity and low-quality firms. Finally, QSs increase the average quality of food and beverage products, as well as that of textile products used for final consumption.

Second, we develop a theoretical model based on monopolistic competition, where firms are heterogeneous in terms of their productivity and the quality of their products. We assume information asymmetry regarding product quality. While consumers only observe the average quality available on the market, producers know exactly the quality of their product and can undertake costly signaling activity. Under this setting, the enforcement of a QS by a policy maker to correct for market failures leads to the exit of low-quality firms that are not able to satisfy the requirements, regardless of their productivity. By contrast, high-productivity firms selling high-quality products can profitably disclose information about their quality and therefore exhibit a higher export probability and large export sales.

From a policy perspective, this paper suggests that QSs do not necessarily act as pure trade barriers as do tariffs. By correcting market failures, QSs may force firms selling low-quality products to exit foreign markets, and contribute to raising the exports of high-quality products provided that the productivity of producers is high enough. These effects further translate into an improvement of the average quality of products traded on the market.

References

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, 84(3):488–500.

Amiti, M. and Khandelwal, A. K. (2013). Import Competition and Quality Upgrading. *The Review of Economics and Statistics*, 95(2):476–490.

Andriamananjara, S., Dean, J. M., Feinberg, R., Ferrantino, M. J., Ludema, R., and Tsigas, M. E. (2004). The Effects of Non-Tariff Measures on Prices, Trade, and Welfare: CGE Implementation of Policy-Based Price Comparisons. Working Papers 2004-04-A, United States International Trade Commission, Office of Economics.

Bagwell, K. and Staiger, R. W. (1989). The role of export subsidies when product quality is unknown. *Journal of International Economics*, 27(1-2):69–89.

Baldwin, R. and Harrigan, J. (2011). Zeros, Quality, and Space: Trade Theory and Trade Evidence. *American Economic Journal: Microeconomics*, 3(2):60–88.

Bastos, P., Dias, D., and Timoshenko, O. (2018a). Learning, prices and firm dynamics. *Canadian Journal of Economics*, 51(4):1257–1311.

Bastos, P., Silva, J., and Verhoogen, E. (2018b). Export destinations and input prices. *American Economic Review*, 108(2):353–392.

Beghin, J., Disdier, A.-C., and Marette, S. (2015). Trade restrictiveness indices in presence of externalities. an application to non-tariff measures. *Canadian Journal of Economics*, 48(4):1513–1536.

Bernard, A., Redding, S. J., and Schott, P. K. (2011). Multi-Product Firms and Trade Liberalization. *Quarterly Journal of Economics*, 126(3):1271–1318.

Bond, E. (1982). A direct test of the lemons model: the market for pickup trucks. *American Economic Review*, 72(4):836–840.

Broda, C., Greenfield, J., and Weinstein, D. (2006). From Groundnuts to Globalization: A Structural Estimate of Trade and Growth. Working Paper 12512, National Bureau of Economic Research.

Cagé, J. and Rouzet, D. (2015). Improving “national brands”: Reputation for quality and export promotion strategies. *Journal of International Economics*, 95(2):274–290.

Correia, S. (2014). REGHDFE: Stata module to perform linear or instrumental-variable regression absorbing any number of high-dimensional fixed effects. Statistical Software Components, Boston College Department of Economics.

Correia, S. (2015). Singletons, Cluster-Robust Standard Errors and Fixed Effects: A Bad Mix. Technical Note, Duke University.

Crampes, C. and Hollander, A. (1995). How many karats is gold: Welfare effects of easing a denomination standard. *Journal of Regulatory Economics*, 7(2):131–143.

Curzi, D., Raimondi, V., and Olper, A. (2015). Quality upgrading, competition and trade policy: evidence from the agri-food sector. *European Review of Agricultural Economics*, 42(2):239–267.

Das, S. P. and Donnenfeld, S. (1989). Oligopolistic competition and international trade. *Journal of International Economics*, 27(3):299–318.

Disdier, A.-C., Fontagné, L., and Mimouni, M. (2008). The impact of regulations on agricultural trade: Evidence from the sps and tbt agreements. *American Journal of Agricultural Economics*, 90(2):336–350.

Disdier, A.-C., Gaigné, C., and Herghelegiu, C. (2018). Do standards improve the quality of traded products. ECARES, Working Paper 2018-38, Université Libre de Bruxelles.

Dranove, D. and Jin, G. Z. (2010). Quality disclosure and certification: Theory and practice. *Journal of Economic Literature*, 48(4):935–963.

Dulleck, U., Kerschbamer, R., and Sutter, M. (2011). The economics of credence goods: An experiment on the role of liability, verifiability, reputation, and competition. *The American Economic Review*, 101(2):526–555.

Eckel, C., Iacovone, L., Javorcik, B., and Neary, P. (2016). Testing the core-competency model of multi-product exporters. *Review of International Economics*, 24(4):699–716.

Eckel, C. and Neary, P. (2010). Multi-product firms and flexible manufacturing in the global economy. *The Review of Economic Studies*, 77(1):188–217.

Engers, M., Hartmann, M., and Stern, S. (2009). Are lemons really hot potatoes? *International Journal of Industrial Organization*, 27(2):250–263.

Fajgelbaum, P., Grossman, G., and Helpman, E. (2011). Income distribution, product quality, and international trade. *Journal of Political Economy*, 119(4):721–765.

Fan, H., Lai, E. L.-C., and Li, Y. (2015). Credit constraints, quality, and export prices: Theory and evidence from china. *Journal of Comparative Economics*, 43(2):390–416.

Fernandes, A. M., Ferro, E., and Wilson, J. M. (2019). Product standards and firms' export decisions. *World Bank Economic Review*, 33(2):353–374.

Fontagné, L. and Orefice, G. (2018). Let's try next door: Technical barriers to trade and multi-destination firms. *European Economic Review*, 101:643–663.

Fontagné, L., Orefice, G., Piermartini, R., and Rocha, N. (2015). Product standards and margins of trade: Firm-level evidence. *Journal of International Economics*, 97(1):29–44.

Fugazza, M., Olarreaga, M., and Ugarte, C. (2018). On the heterogeneous effects of market access barriers: evidence from small and large Peruvian exporters. CEPR Discussion Papers 12876.

Gaigné, C. and Larue, B. (2016). Quality standards, industry structure, and welfare in a global economy. *American Journal of Agricultural Economics*, 98(5):1432–1449.

Genesove, D. (1993). Adverse selection in the wholesale used car market. *Journal of Political Economy*, 101(4):644–665.

Hallak, J. C. and Sivadasan, J. (2013). Product and process productivity: Implications for quality choice and conditional exporter premia. *Journal of International Economics*, 91(1):53–67.

Hendel, I., Lizzeri, A., and Siniscalchi, M. (2005). Efficient sorting in a dynamic adverse selection model. *Review of Economic Studies*, 72(2):467–497.

Hoekman, B. and Nicita, A. (2011). Trade Policy, Trade Costs, and Developing Country Trade. *World Development*, 39(12):2069–2079.

Khandelwal, A. K. (2010). The Long and Short of Quality Ladders. *The Review of Economic Studies*, 77(4):1450–1476.

Khandelwal, A. K., Schott, P. K., and Wei, S.-J. (2013). Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters. *The American Economic Review*, 103(6):2169–2195.

Kugler, M. and Verhoogen, E. (2012). Prices, Plant Size, and Product Quality. *The Review of Economic Studies*, 79(1):307–339.

Leland, H. E. (1979). Quacks, lemons, and licensing: A theory of minimum quality standards. *Journal of Political Economy*, 87(6):1328–1346.

Manova, K. and Yu, Z. (2017). Multi-product firms and product quality. *Journal of International Economics*, 109:116–137.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, 71(6):1695–1725.

Olper, A., Curzi, D., and Pacca, L. (2014). Do food standards affect the quality of eu imports? *Economics Letters*, 122(2):233–237.

Peterson, J. R. and Schneider, H. S. (2014). Adverse selection in the used-car market: evidence from purchase and repair patterns in the consumer expenditure survey. *RAND Journal of Economics*, 45(1):140–154.

Peterson, J. R. and Schneider, H. S. (2017). Beautiful lemons: Adverse selection in durable-goods markets with sorting. *Management Science*, 63(9):3111–3127.

Prahalad, C. K. and Hamel, G. (1990). The Core Competence of the Corporation. *Harvard Business Review*, May-June:79–91.

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

Ronnen, U. (1991). Minimum quality standards, fixed costs, and competition. *The RAND Journal of Economics*, 22(4):490–504.

Shapiro, C. (1983). Premiums for high quality products as returns to reputations. *The Quarterly Journal of Economics*, 98(4):659–679.

UNCTAD (2016). *Guidelines to Collect Data on Official Non-Tariff Measures - January 2016 Version*. UNCTAD, Geneva.

UNCTAD (2018). *Non-Tariff Measures: Economic Assessment and Policy Options for Development*. UNCTAD, Geneva.

Verhoogen, E. (2008). Trade, quality upgrading and wage inequality in the Mexican manufacturing sector. *Quarterly Journal of Economics*, 123(2):489–530.

WTO (2012). *World Trade Report 2012 - Trade and public policies: A closer look at non-tariff measures in the 21st century*. WTO, Geneva.

Appendix A Appendix

A.1 NTMs 16 chapters

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

Source: UNCTAD (2016) .

Notes: 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 A.2: Countries included in the TRAINS NTMs database

Afghanistan	Jordan
Algeria	Kazakstan
Antigua and Barbuda	Kuwait
Argentina	Kyrgyzstan
Australia	Lao PDR
Bahamas	Lebanon
Bahrain	Liberia
Bangladesh	Malaysia
Barbados	Mali
Belarus	Mauritania
Benin	Mauritius
Bolivia	Mexico
Botswana	Morocco
Brazil	Nepal
Brunei Darussalam	New Zealand
Burkina Faso	Nicaragua
Burma	Niger
Cambodia	Nigeria
Cameroon	Oman
Canada	Palestine
Cape Verde	Panama
Chile	Papua New Guinea
China	Paraguay
Colombia	Peru
Costa Rica	Philippines
Cuba	Qatar
Cote d'Ivoire	Russian Federation
Dominica	Saudi Arabia
Ecuador	Senegal
El Salvador	Singapore
Ethiopia	Sri Lanka
Gambia	Suriname
Ghana	Switzerland
Grenada	Tajikistan
Guatemala	Thailand
Guinea	Togo
Guyana	Trinidad and Tobago
Honduras	Tunisia
Hong Kong	United Arab Emirates
India	United States
Indonesia	Uruguay
Israel	Venezuela
Jamaica	Vietnam
Japan	Zimbabwe

Source: UNCTAD (2016) (https://trains.unctad.org/).
Note: Based on the data made available in February 2021.

Table A.3: Extensive margin: Export participation - Robustness checks

	Export participation ($Prob(y^k_{fjt}) > 0$)					
	(1) Dummy for QSs	(2) Altern. count of QSs	(3) Cluster$_{kjt}$	(4) Wo. lagged imports	(5) Max. price	(6) Nb. French firms
QSs$^k_{jt}$	0.038^a	0.006^a	0.005^a	0.007^a	0.003^a	-0.005^a
	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
QSs$^k_{jt}$ × ln productivity$^k_{f,t-1}$	-0.015^a	-0.003^a	-0.002^a	-0.002^a	-0.002^a	-0.002^a
	(0.001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
QSs$^k_{jt}$ × ln quality$^k_{fj,t-1}$	-0.010^a	-0.001^a	-0.001^a	-0.001^a	-0.001^a	-0.001^a
	(0.001)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
QSs$^k_{jt}$ × ln productivity$^k_{f,t-1}$ × ln quality$^k_{fj,t-1}$	0.004^a	0.001^a	0.001^a	0.001^a	0.001^a	0.001^a
	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ln productivity$^k_{f,t-1}$	0.023^a	0.023^a	0.023^a	0.025^a	0.024^a	0.023^a
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
ln quality$^k_{fj,t-1}$	0.027^a	0.026^a	0.026^a	0.027^a	0.027^a	0.027^a
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Other import-related NTMs$^k_{jt}$	-0.0002	-0.0001	-0.001	0.006^a	-0.006^a	-0.015^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln applied protection$^k_{jt}$	-0.006^a	-0.006^a	-0.006^a	-0.008^a	-0.008^a	-0.003^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln imports$^k_{j,t-1}$	0.023^a	0.023^a	0.023^a			-0.037^a
	(0.0003)	(0.0003)	(0.0003)			(0.0003)
ln maximum price$^k_{jt}$					0.015^a	
					(0.0003)	
ln number French exporters$^k_{jt}$						0.136^a
						(0.0004)
Observations	4,707,654	4,707,654	4,707,654	4,707,654	4,382,007	4,707,654
Adjusted R^2	0.179	0.179	0.179	0.178	0.175	0.197
Fixed effects: Firm$_f$& HS4-Destination-Year$_{HS4jt}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the probability that firm f exports product k to destination j in year t. QSs$^k_{jt}$ is the sum of SPS and TBT measures enforced on product k by destination j in year t (except in column 1). See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

Table A.4: Intensive margin: Value of exports - Robustness checks

	Value (logs) of exports (ln v^k_{fjt})					
	(1) Dummy for QSs	(2) Altern. count of QSs	(3) Cluster$_{kjt}$	(4) Wo. lagged imports	(5) Max. price	(6) Nb. French firms
QSs$^k_{jt}$	0.397^a	0.042^a	0.029^a	0.040^a	0.044^a	0.034^a
	(0.025)	(0.006)	(0.007)	(0.005)	(0.005)	(0.005)
QSs$^k_{jt}$ × ln productivity$^k_{f,t-1}$	-0.148^a	-0.029^a	-0.020^a	-0.020^a	-0.020^a	-0.020^a
	(0.006)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
QSs$^k_{jt}$ × ln quality$^k_{fj,t-1}$	-0.164^a	-0.029^a	-0.021^a	-0.022^a	-0.021^a	-0.021^a
	(0.007)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
QSs$^k_{jt}$ × ln productivity$^k_{f,t-1}$ × ln quality$^k_{fj,t-1}$	0.055^a	0.011^a	0.008^a	0.008^a	0.008^a	0.008^a
	(0.002)	(0.0004)	(0.001)	(0.0003)	(0.0003)	(0.0003)
ln productivity$^k_{f,t-1}$	0.454^a	0.454^a	0.454^a	0.467^a	0.467^a	0.454^a
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
ln quality$^k_{fj,t-1}$	0.267^a	0.265^a	0.266^a	0.267^a	0.267^a	0.265^a
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Other import-related NTMs$^k_{jt}$	-0.033^a	-0.022^a	-0.021^a	0.019^a	0.031^a	-0.013^c
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ln applied protection$^k_{jt}$	-0.069^a	-0.069^a	-0.069^a	-0.076^a	-0.074^a	-0.070^a
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
ln imports$^k_{j,t-1}$	0.128^a	0.128^a	0.128^a			0.169^a
	(0.001)	(0.001)	(0.002)			(0.002)
ln maximum price$^k_{jt}$					-0.050^a	
					(0.001)	
ln number French exporters$^k_{jt}$						-0.086^a
						(0.002)
Observations	2,211,097	2,211,097	2,211,097	2,211,097	2,199,037	2,211,097
Adjusted R^2	0.389	0.389	0.389	0.385	0.386	0.389
Fixed effects: Firm$_f$ & HS4-Destination-Year$_{HS4jt}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the export value in logs by firm f of product k to destination j in year t. QSs^k_{jt} is the sum of SPS and TBT measures enforced on product k by destination j in year t (except in column 1). See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} and ^{c} denoting significance at the 1% and 10% level respectively.

Table A.5: Intensive margin: Volume of exports - Robustness checks

	Volume (logs) of exports ($\ln q^k_{fjt}$)					
	(1) Dummy for QSs	(2) Altern. count of QSs	(3) Cluster$_{kjt}$	(4) Wo. lagged imports	(5) Max. price	(6) Nb. French firms
QSs^k_{jt}	0.496^a	0.065^a	0.048^a	0.060^a	0.091^a	0.059^a
	(0.031)	(0.008)	(0.009)	(0.006)	(0.006)	(0.006)
$\text{QSs}^k_{jt} \times \ln \text{productivity}^k_{f,t-1}$	-0.153^a	-0.030^a	-0.021^a	-0.021^a	-0.021^a	-0.021^a
	(0.007)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
$\text{QSs}^k_{jt} \times \ln \text{quality}^k_{fj,t-1}$	-0.180^a	-0.033^a	-0.025^a	-0.026^a	-0.028^a	-0.025^a
	(0.008)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\text{QSs}^k_{jt} \times \ln \text{productivity}^k_{f,t-1} \times \ln \text{quality}^k_{fj,t-1}$	0.051^a	0.010^a	0.008^a	0.008^a	0.008^a	0.008^a
	(0.002)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.0004)
$\ln \text{productivity}^k_{f,t-1}$	0.540^a	0.539^a	0.539^a	0.552^a	0.552^a	0.538^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\ln \text{quality}^k_{fj,t-1}$	-0.088^a	-0.091^a	-0.090^a	-0.088^a	-0.089^a	-0.092^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Other import-related NTMs^k_{jt}	-0.063^a	-0.053^a	-0.050^a	-0.009	0.066^a	-0.033^a
	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)
$\ln \text{applied protection}^k_{jt}$	-0.042^a	-0.042^a	-0.042^a	-0.049^a	-0.048^a	-0.044^a
	(0.005)	(0.005)	(0.007)	(0.005)	(0.005)	(0.005)
$\ln \text{imports}^k_{j,t-1}$	0.130^a	0.131^a	0.130^a			0.213^a
	(0.002)	(0.002)	(0.002)			(0.002)
$\ln \text{maximum price}^k_{jt}$					-0.272^a	
					(0.002)	
$\ln \text{number French exporters}^k_{jt}$						-0.174^a
						(0.003)
Observations	2,197,310	2,197,310	2,197,310	2,197,310	2,196,109	2,197,310
Adjusted R^2	0.587	0.587	0.587	0.586	0.593	0.588
Fixed effects: Firm$_f$ & HS4-Destination-Year$_{HS4jt}$	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the export volume in logs by firm f of product k to destination j in year t. QSs^k_{jt} is the sum of SPS and TBT measures enforced on product k by destination j in year t (except in column 1). See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

Table A.6: Extensive and intensive margins - Various sub-samples

	Export participation ($Prob(y^k_{fjt}) > 0$)		Value (logs) of exports ($\ln v^k_{fjt}$)		Volume (logs) of exports ($\ln q^k_{fjt}$)	
	(1) Differentiated products	(2) Multi-product & multi-dest. firms	(3) Differentiated products	(4) Multi-product & multi-dest. firms	(5) Differentiated products	(6) Multi-product & multi-dest. firms
QSs^k_{jt}	0.004^a	0.005^a	0.046^a	0.032^a	0.059^a	0.051^a
	(0.001)	(0.001)	(0.006)	(0.006)	(0.008)	(0.007)
$\text{QSs}^k_{jt} \times \ln \text{productivity}^k_{f,t-1}$	-0.002^a	-0.002^a	-0.027^a	-0.020^a	-0.025^a	-0.020^a
	(0.0002)	(0.0002)	(0.001)	(0.001)	(0.002)	(0.002)
$\text{QSs}^k_{jt} \times \ln \text{quality}^k_{fj,t-1}$	-0.001^a	-0.001^a	-0.026^a	-0.023^a	-0.028^a	-0.026^a
	(0.0003)	(0.0002)	(0.002)	(0.001)	(0.002)	(0.002)
$\text{QSs}^k_{jt} \times \ln \text{prod.}^k_{f,t-1} \times \ln \text{quality}^k_{fj,t-1}$	0.001^a	0.001^a	0.010^a	0.008^a	0.009^a	0.008^a
	(0.0001)	(0.0001)	(0.0005)	(0.0004)	(0.001)	(0.0004)
$\ln \text{productivity}^k_{f,t-1}$	0.024^a	0.024^a	0.445^a	0.463^a	0.527^a	0.549^a
	(0.0003)	(0.0002)	(0.001)	(0.001)	(0.002)	(0.002)
$\ln \text{quality}^k_{fj,t-1}$	0.026^a	0.026^a	0.261^a	0.271^a	-0.081^a	-0.095^a
	(0.0003)	(0.0003)	(0.002)	(0.001)	(0.002)	(0.002)
Other import-related NTMs^k_{jt}	-0.001	-0.002	-0.020^a	-0.025^a	-0.050^a	-0.059^a
	(0.001)	(0.001)	(0.008)	(0.007)	(0.009)	(0.009)
$\ln \text{applied protection}^k_{jt}$	-0.004^a	-0.006^a	-0.058^a	-0.074^a	-0.047^a	-0.048^a
	(0.001)	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)
$\ln \text{imports}^k_{j,t-1}$	0.025^a	0.023^a	0.126^a	0.126^a	0.131^a	0.130^a
	(0.0003)	(0.0003)	(0.002)	(0.001)	(0.002)	(0.002)
Observations	3,703,145	4,171,290	1,718,575	1,978,637	1,715,396	1,968,413
Adjusted R^2	0.174	0.169	0.378	0.379	0.556	0.576
Fixed effects: Firm_f & HS4-Destination-Year_{HS4jt}	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable is the probability that firm f exports product k to destination j in year t in columns 1-2, the export value in logs by firm f of product k to destination j in year t in columns 3-4, and the export volume in logs by firm f of product k to destination j in year t in columns 5-6. QSs^k_{jt} is the sum of SPS and TBT measures enforced on product k by destination j in year t. See the text for the definition of variables and data sources. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

Table A.7: Simulation: Number of firms

	Number (logs) of exporters ($\ln n^k_{jt}$)
No. QSs^k_{jt}	-0.002^a
	(0.001)
$\ln$ average $\text{productivity}^k_{j,t-1}$	0.051^a
	(0.001)
$\ln$ average $\text{quality}^k_{j,t-1}$	0.076^a
	(0.001)
No. other import-related NTMs^k_{jt}	-0.012^a
	(0.002)
$\ln$ applied protection^k_{jt}	-0.012^a
	(0.001)
$\ln$ $\text{imports}^k_{j,t-1}$	0.161^a
	(0.001)
Observations	612,356
Adjusted R^2	0.618
Fixed effects:	
Product_k & $\text{Destination-Year}_{jt}$	Yes

Note: The dependent variable is the number of firms in logs within a destination-product-year triplet kjt. The number of QSs is the sum of SPS and TBT measures enforced on product k by destination j in year t. See the text for the definition of variables and data sources. Average productivity and quality are computed as the mean of $\text{productivity}^k_{f,t-1}$ and $\text{quality}^k_{fj,t-1}$ across all firms f within a product-destination-year triplet kjt, respectively. Robust standard errors in parentheses, with ^{a} denoting significance at the 1% level.

Les **Working Papers SMART – LERECO** sont produits par l'UMR SMART-LERECO

- **UMR SMART-LERECO**

L'Unité Mixte de Recherche (UMR 1302) *Laboratoire d'Etudes et de Recherches en Economie sur les Structures et Marchés Agricoles, Ressources et Territoires* comprend les unités de recherche en Economie INRAE de Rennes, INRAE de Nantes et les membres des Unités Pédagogiques de Rennes et Angers du département Economie, Gestion et Société de L'institut Agro-Agrocampus Ouest.

Adresse:
UMR SMART-LERECO, 4 allée Adolphe Bobierre, CS 61103, 35011 Rennes cedex

Site internet : https://www6.rennes.inrae.fr/smart

Liste complète des Working Papers SMART – LERECO :
https://www6.rennes.inrae.fr/smart/Working-Papers
https://ideas.repec.org/s/rae/wpaper.html
http://ageconsearch.umn.edu/handle/204962/

The **Working Papers SMART – LERECO** are produced by UMR SMART-LERECO

- **UMR SMART-LERECO**

The « Mixed Unit of Research » (UMR1302) *Laboratory for Empirical Research in Economics on Structures and Markets in Agriculture, Resources and Territories* is composed of the research units in Economics of INRAE Rennes and INRAE Nantes and of the members of L'institut Agro-Agrocampus Ouest's Department of Economics, Management and Society located in Rennes and Angers.

Address:
UMR SMART-LERECO, 4 allée Adolphe Bobierre, CS 61103, 35011 Rennes cedex

Website: https://www6.rennes.inrae.fr/smart_eng/

Full list of the Working Papers SMART – LERECO:
https://www6.rennes.inrae.fr/smart/Working-Papers
https://ideas.repec.org/s/rae/wpaper.html
http://ageconsearch.umn.edu/handle/204962/

Contact

Working Papers SMART – LERECO
INRAE, UMR SMART-LERECO
4 allée Adolphe Bobierre, CS 61103
35011 Rennes cedex, France
Email : smart-lereco-wp@inrae.fr

2021

Working Papers SMART – LERECO

UMR INRAE-L'institut Agro **SMART-LERECO** (Laboratoire d'Etudes et de Recherches en Economie sur les Structures et Marchés Agricoles, Ressources et Territoires)

Rennes, France