Rev Agric Food Environ Stud (2016) 97:141–148
DOI 10.1007/s41130-016-0012-7

RESEARCH ARTICLE

Public quality standards and the food industry's structure in a global economy

Carl Gaigné[1,2] **· Bruno Larue**[2]

Received: 10 September 2014 / Accepted: 31 March 2015 / Published online: 6 April 2016

Abstract We study the impact of public quality standards on industry structure in a context of international trade. We consider vertical differentiation in an international trade model based on monopolistic competition in which firms differ in terms of their productivity and must incur two fixed export costs when exporting to any given destination: a generic one (i.e., setting up a distribution system) and a destination-specific one to meet the quality standard prevailing in the importing country. Variable costs are also increasing in quality. The absolute mass of firms in any given country is decreasing in the domestic standard, but the relative mass (market share) of foreign firms is increasing in the domestic standard. Increasing public quality standards benefit highly productive foreign firms which gain from the quality-induced exit of less productive domestic and foreign firms. The increase in industry productivity following stricter public standards does not result from induced innovation as in the Porter hypothesis but from the exit of less productive firms.

Keywords Quality standards · Industry structure · Welfare

JEL Classification F12 · L50

✉ Carl Gaigné
carl.gaigne@rennes.inra.fr

1 INRA, UMR1302 SMART, F-35000 Rennes, France

2 CREATE, Université Laval, Québec, Canada

Introduction

Food standards go back to at least 2500 BC as Egyptian laws attempted to reduce meat contamination (Ihegwuagu Nnemeka and Emeje Martins 2012 p. 422). Public quality standards have become increasingly common and controversial in the aftermath of epizootics, like the bovine spongiform encephalopathy, and well-publicized cases of bacterial contamination, like the 2006 spinach contamination in the USA. Countries have developed their own set of standards with some guidance from the *Codex Alimentarius* and the World Trade Organization's Sanitary and Phytosanitary Agreement. Technological progress has been rapid in food manufacturing (Reardon and Farina 2002).

Analyses about the effect of public quality standards on welfare predate recent epizootics. In an oligopoly setting, Das and Donnefeld (1989) and Larue and Lapan (1992) showed that minimum quality limits tend to decrease welfare. In Lutz et al. (2000) duopoly model, the high-quality firm can induce the government to use a weaker public standard that ends up reducing welfare by committing to a quality standard before the government regulates. In this paper, we propose a general approach to study the impact of public standards on the entry/exit of firms and welfare in a context of international trade. We consider a general equilibrium model where firms are heterogeneous and the public standard differs among countries.[1] Consumers' preferences are modeled in a more general manner than in the recent literature, and we allow quality to impact on fixed and variable costs. Ferro et al. (2015) found that stricter pesticide residue limits tend to

[1] Olper et al. (2014a, b) report on empirical studies pointing out that public and voluntary private standards have different effects on trade. The former tend to have an adverse effect on trade flows while the latter tend to boost trade through a regulatory harmonization effect.

increase fixed export costs, thus reducing the probability of agricultural exports, but other standards (like the removal of specified risk materials in the slaughter of beef cattle in response to bovine spongiform encephalopathy epidemics) can have an incidence at both the extensive and intensive margins of trade.

Our contribution builds on Melitz 's (2003) framework which explains the small fraction of firms that engage in export activities, as documented by Bernard et al. (2011a) by introducing heterogeneity in productivity between firms and a fixed export cost. There has been much interest recently in the introduction of vertical quality differentiation to explain certain regularity found in international trade data. Kugler and Verhoogen (2012) show that larger plants specialize in higher quality products and pay higher input prices. One of their hypotheses is that plant productivity and input quality are complements. This implies that quality-induced increases in production costs are lower for larger plants. The empirical evidence about Columbian plants confirms that in industries with a higher degree of vertical quality differentiation (proxied by R&D and advertising intensity) larger firms specialize in higher quality products and pay more for their inputs. Crozet et al. (2012) also exploit the link between productivity and quality when they contend that firms that are productive enough to export to a larger number of destinations specialize in higher quality products. Data from the Champagne industry provides empirical support for their hypothesis. In Hallak and Sivadasan (2013), firms are heterogeneous in terms of their process productivity and in terms of their product productivity. The former can be construed as the standard concept of productivity while the latter is about how fast fixed costs are rising with respect to quality. They show that smaller firms with a high product productivity level can export, but that exporting firms sell higher quality products than firms of equal size that do not export.

The recent developments in trade theory based on monopolistic competition, product differentiation, and firm heterogeneity have induced a new research agenda which is particularly relevant for the food industry for different reasons (Gaigné and Le Mener 2014). First, the features of this type of framework fit well with the food industry. On the one hand, food industry is composed of a large number of firms which are heterogeneous in terms of productivity (Blanchard et al. 2012). On the other hand, these food firms operate under imperfect competition and supply differentiated products (MacCorriston 2002). Second, the main predictions of this literature have been confirmed for the food industry. For example, it has been showed that (i) more productive French and Dutch food firms are larger, more likely to export, and serve more, and distant, markets (Chevassus-Lozza et al. 2013; Chevassus-Lozza and Latouche 2012; Vancauteren 2013) confirming a self-selection mechanism where only the most productive firms can recover the transaction (sunk) costs for serving foreign markets and become exporters and (ii) more efficient Italian food firms sell higher quality goods at higher prices and serve more distant markets (Curzi and Olper 2012) confirming the relationship between productivity, product quality, and export performance.[2]

From our framework, we found results that have interesting policy implications. For instance, a stricter national public standard hurts *relatively* more domestic firms than foreign ones. Increasing quality standards benefit highly productive foreign firms which gain from the quality-induced exit of less productive domestic and foreign firms. In addition, we show that a higher public standard may increase welfare even though it creates a distortion in quality, provided that the public standard is not too high. There exists an inverted U-shaped relationship between welfare and the public standard. This is an interesting result because the usefulness of standards typically rests on information asymmetry.

The rest of the paper is organized as follows. In the next section, we develop our framework whereas Section 3 analyzes the impact of domestic quality standards on industry structure and welfare.

The model

As in Melitz (2003), firms have heterogeneous productivity and consumers in K countries have identical Spence-Dixit-Stiglitz preferences. Quality is valued by consumers and the technology is such that quality increases entail increases in fixed and variable costs on firms. We consider a single period of production, but we can easily extend our framework to multiple periods by assuming an exogenous probability about the survival of firms as in Melitz (2003). All firms must comply with the public standard in the market they sell in. Therefore, quality may differ across countries, but it is determined by the public standard within a country. In essence, consumers react to the level of the public standard but are assumed oblivious to any quality claim made independently by individual firms. In this context, firms do not have incentive to exceed the public standard. Domestic and foreign goods available in a given market are horizontally differentiated but vertically homogenous.[3] In what follows, we describe the economy for a given distribution of standards, prices, and mass of firms. In the next sections, prices and the mass of firms are determined with respect to the level of public standards.

[2] In Curzi and Olper (2012), product quality is proxied by investment intensity, R&D expenditure, product and process innovations, as well as quality standard certifications (the ISO 9000 certification). They found that more efficient firms have higher export performance as they sell higher quality goods at higher prices.

[3] We consider the mixed case of public and private standards in Gaigné and Larue (forthcoming).

Preferences and demand

Consumers have identical Cobb-Douglas preferences over differentiated products and a homogeneous aggregate good. We posit a constant elasticity of substitution (CES) sub-utility function for the differentiated products:

$$U = \left(\left[\int_{\Omega_\upsilon} \theta(\upsilon)^\beta q(\upsilon)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}\upsilon \right]^{\frac{\varepsilon}{\varepsilon-1}} \right)^\kappa z^{1-\kappa} \tag{1}$$

where q and θ are the quantity and quality purchased for each variety, Ω_υ is the set of varieties available in the country, ε is the substitution elasticity between varieties, and z is the homogenous aggregate good whose price is normalized at 1. This is a generalization of the utility function used in Kugler and Verhoogen (2012) which restricts β to be equal to $(\varepsilon-1)/\varepsilon$. An increase in β signals greater appreciation for vertically differentiated products while an increase in ε limits the scope for horizontal product differentiation. Each country selects its standard $\theta(\upsilon)$. This standard is a scalar that embodies a very large number of standards like pesticide residue limits, veterinary drugs, additives, and manufacturing processes. Even if two importing countries have the same score, they are assumed to have different standards. For example, they might have the same average pesticide residue limit, but their limits on a given pesticide might differ. When governments choose standards, these standards apply to all products marketed in the domestic market whether they are manufactured by foreign or by domestic firms. Thus, in this instance, there is a single θ_j for each country.

We show in Appendix 1 that the equilibrium demand for a variety produced in country i is given by

$$q_{ij} = p_{ij}^{-\varepsilon} \theta_j^{\beta\varepsilon} P_j^{\varepsilon-1} L_j \tag{2}$$

where p_{ij} is the price of variety υ,P_j is the price index in country j, and L_j is the part of the total labor force in country j allocated to the differentiated product sector (i.e., $L_j \equiv \kappa \overline{L}_j$). The price elasticity is $-\varepsilon$, typical in models with CES preferences, but the elasticity of substitution also impacts on the quality elasticity, $\frac{\partial q_{ij}}{\partial p_{ij}} \frac{p_{ij}}{q_{ij}} = \beta\varepsilon$. Thus, an increase in the elasticity of substitution makes the demand more sensitive to price and more so to quality. Hence, the expenditures for a variety produced in country i is

$$p_{ij} q_{ij} = \theta_j^{\beta\varepsilon} p_{ij}^{1-\varepsilon} P_j^{\varepsilon-1} L_j \tag{3}$$

with the price index defined as

$$P_j^{1-\varepsilon} = \sum_k^K \int_\varphi \theta_j^{\beta\varepsilon} \left[p_{kj}(\varphi) \right]^{1-\varepsilon} M_{kj} \mu_{kj}(\varphi) \mathrm{d}\varphi \tag{4}$$

where M_{kj} is the mass of varieties produced in country, k and consumed in country j and $\mu_{kj}(\varphi)$ is the ex post distribution of productivity conditional on a variety produced in country k and consumed in country j over a subset of $[1,\infty)$. Note that, for a given mass of firms and prices, the price index reacts negatively in response to a generalized increase in quality.

Technology and profits

The aggregate good z is produced under constant returns to scale, with one unit of labor producing one unit of good z, by competitive firms. Intersectoral labor mobility implies that the wage rate equals 1.

In the differentiated sector, serving country j implies a fixed distribution cost f_{ij} which is specific to each destination with $f_{jj} < f_{ij}$ when $j \neq i$. For simplicity, we assume that $f_{ij} = f_{ii} + f_j$. Firms must also incur two additional costs which are standard specific. Firms have to pay a fixed cost ϕ_j to cover expenses associated with the implementation of new technology and additional labor training to operate in country j. We assume that it is increasing with the level of quality embodied in the standard

$$\phi_j = \theta_j^\eta \Big/ \eta \tag{5}$$

where $\eta > 0$. As in the industrial organization literature, we assume that the production of quality requires fixed costs (Sutton 2007).

We also assume that serving country j causes a shift in variable costs because firms have to adapt their product for each country. To meet the standard applied in country j, a firm must hire additional labor units $\delta_j q_{ij}/\varphi$ with q_{ij} the exports, φ the productivity of the firm, and $\delta_j \geq 1$ the cost shifter due to the standard adopted in country j. We assume that the cost shifter increases with quality θ. For simplicity, we consider $\delta_j = \theta_j^\alpha$. Hence, the production costs incurred by a firm producing variety υ located in country i is given by

$$C_i(\upsilon) = \sum_j^K \left(c_{ij} q_{ij} + \frac{\theta_j^\eta}{\eta} + f_j \right) = \sum_j^K \left(\frac{\theta_j^\alpha \tau_{ij}}{\varphi} q_{ij} + \frac{\theta_j^\eta}{\eta} + f_{ij} \right)$$

and the profit of the firm producing variety v located in country i is given by

$$\pi_i = \sum_j^K \pi_{ij} = \sum_j^K \left[\left(p_{ij} - \theta_j^\alpha \frac{\tau_{ij}}{\varphi} \right) q_{ij} - \frac{\theta_j^\eta}{\eta} - f_{ij} \right] \tag{6}$$

Firms produce under monopolistic competition. They maximize profit, treating the price index P_j as a constant, but from (2) they are indirectly connected through the price index.

Firms have to pay a sunk entry cost equal to f_e units of labor and do not know a priori their productivity. A risk neutral firm enters the market as long as the expected value of entry is higher than the sunk entry cost. The expected profit of a manufacturer prior to entering the market is given by $[1 - G(\varphi_{ii})]\overline{\pi}_i$

where $[1-G(\varphi_{ii})]$ is the probability to enter the market and $\overline{\pi}_i$ is the expected profit conditional on a successful entry. We have[4]

$$\overline{\pi}_i = \sum_j^K \lambda_{ij} \int_{\varphi_{ij}}^{\infty} \pi_{ij} \frac{g(\varphi)}{1-G\left(\varphi_{ij}\right)} \mathrm{d}\varphi \quad (7)$$

where $\lambda_{ij}=[1-G(\varphi_{ij})]/[1-G(\varphi_{ii})]$ is the probability to serve country j conditional on a successful entry. To simplify the analysis, we specify the distribution of productivity. As in Arkolakis et al. (2008), we assume φ follows a Pareto distribution over $[1,+\infty)$ with a shape parameter γ (with $\gamma>\varepsilon-1$) and with a lower productivity bound $\varphi_{\min}$ ($G(\varphi)\equiv 1-\varphi^{-\gamma}/\varphi_{\min}^{-\gamma}$ and $g(\varphi)=\gamma\varphi_{\min}^{\gamma}\varphi^{-\gamma-1}$).[5] We normalize $\varphi_{\min}$ to 1 such that $\lambda_{ij}=\varphi_{ij}^{-\gamma}\varphi_{ii}^{\gamma}$ and $1-G(\varphi)=\varphi^{-\gamma}$.

Public standards and industrial structure

Conditional on the public standard, profit maximization yields the following equilibrium price:

$$p_{ij}^* = \frac{\varepsilon}{\varepsilon-1}\frac{\tau_{ij}}{\varphi}\theta_j^{\alpha} \quad (8)$$

which implies the usual constant mark-up relation: $(p_{ij}^*-c_{ij})/p_{ij}^*=1/\varepsilon$. The price is increasing in the quality standard but decreasing in the productivity of firms. Even though there is no vertical quality differentiation, prices differ across firms because of horizontal quality differentiation. The volume produced by firms is increasing in the productivity of the firm. To see this, consider two firms with productivity $\varphi_1>\varphi_2$, then it can be shown from (8) and (2) that $q_1/q_2=(\varphi_1/\varphi_2)^{\varepsilon}$. Thus, more productive firms produce more than less productive ones. Profit can then be written as:

$$\pi_{ij} = \frac{\varphi^{\varepsilon-1}}{\varepsilon}\left(\frac{\varepsilon\tau_{ij}}{\varepsilon-1}\right)^{1-\varepsilon}\theta_j^{\Lambda}P_j^{\varepsilon-1}L_j-\left(\phi_j+f_{ij}\right) \quad (9)$$

with

$$\Lambda\equiv\beta\varepsilon-\alpha(\varepsilon-1) \quad (10)$$

Because $\varepsilon-1>0$, the profit of an incumbent firm based in country i serving country j is increasing in its productivity level φ and in country size L_j but decreasing in trade cost τ_{ij}.

Entry and mass of firms

A firm serves country j if and only if $\pi_{ij}^*\geq 0$. From the constant mark-up relation, the weakly positive profit condition can be expressed as $p_{ij}^*q_{ij}^*\geq\varepsilon(\phi_j+f_j)$ or, equivalently, in terms of a minimum productivity threshold φ_{ij} for market j given by

$$\varphi_{ij}^{\varepsilon-1}\equiv\theta_j^{-\Lambda}\left(\frac{\varepsilon\tau_{ij}}{\varepsilon-1}\right)^{\varepsilon-1}\frac{\varepsilon\left(\phi_j+f_{ij}\right)}{L_jP_j^{\varepsilon-1}} \quad (11)$$

Setting $f_{ij}=0$ and $\tau_{ij}=1$ when $j=i$, we can define the minimum productivity of firms from country i to operate in their own market:

$$\varphi_{ii}^{\varepsilon-1} = \theta_i^{-\Lambda}\left(\frac{\varepsilon}{\varepsilon-1}\right)^{\varepsilon-1}\frac{\varepsilon(\phi_i+f_{ii})}{L_iP_i^{\varepsilon-1}} \quad (12)$$

and derive the ratio of minimum productivities required for foreign and domestic firms to operate in the domestic market:

$$\frac{\varphi_{ki}}{\varphi_{ii}} = \tau_{ki}\left(1+\frac{f_k}{\phi_i+f_{ii}}\right)^{\frac{1}{\varepsilon-1}} \quad (13)$$

Note that the ratio of minimum productivities is decreasing in the standard-related fixed cost: $\partial(\varphi_{ki}/\varphi_{ii})/\partial\phi_i<0$.

By using the labor market clearing in country i (see Appendix 2.2) the mass of firms producing in country i is given by:

$$M_i = \frac{L_i(\varepsilon-1)}{\varphi_{ii}^{\gamma}f_e\gamma\varepsilon} \quad (14)$$

Similar expressions can be found in the literature (e.g., equation (4) in Arkolakis et al. 2008). The notable difference in our expression is that ϕ_i impacts the mass of firms through φ_{ii} as noted in (12) which is conditioned by exogenous variables and the price index P_i.

The effect of a stricter public standard on the mass of firms or probability of producing in the domestic market is a priori ambiguous. On the one hand, according to expression (9), the profits increase due to a better quality of products valued by consumers (as long as $\Lambda>0$). On the other hand, a change in the public standard modifies the price index. From Appendix 2.3, the price index can be expressed only in terms of exogenous variables and it becomes apparent that a stricter public standard decreases the price index and, ceteris paribus, profits. This means that a stricter public standard strengthens competition among firms. Hence, the effect of the public standard on the probability of entering is ambiguous. By inserting the price index expression in (12), we obtain the equilibrium minimum productivity of domestic firms to be active in the domestic market:

$$\varphi_{ii}^{\gamma} = \frac{\varepsilon-1}{\gamma-(\varepsilon-1)}\frac{\phi_i+f_{ii}}{f_e}\frac{1}{L_i}\sum_k\frac{L_k}{\tau_{ki}^{\gamma}}\left(1+\frac{f_k}{\phi_i+f_{ii}}\right)^{\frac{-\gamma+\varepsilon-1}{\varepsilon-1}}$$

[4] We do not use the expectation operator to simplify the notation.

[5] Redding (2010, p. 13) justifies the popularity of the Pareto distribution by noting that a Pareto distributed random variable truncated from below remains Pareto distributed and that a power function of a Pareto random variable is Pareto distributed. This makes the analysis tractable in the case of a CES demand system because revenue is a power function of productivity.

Increases in the fixed cost required to meet the domestic standard cause increases in the minimum productivity as $\partial\varphi_{ii}/\partial\phi_i > 0$. Hence, the more productive firms can survive when the public standard becomes stricter. In addition, we have $\partial^2\varphi_{ii}/\partial\tau_{ki}\partial\phi_i < 0$. The effect of a stricter public standard on the exit of firms is magnified when the trade openness of the domestic country is high (low τ_{ki}) due to fiercer competition from foreign firms.

Proposition 1 *A stricter public standard (high θ_i) forces the exit of domestic firms even if the consumers value the increase in product quality. This effect is amplified when trade barriers in the domestic country are low.*

The mass of foreign firms producing country in j and serving country i is given by

$$M_{ki} = \frac{M_k \varphi_{kk}^{\gamma}}{\varphi_{ki}^{\gamma}} = \frac{L_k(\varepsilon-1)}{\varphi_{ki}^{\gamma} f_e \gamma \varepsilon} \tag{15}$$

with

$$\varphi_{ki}^{\gamma} = \frac{\varepsilon-1}{\gamma-(\varepsilon-1)} \frac{(\phi_i + f_{ii})}{f_e} \frac{\tau_{ki}^{\gamma}}{L_i} \left(1 + \frac{f_k}{\phi_i + f_{ii}}\right)^{\frac{\gamma}{\varepsilon-1}} \sum_k \frac{L_k}{\tau_{ki}^{\gamma}} \left(1 + \frac{f_k}{\phi_i + f_{ii}}\right)^{1+\frac{-\gamma}{\varepsilon-1}} \tag{16}$$

where we have used (11) and the price index in Appendix 2.3. The share of foreign firms serving the domestic country is

$$\frac{M_{ki}}{M_i} = \tau_{ki}^{-\gamma} \left(\frac{L_k}{L_i}\right) \left(1 + \frac{f_k}{\phi_i + f_{ii}}\right)^{\frac{-\gamma}{\varepsilon-1}}.$$

Proposition 2 *Foreign firms have a larger market share when trade costs τ_{ki} are low and the fixed cost $\phi_i \equiv \theta_i^{\eta}/\eta$ required to meet the public standard is high.*

The intuition behind this result is that the relative advantage of domestic firms in terms of fixed costs, $\frac{\phi_i + f_{ii} + f_k}{\phi_i + f_{ii}}$, is decreasing with the national standard ϕ_i. The effect of tariffs and distance on quality has been the object of several studies recently. Amiti and Khandelwal (2013) argue that tariff reductions induces quality upgrading for firms that are near the "world technology frontier" because quality upgrading can be seen as a mean to escape more intense competition.[6] Having a public standard defining the vertical level of quality entails that some firms are forced to use a higher level of quality than they would like and that the reverse is true for other more productive firms. Since more productive firms cannot deflect competition by increasing quality beyond the standard, they use their productivity advantage to gain market share. Empirical evidence from Olper et al. (2014a, b) confirms the strong relationship between market penetration and productivity growth. Khandelwal (2010) demonstrates that in sectors where firms have less room to deflect competition through quality upgrading that competition from low-wage countries is more disruptive.

[6] From the importing firms' perspective, a higher specific tariff tends to reduce the relative price of high-quality products vis-à-vis lower quality products subject to the same unit tax. Distance has similar effects in inducing reductions in the volume of trade and in skewing the composition of trade toward higher quality products. Curzi and Olper (2012) report supportive evidence from Italian firms.

Market shares and profits

The sales in country i are given by (3) or, equivalently, by

$$p_{ii}q_{ii} = \varepsilon\varphi^{\varepsilon-1} \left\{ \frac{\gamma-(\varepsilon-1)}{\varepsilon-1} f_e L_i \left[\sum_k L_k \tau_{ki}^{-\gamma} (\phi_i + f_{ki})^{\frac{-\gamma+\varepsilon-1}{\varepsilon-1}} \right]^{-1} \right\}^{\frac{\varepsilon-1}{\gamma}} \tag{17}$$

Sales increase with ϕ_i and more rapidly when productivity and the fixed distribution cost are high (i.e., $\partial^2 p_{ii}q_{ii}/\partial\phi_i\partial\varphi > 0$, $\partial^2 p_{ii}q_{ii}/\partial\phi_i\partial f_{ki} > 0$). Through ϕ_i, a higher θ_i increases the sales of surviving domestic firms. Because the total market size is constant, $\sum_k \int_{\varphi_{ki}}^{\infty} p(\varphi)q(\varphi)\mu_{ki}(\varphi)\, d\varphi = L_i$, there is a reallocation of demand from less to more productive firms.

As shown in Appendix 2.4, $\pi_{ki} = \varphi^{\varepsilon-1}\varphi_{ki}^{1-\varepsilon}\phi_i - \phi_i$ and it is straightforward to see that

$$\frac{d\pi_{ki}}{d\phi_i} = \frac{\varphi^{\varepsilon-1}}{\varphi_{ki}^{\varepsilon-1}} \left[1-(\varepsilon-1)\varphi_{ki}^{-1}\phi_i \frac{\partial\varphi_{ki}}{\partial\phi_i}\right] - 1,$$

where the term in brackets is positive, as all surviving firms enjoy higher sales when ϕ_i increases, but is less than 1. For surviving firms with a productivity close to the minimum threshold, $\partial\pi_{ii}/\partial\phi_i < 0$, because the rise in operating profits is not sufficient to cover the increase in fixed costs associated with the higher standard while for highly productive firms, their profit raise with higher fixed costs ϕ_i. Hence,

Proposition 3 *An increase in the public standard reduces (increases) the profit of the least (most) productive surviving firms due to a reallocation of market share. As a result, industry productivity increases.*

Proof The marginal firm whose profit was zero before the increase in the public standard is forced to exit. The surviving firms are more productive than the ones exiting and average productivity increases. The expression $\frac{d\pi_{ki}}{d\phi_i} = \frac{\varphi^{\varepsilon-1}}{\varphi_{ki}^{\varepsilon-1}} \left[1-(\varepsilon-1)\varphi_{ki}^{-1}\phi_i \frac{\partial\varphi_{ki}}{\partial\phi_i}\right]$ -1 is positive (negative) for firms that have a high (low) level of productivity. QED

A stricter national standard makes winners and losers. Figure 1 illustrates the result. The increase in the national standard raises the minimum productivity level required for

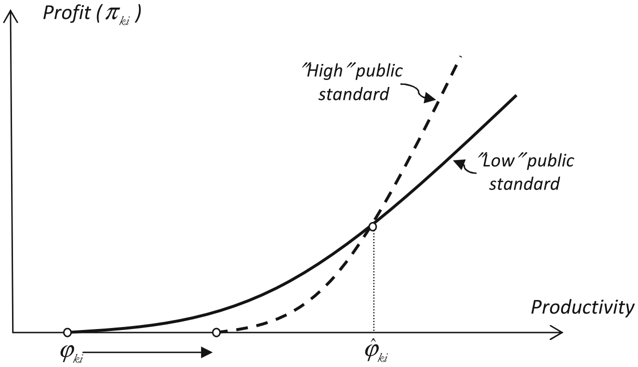

Fig. 1 Profits under a stricter public standard

a firm to survive. Accordingly, some firms are forced out. The level of profit of a firm is increasing with its productivity but more so under a stricter/higher standard. As a result, not all surviving firms are better off after the introduction of a stricter standard. Firms with productivity $\varphi \in [\varphi_{ki}, \hat{\varphi}_{ki})$ unambiguously lose under a stricter national standard while more productive firms with $\varphi > \hat{\varphi}_{ki}$ enjoy higher profits and have fewer rivals. The fact that a higher standard induces the exit of the less productive firms which in turn increases industry productivity can be likened to a Porter-like outcome. The main difference is that the standard-induced increase in average productivity is not due to induced innovation.

The impact of a stricter public standard on welfare

Quality standards have different welfare implications through the number of varieties, the prices of these varieties, and the vertical quality level valued by consumers. Individual welfare is given by the real wage $V_i = P_i^{-1}$. In Melitz's (2003) model, this reduces to $M_i^{1/(\varepsilon-1)}(\varepsilon-1)\tilde{\varphi}/\varepsilon$ where $\tilde{\varphi}$ is an average productivity index and a higher elasticity of substitution ε tends to deflate the gain from variety while increasing the gain from productivity. In our setting, an increase in the public standard may be beneficial because it raises product quality and the average productivity (via a selection of more productive firms). However, a stricter public standard decreases the mass of varieties available in the domestic market. Remember that an increase in the public standard raises the variable and fixed costs of domestic and foreign firms, but it lowers the relative fixed cost advantage of domestic firms. Therefore, the impact of public standard on welfare is ambiguous. From Appendix 2.3, we have

$$V_i = \left(\theta_i^{\frac{\Lambda\gamma}{(\varepsilon-1)}} \frac{L_i^{\frac{\gamma-(\varepsilon-1)}{\varepsilon-1}} \varepsilon^{\frac{-\varepsilon\gamma}{\varepsilon-1}} (\varepsilon-1)^{1+\gamma}}{[\gamma-(\varepsilon-1)] f_e} \sum_k L_k \tau_{ki}^{-\gamma} \left(\frac{\theta_i^\eta}{\eta} + f_{ki} \right)^{\frac{-[\gamma-(\varepsilon-1)]}{\varepsilon-1}} \right)^{\frac{1}{\gamma}} \quad (18)$$

Without loss of generality, we consider that $f_{ki} = f_i$ regardless of origin country k. In this case, maximizing welfare with respect to the public standard leads to the optimal level of public standard:

$$\hat{\theta}_i = \left[\frac{\eta\gamma\Lambda f_i}{\eta(\gamma-(\varepsilon-1))-\gamma\Lambda} \right]^{1/\eta} \quad (19)$$

with $d^2V_i/d\theta_i^2 < 0$ as long as $\hat{\theta}_i > 0$. When this condition holds and there is an increase in the distribution costs for serving the domestic country, (f_i) and/or a decrease in the elasticity of fixed costs to meet the public standard η, then a stricter public standard enhances welfare.

Proposition 4 *The level of the public standard maximizing welfare is increasing in the fixed distribution costs faced by foreign exporters f_i and with the concentration of firms with a low productivity.*

The intuition behind the relationship between the public standard and fixed distribution costs is that high fixed distribution costs insure that foreign firms operating in the domestic market are highly productive. As a result, the adverse effects of the public standard on the exit of firms and on pricing, through the variable cost parameter α and the fixed cost parameter η are mitigated. Naturally, when the distribution of productivities is more concentrated toward the minimum (high γ), the public standard must be lower to insure that there is enough varieties being offered. Finally, the public standard is also increasing in the valuation of quality by consumers, β, and decreasing in the effect of quality on variable costs, α.

Concluding remarks

Public standards play an important role in industry structure by impacting the distribution of output price and product quality, entry/exit of firms, and the numbers of importers and exporters. There is a widespread perception that setting high public standards help small domestic firms compete against foreign firms. We show that high public standards benefit most to highly productive foreign firms. In addition, we have showed that a stricter public standard may improve welfare by forcing less productive firms to exit. Thus, as in the Porter hypothesis, we find that stricter regulations can improve welfare, but the rise in productivity does not stem from induced innovation but from the ejection of less productive firms. Taken together, our results show that standards can have unsuspecting effects and governments must be careful in setting them.

Appendix 1. Quality and demand

Maximizing $U=\left[\int_{\Omega_v}\theta(v)^{\beta}q(v)^{\frac{\varepsilon-1}{\varepsilon}}\mathrm{d}v\right]^{\frac{\varepsilon}{\varepsilon-1}}$ subject to the budget constraint under a unitary wage rate $L=\int_{\Omega_v}pq$ d v leads to the following demand and expenditures equations:

$$q(v)=\theta^{\beta\varepsilon}\left[\int_{\Omega_v}\theta^{\beta}q(v)^{\frac{\varepsilon-1}{\varepsilon}}\mathrm{d}v\right]^{\frac{\varepsilon}{\varepsilon-1}}p(v)^{-\varepsilon}/\lambda^{\varepsilon} \tag{20}$$

$$p(v)q(v)=\theta^{\beta\varepsilon}\left[\int_{\Omega_v}\theta^{\beta}q(v)^{\frac{\varepsilon-1}{\varepsilon}}\mathrm{d}v\right]^{\frac{\varepsilon}{\varepsilon-1}}p(v)^{1-\varepsilon}/\lambda^{\varepsilon} \tag{21}$$

Plugging (21) in the budget constraint and isolating the marginal utility of income yields

$$L\equiv\int_{\Omega_v}p(v)q(v)\mathrm{d}v=\left[\int_{\Omega_v}\theta^{\beta}q(v)^{\frac{\varepsilon-1}{\varepsilon}}\mathrm{d}v\right]^{\frac{\varepsilon}{\varepsilon-1}}\int_{\Omega_v}\theta^{\beta\varepsilon}p(v)^{1-\varepsilon}\mathrm{d}v/\lambda^{\varepsilon}$$
$$\lambda^{\varepsilon}=\left[\int_{\Omega_v}\theta^{\beta}q(v)^{\frac{\varepsilon-1}{\varepsilon}}\mathrm{d}v\right]^{\frac{\varepsilon}{\varepsilon-1}}\int_{\Omega_v}\theta^{\beta\varepsilon}p(v)^{1-\varepsilon}\mathrm{d}v/L \tag{22}$$

Plugging (22) into the expenditure Eq. (21), we get (3):

$$p(v)q(v)=\theta^{\beta\varepsilon}L\left(\int_{\Omega_v}\theta^{\beta\varepsilon}p(v)^{1-\varepsilon}\mathrm{d}v\right)^{-1}p(v)^{1-\varepsilon}.$$

Appendix 2. Industrial structure and prices under a public standard

Expected profits

Because φ follows a Pareto distribution over $[1,+\infty)$ with shape parameter γ (with $\gamma>\varepsilon-1$) and with lower productivity bound $\varphi_{\min}=1$ ($G(\varphi)=\varphi^{-\gamma}$ and $g(\varphi)=\gamma\varphi^{-\gamma-1}$) and inserting (11) into (9) and then in (7), we obtain

$$\overline{\pi}_i=\sum_j\varphi_{ii}^{\gamma}\int_{\varphi_{ij}}^{\infty}\left[\left(\frac{\varphi^{\varepsilon-1}}{\varphi_{ij}^{\varepsilon-1}}-1\right)\left(\phi_j+f_j\right)\right]\gamma\varphi^{-\gamma-1}\mathrm{d}\varphi$$
$$=\frac{\varepsilon-1}{\gamma-(\varepsilon-1)}\varphi_{ii}^{\gamma}\sum_j\varphi_{ij}^{-\gamma}\left(\phi_j+f_{ij}\right)$$

Because the expected profit, conditional on a successful entry, must be equal to the sunk entry cost, $[1-G(\varphi_{ii})]\overline{\pi}_i=f_e$, we can rearrange to solve for the sunk entry cost:

$$\frac{\varepsilon-1}{\gamma-(\varepsilon-1)}\sum_j\varphi_{ij}^{-\gamma}\left(\phi_j+f_{ij}\right)=f_e \tag{23}$$

From the above expression, the level of minimum productivity of firms selling in the market must increase when the fixed cost that must be incurred to meet the public standard is augmented: $\partial\varphi_{ij}/\partial\phi_j>0$.

Labor market clearing and the mass of firms

By using the labor market clearing condition in country i, we have

$$L_i=\sum_j M_i\varphi_{ii}^{\gamma}\int_{\varphi_{ij}}^{\infty}\frac{\theta_j^{\alpha}q(\varphi)\tau_{ij}}{\varphi}g(\varphi)\mathrm{d}\varphi+M_ef_e$$
$$+\sum_j M_i\varphi_{ii}^{\gamma}\varphi_{ij}^{-\gamma}\left(\phi_j+f_{ij}\right) \tag{24}$$

with the mass of entering firms M_e being equal to the mass of firms in country i, M_i, times the reciprocal of the probability of entry, $M_e=M_i\varphi_{ii}^{\gamma}$ and where τ_{ij} is an iceberg trade cost parameter. Variable labor requirement can be expressed as

$$\int_{\varphi_{ij}}^{\infty}\frac{\theta_j^{\alpha}q(\varphi)\tau_{ij}}{\varphi}g(\varphi)\mathrm{d}\varphi=\int_{\varphi_{ij}}^{\infty}\frac{\theta_j^{\alpha}\tau_{ij}p(\varphi)^{-\varepsilon}\theta_j^{\beta\varepsilon}P^{\varepsilon-1}L_j}{\varphi}g(\varphi)\mathrm{d}\varphi$$
$$=\int_{\varphi_{ij}}^{\infty}\frac{\theta_j^{\alpha}\tau_{ij}p_{ij}(\varphi)^{-\varepsilon}\varepsilon\left(\phi_j+f_{ij}\right)}{\varphi p\left(\varphi_{ij}\right)^{1-\varepsilon}}g(\varphi)\mathrm{d}\varphi$$
$$=\int_{\varphi_{ij}}^{\infty}\frac{\theta_j^{\alpha}\tau_{ij}\theta_j^{-\alpha\varepsilon}\varphi^{\varepsilon-1}(\varepsilon-1)\left(\phi_j+f_{ij}\right)}{\theta_j^{\alpha(1-\varepsilon)}\varphi_{ij}^{\varepsilon-1}}g(\varphi)\mathrm{d}\varphi$$
$$=\frac{\gamma(\varepsilon-1)}{\gamma-(\varepsilon-1)}\sum_j\varphi_{ij}^{-\gamma}\left(\phi_j+f_{ij}\right) \tag{25}$$

Plugging (23) and (25) into (24) yields (14):

$$M_i=\frac{L_i(\varepsilon-1)}{\varphi_{ii}^{\gamma}f_e\gamma\varepsilon}$$

Price index

From (4), (8), $\mu_{ki}(\varphi)=\lambda_{ki}/[1-G(\varphi_{ki})]=\varphi_{kk}^{\gamma}$, and $g(\varphi)\equiv\gamma\varphi^{-\gamma-1}$, the price index can be expressed as follows:

$$P_i^{1-\varepsilon}=\frac{\theta_i^{\Lambda}\gamma}{\gamma-(\varepsilon-1)}\sum_k\frac{M_k}{\varphi_{kk}^{-\gamma}}\left(\frac{\varepsilon}{\varepsilon-1}\tau_{ki}\right)^{1-\varepsilon}\varphi_{ki}^{-\gamma+\varepsilon-1}$$

with $\Lambda\equiv\beta\varepsilon-\alpha(\varepsilon-1)>0$. Using (14) and (11) to account for the impact of the standard on the minimum productivities for firms of country k to export to country i, the reciprocal of the price index, which is the level of welfare V_i, can then be expressed only in terms of exogenous variables:

$$V_i = P_i^{-1}$$
$$= \frac{\theta_i^{\frac{\Lambda}{\varepsilon-1}} L_i^{\frac{\gamma-(\varepsilon-1)}{\gamma(\varepsilon-1)}} \varepsilon^{\frac{-\varepsilon}{\varepsilon-1}} (\varepsilon-1)^{\frac{1+\gamma}{\gamma}}}{[\gamma-(\varepsilon-1)]^{\frac{1}{\gamma}} f_e^{\frac{1}{\gamma}}} \left(\sum_k L_k \tau_{ki}^{-\gamma} \left(\frac{\theta_i^{\eta}}{\eta} + f_{ki} \right)^{\frac{-\gamma+\varepsilon-1}{\varepsilon-1}} \right)^{\frac{1}{\gamma}}$$

The imposition of a public standard increases the average quality of products consumed, and this is clearly a source of welfare gains. However, public standards increase fixed and variable costs and reduce competition. The resulting higher prices lower welfare. Governments increase standards until the marginal gain is just equal to the marginal cost.

Profits

$$\pi_{ii} = \frac{p_{ii}(\varphi) q_{ii}(\varphi)}{\varepsilon} - (\phi_i + f_{ii})$$
$$= \frac{p_{ii}(\varphi) q_{ii}(\varphi)}{p_{ii}(\varphi_{ii}) q_{ii}(\varphi_{ii})} \frac{p_{ii}(\varphi_{ii}) q_{ii}(\varphi_{ii})}{\varepsilon} - (\phi_i + f_{ii})$$

Because $\pi_{ij}(\varphi_{ij}) = 0$, then $\frac{p_{ii}(\varphi_{ii}) q_{ii}(\varphi_{ii})}{\varepsilon} = \phi_i + f_{ii}$, and from (3) with $\phi_{ij} = \phi_j$ and (8), then $\pi_{ii} = \varphi^{\varepsilon-1} \varphi_{ii}^{1-\varepsilon} (\phi_i + f_{ii}) - (\phi_i + f_{ii}) \geq 0$. An increase in the minimum productivity to be active in the domestic market reduces the profit of surviving domestic firms in the domestic market.

References

Amiti M, Khandelwal A (2013) Import competition and quality upgrading. Rev Econ Stat 95(2):476–490

Arkolakis C, Demidova S, Klenow P, Rodríguez-Clare A (2008) Endogenous variety and the gains from trade. Am Econ Rev 98(2):444–450

Bernard A, Jensen B, Redding S, Schott P (2011) The empirics of firm heterogeneity and international trade, NBER working paper 17627, Cambridge, U.S.A., 40 p

Blanchard P, Huiban J-P, Mathieu C (2012) The determinants of firm exit in the French food industries. Rev Agric Environ Stud 93(2):193–212

Chevassus-Lozza E, Latouche K (2012) Firms, markets and trade costs: access of French exporters to European agri-food markets. Eur Rev Agric Econ 39(2):257–288

Chevassus-Lozza E, Gaigné C, Le Mener L (2013) Does input trade liberalization boost downstream firms' exports? Theory and firm-level evidence. J Int Econ 90(2):391–402

Crozet, Head, Mayer (2012) Quality sorting and trade: firm-level evidence for French wine. Rev Econ Stud 79(2):609–644

Curzi D, Olper A (2012) Export behavior of Italian food firms: does product quality matter? Food Policy 37(5):493–503

Das S, Donnefeld S (1989) Oligopolistic competition and international trade: quantity and quality restrictions. J Int Econ 27(3-4):299–318

Ferro E, Otsuki T, Wilson J (2015) The effect of product standards on agricultural exports. Food Policy 50:68–79

Gaigné C, Larue B (2016) Quality standards, industry structure and welfare in a global economy. forthcoming in Am J Agric Econ

Hallak JC, Sivadasan J (2013) Product and process productivity: implications for quality choice and conditional exporter premia. J Int Econ 91(1):53–67

Ihegwuagu Nnemeka E, Emeje Martins O (2012) Food quality control: history, present and future, in: Scientific, Health and Social Aspects of the Food Industry, Benjamin Valdez (Ed.), (Rijeka, Croatia: InTech), ISBN: 978-953-307-916-5, InTech, doi: 10.5772/33151, URL: http://www.intechopen.com/books/scientific-health-and-social-aspects-of-the-food-industry/food-quality-control-history-present-and-future

Khandelwal A (2010) The long and short (of) quality ladders. Rev Econ Stud 77(4):1450–1476

Kugler M, Verhoogen E (2012) Prices, plant size and product quality. Rev Econ Stud 79(1):307–339

Larue B, Lapan H (1992) Market structure, quality and the world wheat market. Can J Agric Econ 40(2):311–328

Lutz S, Lyon T, Maxwell J (2000) Quality leadership when regulatory standards are forthcoming. J Ind Econ 48(3):331–348

MacCorriston S (2002) Why should imperfect competition matter to agricultural economists? Eur Rev Agric Econ 29(3):349–371

Melitz M (2003) The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71(6):1695–1725

Olper A, Curzi D, Pacca L (2014a) Do food standards affect the quality of EU imports? Econ Lett 122(2):233–237

Olper A, Pacca L, Curzi D (2014b) Trade, import competition and productivity growth in the food industry. Food Policy 49(1):71–83

Reardon T, Farina E (2002) The rise of private food quality and safety standards: illustrations from Brazil. Int Food Agribusiness Manag Rev 4(4):413–421

Redding S (2010) Theories of heterogeneous firms and trade, NBER working paper 16562, Cambridge, U.S.A., 38 p

Sutton (2007) Quality, trade and the moving window: the globalisation process. Econ J 117(524):F469–F498

Vancauteren M (2013) The role of EU harmonization in explaining the export-productivity premium of food processing firms, in: Frontiers of Economics and Globalization, volume 12, Nontariff Measures with Market Imperfections: Trade and Welfare Implication (H. Beladi and K. Choi, eds), URL: http://hdl.handle.net/1942/14788