

Standards, Reputation and Trade:  
Evidence from US Horticultural Import  
Refusals

**Web Appendix**

**The setting: disentangling productivity and quality sorting**

As usual, the model relates quality and productivity through a power function of the type:

$$q = c^\theta \tag{1}$$

with  $q$  the quality parameter,  $c$  firms' factor requirement and  $\theta$  the elasticity connecting quality and factor requirements.

I endogenize the power parameter relating quality to productivity  $\theta_i$ , defined over  $[0, +\infty[$ , and make it specific to the exporting country. This parameter characterizes the capacity  $1/\theta_i$  of the exporting country to produce quality. The physical factor requirement necessary to produce one unit of productivity product is  $c$  and  $c_q$  is the physical factor requirement necessary to produce one unit of quality product so that:

$$c_q = c^{(1+\theta_i)} \tag{2}$$

**1. The consumer's problem**

I consider a world of  $C$  countries indexed by  $i$ , varying in size and location, in which consumers maximize a CES utility across a continuum of varieties over the set  $V$  available in country  $i$ .

I assume consumers/buyers are able to recognize "quality" from "productivity" products. Heterogeneity among consumers of various countries relies on the intensity of their preference for quality  $q_i$ . Like in Eaton, Kortum and Kramarz (2008), I introduce the term  $\alpha_i$  representing an endogenous shock to the quality parameter in country  $i$ . This shock has a

downgrading effect on the quality parameter, in other words it represents the effect of a bad reputation on consumers' valuation of quality. For productivity products, the quality term becomes  $\alpha_i q_i = 1$ . The consumer maximizes utility according to a quality-adjusted demand  $\tilde{x}_i(v) = \alpha_i q_i x_i(v)$ , such that:

$$U_i = \left[ \int_{v \in V_i} [\tilde{x}_i(v)]^{\frac{\sigma-1}{\sigma}} dv \right]^{\frac{\sigma}{\sigma-1}} \quad (3)$$

The parameter  $\sigma$  is the elasticity of substitution across products and as usual, it is the same across countries.<sup>1</sup> Given the budget constraint of country  $i$  where the income  $Y_i$  equals to expenditure  $Y_i = w_i L_i$ , with  $L_i$ , the consumers' supply of labor to firms and  $w_i$  their wage, the quality-adjusted demand for the variety  $v$  becomes:

$$\tilde{x}_i(v) = \tilde{p}_i(v)^{-\sigma} \tilde{P}_i^{\sigma-1} Y_i \quad (4)$$

where  $\tilde{p}_i(v) = \frac{p_i(v)}{\alpha_i q_i}$  is the quality-adjusted price and  $\tilde{P}_i = \left( \int_{v \in V_i} [\tilde{p}_i(v)]^{1-\sigma} dv \right)^{\frac{1}{1-\sigma}}$  the quality-adjusted price index. This allows defining a physical demand<sup>2</sup> quite similar to Johnson (2009) with:

$$x_i(v) = [\alpha_i q_i]^{\sigma-1} p_i(v)^{-\sigma} \tilde{P}_i^{\sigma-1} Y_i \quad (5)$$

## 2. The producer's problem

As usual in the literature, a Dixit-Stiglitz framework of monopolistic competition characterizes the supply-side of the model so that a single firm produces each variety and there is free entry into the industry. Firms are heterogeneous in their productivity in the sense that marginal cost varies across firms. Firms from  $i$  incur fixed costs  $f_{ij}$  of selling to market  $j$ . Firms' productivity is Pareto distributed, with the distribution function  $g(\varphi)$  over  $(\varphi_0, +\infty)$

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<sup>1</sup> Melitz and Ottaviano (2008) relaxed this hypothesis by developing a model in which each firm faces a linear demand. This model allows for mark-up variations across firms and destination markets. Their conclusions will be discussed further in this paper.

<sup>2</sup> Usual productivity-sorting demand is expressed as:  $x_i(v) = \frac{(p_i(v))^{-\sigma}}{P_i^{1-\sigma}} Y_i$

and a continuous cumulative distribution  $G(\varphi)$ . Operating profits of a country  $i$ 's firm producing variety  $v$  and selling to  $j$  is classically expressed as:

$$\pi_{ij}(v) = \frac{R_{ij}(v)}{\sigma} - f_{ij} \quad (6)$$

Assuming a continuum of firms and a reasonable number of them allows for the disappearance of strategic interactions. Thus, when maximizing their profits, firms charge a mill price with a constant mark-up over marginal costs:  $p_i(v) = [\sigma/(\sigma - 1)]w_i c$ . The country specific factor cost is  $w_i$  and  $c = 1/\varphi$  is the firm's specific factor requirement, or the inverse of its productivity, needed to produce one unit of the variety  $v$ . If a firm from  $i$  seeks to sell its products to consumers in  $j$ , those consumers bear an additional transport cost  $\tau_{ij}$  defined in a Samuelson's iceberg costs fashion. Therefore, consumers price becomes:

$$p_i(v) = [\sigma/(\sigma - 1)]\tau_{ij}w_i c$$

According to (1), the quality product mill price is  $p_i(v) = [\sigma/(\sigma - 1)]w_i c^{(1+\theta_i)}$ . Thus the capacity of a given firm to produce quality depends on the interaction of three parameters:

- The firm's productivity  $\varphi = 1/c$ : the higher a firm's productivity, the more likely it produces quality products.
- The country's capacity to produce quality  $1/\theta_i$ : the higher this capacity, the lower the additional costs of producing quality.
- The intensity of consumers' preference for quality  $q_i$ : the more one country's consumers find utility in consuming quality products, the more firms are prompt to switch to a quality strategy. The higher the shock on the quality parameter, the lower  $\alpha_i q_i$ .

Thus the quality threshold is reflected by the upper limit level of factor requirement  $\bar{c}$  for which it is profitable to switch to a quality strategy. This threshold corresponds to the specific productivity level for which  $p_i(v) = \tilde{p}_i(v)$  implying  $\alpha_i q_i = \bar{c}^{\theta_i}$ . This allows to define a quality-adjusted price such that:

$$\tilde{p}_i(v) = [\sigma/(\sigma - 1)]w_i \bar{c} \quad (7)$$

where  $\tilde{c} = \frac{c^{(1+\theta_i)}}{\bar{c}^{\theta_i}}$  represents the quality-adjusted factor requirement. It can be highlighted that  $\tilde{c} > c$  if  $c > \bar{c}$  and  $\tilde{c} < c$  if  $c < \bar{c}$ . Every firm with a factor requirement  $c \leq \bar{c}$  has a quality-adjusted price  $\tilde{p}_i(v) \leq p_i(v)$  and thus finds an advantage in switching from productivity to quality products.

I consider that fixed cost is the same whether the firm decides to produce under quality or productivity strategy.<sup>3</sup> I assume that  $f_{ii} = 0$ . A firm exports to country  $j$  if and only if  $\pi_{ij} \geq 0$  with firm's revenues from selling to country  $j$  such as:<sup>4</sup>

$$R_{ij}(v) = p_{ij}(v)x_j(v) = (\tau_{ij}p_i(v))^{1-\sigma} [\alpha_{ij}q_j]^{\sigma-1} P_j^{\sigma-1} Y_j \quad (8)$$

Thus, the condition for one firm of country  $i$  to export to country  $j$  is  $\frac{R_{ij}(v)}{\sigma} \geq f_{ij}$ , implying the following cut-off condition:

$$\varphi_{ij} = A \frac{\tau_{ij}w_i}{P_j} \left( \frac{f_{ij}}{Y_j} \right)^{\frac{1}{\sigma-1}} \quad \text{with } A, \text{ a set of parameters} \quad (9)$$

The cut-off condition for a firm to export productivity products is the same as in the benchmark productivity-sorting model. If  $c_{ij} > \bar{c}$  then  $\tilde{c}_{ij} > c_{ij}$ , at the cut-off, firms do not find any advantage in producing under a quality strategy. Under this condition, the existence of the quality strategy does not increase the number of firms able to export to  $j$ . Firms from  $i$  are only able to export to  $j$  if their productivity is at least  $\varphi_{ij} = 1/c_{ij}$ . A specificity of this model lies in the extreme case where all firms from  $i$  export under quality-sorting; that is where  $c_{ij} < \bar{c}_{ij}$  and  $\tilde{c}_{ij} < c_{ij}$ . Therefore, around the cut-off, some firms that would not have been able to export to  $j$  under productivity-sorting are now able to export under quality-sorting. In other words, the possibility to switch to quality production can enable firms with a factor requirement  $c$  such that  $\tilde{c}_{ij} < \tilde{c} < c_{ij} < c < \bar{c}_{ij}$  to export to  $j$ . For convenience, I focus

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<sup>3</sup> Making fixed costs differ whether producing quality or productivity products complicates unnecessarily the model without yielding more interesting results for the purpose of this paper.

<sup>4</sup> Productivity sorting firm's revenues are expressed as  $R_{ij}(v) = \frac{(\tau_{ij}w_i c)^{1-\sigma}}{\left(\left(1-\frac{1}{\sigma}\right)P_j\right)^{1-\sigma}} Y_j$

on a benchmark case for which  $c_{ij} > \bar{c}_{ij}$  implying that both productivity and quality products are exported. Other cases are extreme situations. In our benchmark situation – all other things equal – the number of exporting firms to one country are constant and only depend of the entry threshold. As a result of (8),  $R_{ij} \neq 0$  if and only if  $c \leq c_{ij}$ . If  $c_0 > c_{ij}$  only a subset  $N_{ij}$ , hence representing  $N_{ij}$  varieties, of the  $N_i$  producing firms in country  $i$  are able to export to country  $j$ . The productivity of those  $N_{ij}$  exporting firms is defined over  $[\varphi_{ij}, +\infty[$ .

### 3. Expected average unit export f.o.b. price

Trade data only provide information on the average unit export f.o.b. price of products at the HS 6-digit level. Therefore I am looking for an expression of the expected unit export f.o.b price of all varieties exported by  $i$  to  $j$ .

According to the productivity-sorting setting, the expected unit export f.o.b price depends solely on the expected productivity level conditional on firms exporting to  $i$ .<sup>5</sup> Thus, under this setting, the expected unit export f.o.b. price of exports from  $i$  to  $j$  is given by:

$$E(p_{ij} | \pi_{ij} \geq 0) = \bar{p}_{ij} = \left( \frac{\sigma}{\sigma-1} \right) \frac{w_i}{E(\varphi | \pi_{ij} \geq 0)} \quad \text{with } \sigma > 1$$

This becomes:

$$E(p_{ij} | \pi_{ij} \geq 0) = \varepsilon \frac{P_j Y_j^{\frac{1}{\sigma-1}}}{\tau_{ij} \varepsilon_{ij}^{\frac{1}{\sigma-1}}} \quad \text{with } \varepsilon \text{ a set of parameters} \quad (10)$$

In the Productivity-Quality-Reputation (PRQ) setting, expected unit export f.o.b. price also depends on the proportion of firms exporting productivity or quality products to this market. Thus, the expected price conditional on exporting from  $i$  to  $j$  is defined as:

$$E(p_{ij} | \pi_{ij} \geq 0) = (\sigma/\sigma - 1) w_i V_{ij} \quad \text{with } V_{ij} = (V_{ijp} + V_{ijq}) \quad (11)$$

<sup>5</sup> Productivity-sorting expected productivity is expressed as:

$$E(\varphi | \pi_{ij} \geq 0) = \frac{1}{1-G(\varphi_{ij})} \int_{\varphi_{ij}}^{+\infty} \varphi g(\varphi) d\varphi = \left( \frac{\kappa}{\kappa+1} \right) \varphi_{ij} \quad \text{with } \kappa \text{ the Pareto distribution parameter.}$$

As in Helpman, Melitz and Rubinstein (2008),  $V_{ijp}$  and  $V_{ijq}$  are two monotonic functions of the proportion of exporters respectively exporting under a productivity or quality strategy to country  $j$ ,  $G(c)$ .

$$V_{ijp} = \begin{cases} \frac{1}{1-G(\bar{c}_{ij})} \int_{\bar{c}_{ij}}^{c_{ij}} c \, dG(c), & \text{for } c_{ij} > c > \bar{c}_{ij} \\ 0, & \text{Otherwise} \end{cases} \quad (12)$$

$$V_{ijq} = \begin{cases} \frac{1}{1-G(\bar{c}_{ij})} \int_0^{\bar{c}_{ij}} c^{(\theta_i+1)} \, dG(c), & \text{for } c_{ij} > \bar{c}_{ij} > c \\ 0, & \text{Otherwise} \end{cases}$$

As already mentioned, I do not consider extreme cases for which firms from one country only export productivity or quality products to a specific market, implying a different number of exporting firms to market  $j$ . Nevertheless, it is possible to identify that the benchmark situation lies between those two extremes, within a framework considering a constant number of exporting firms. The two extreme values of this benchmark situation for  $V_{ij}$  are:  $V_{ijp,max}$  for which all firms with a factor requirement  $c < c_{ij}$  export under productivity-sorting; and  $V_{ijq,max}$  for which all firms export under quality-sorting.

$$V_{ijp,max} = \frac{1}{1-G(c_{ij})} \int_0^{c_{ij}} c \, dG(c) = \frac{\kappa}{\kappa+1} c_{ij}$$

and

$$V_{ijq,max} = \frac{1}{1-G(c_{ij})} \int_0^{c_{ij}} c^{(\theta_i+1)} \, dG(c) = \frac{\kappa}{\theta_i + \kappa + 1} c_{ij}^{\theta_i+1}$$

with  $\kappa$  the Pareto distribution parameter.

According to our assumption, we have  $V_{ijp,max} < V_{ij} < V_{ijq,max}$ .

The assumption in this paper is that the proportion of firms producing quality products varies positively with the capacity of the exporting country and with the preference for quality of the importing country. On the contrary, it is negatively impacted by a shock to

consumers' preference for quality. Thus, the level of the expected price is a function of the quality threshold  $\bar{c} = (\alpha_{ij}q_i)^{1/\theta_i}$ . According to (12), in the benchmark scenario, the value of  $V_{ij}$  is the following:

$$V_{ij} = (V_{ijp} + V_{ijq}) = \frac{1}{1 - G(c_{ij})} \int_{\bar{c}_{ij}}^{c_{ij}} c \, dG(c) + \frac{1}{1 - G(\bar{c}_{ij})} \int_0^{\bar{c}_{ij}} c^{(\theta_i+1)} dG(c)$$

Developing this equation gives us the following value of  $V_{ij}$ , defined over the productivity cut-off condition and the quality threshold:

$$V_{ij} = \frac{\kappa}{\kappa+1} \frac{(c_{ij}^{\kappa+1} - \bar{c}_{ij}^{\kappa+1})}{c_{ij}^{\kappa}} + \frac{\kappa}{\theta_i + \kappa + 1} \bar{c}_{ij}^{\theta_i+1} \quad (13)$$

Because of the second threshold, it is not possible to obtain an empirical procedure that allows estimating parameters' elasticities. Nevertheless, Parameters influencing the average f.o.b price are clearly identified allowing us to derive a reduced form of the average price equation and to identify the signs of these parameters.

$$V_{ij} = h(c_{ij}, \bar{c}_{ij}) = h(c_{ij}, \theta_i, q_j, \alpha_{ij}) \quad (14)$$

#### 4. Additional references

Baldwin, R.E. and T. Ito (2008), "Quality competition versus price competition goods: an empirical classification." working paper, NBER.

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