

# Minimum Quality Standards and Their Effects on International Trade in the Presence of Uncertainty<sup>1</sup>

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## **1.Introduction**

The studies of the effects of different policies on trade in vertically differentiated goods constitute a significant part of the research done both in International Trade and Industrial Organization fields. One of the frameworks most used in these studies goes back to Gabszewicz and Thisse (1979). In the model they developed consumers that had the same preferences but different levels of income demanded different quality levels of the vertically differentiated product. They considered the case when two firms first decide on

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the quality levels of their products and then compete in quantities in a single market. Shake and Sutton (1982) demonstrated how quality differences relax price competition. They considered a two-stage game when two firms first choose quality levels and then compete a la Bertrand in a single market. They found that in the subgame perfect equilibrium for this game both firms would enter the market offering different quality levels of the product and enjoying positive profits. Ronnen (1991) used Shaked and Sutton's framework to study the effects of the quality standards. He showed that if variable costs do not rise "too quickly" with quality it is possible to choose a minimum quality standard that, "by increasing qualities and reducing differentiation, improves social welfare." This standard should be binding. After it is introduced all consumers are better off, more consumers participate in the market, the profits of the firm that produces high quality good fall but remain positive, and the profits of the firm that produces low quality good also remain positive (they may even rise if the standard is set close to the equilibrium quality level this firm would produce in the absence of regulation). Motta and Thisse (1994) focus their attention on the "environmental quality". They used a modification of the Ronnen's model and were able to derive equilibrium qualities explicitly. As Ronnen they found that there exists a minimum quality standard such that, if it is imposed social, welfare will rise. Garella (2003) considers a duopoly case when the firms' products are differentiated both horizontally and vertically. Firms' locations are fixed. Firms first choose qualities and then compete in prices. He demonstrated that the effects of the minimum quality standards on welfare are ambiguous. Crampes and Hollander (1995) studied the case when quality choice affects variable costs of the firms. Contrary to Ronnen(1991) and Motta and Thisse (1994) they found that after the

imposition of the minimum quality standard all consumers are worse off. This suggests that the effect of the minimum quality standard depends on the cost structure of the industry. Das and Donnenfeld (1989) compared the effects of minimum quality standards and quotas in case when a domestic firm and a foreign firm first choose quality of their products and then compete in quantities in the domestic market. The trade policy in this model is chosen by the home government and there is no room for strategic interaction between the governments of different countries. All these studies were limited to the analysis of uniform standards in a single market.

Boom (1995) developed a two-country model where governments can introduce standards to protect their domestic consumers. The markets in her model were assumed to be regionally segmented. Both markets are connected by the quality choices of the two firms. She demonstrated that minimum quality standards (symmetric or asymmetric) can lead to lower prices in both countries, lower profits for the firms, while qualities and consumer's surplus in both countries is higher. However, if standard imposed in one country is too high it can lead to foreign firms exiting the market, reduction of product variety and reducing consumers' welfare. Lutz (2003a, 2003b) extended the framework of Shaked and Sutton for the two-country case. The two firms located in different countries can sell their products in both markets. Lutz (2003b) compared the effects of different standard setting procedures on welfare. He found that whether a particular region will gain or lose from the imposition of the minimum quality standard depends on the choice of the standard setting procedure. For the country with smaller market size and less efficient firm welfare measured, as the sum of profits and consumer surplus will always be largest under Mutual Recognition. If the bigger country's industry has a large

cost advantage its welfare also will be the largest under Mutual Recognition. These findings imply that Mutual Recognition of standards is more likely to prevail for industries with large cost differences.

In all these studies, except Garella (2003), consumers know the quality of the product with certainty. Thus, minimum quality standards affect social welfare only if they are set above the lowest quality level chosen in the equilibrium without regulation. However, if consumers are uncertain about the quality of some of the products, we can expect that even the minimum quality standard that is below the lowest quality level chosen in the equilibrium without regulation will have effect on the consumers' and firms' decisions by reducing at least some uncertainty. We consider a two-country model with regionally segmented markets in which consumers are uncertain about the quality of the imported good and analyze what effects different minimum quality standard setting procedures may have on the social welfare and the pattern of trade. We then plan to compare the results with the certainty case.

## **2. The Model**

### 2.1 The Basic Model

We use a two-country partial equilibrium model of vertical product differentiation, which in many aspects is very similar to the modification of Shaked and Sutton model used Lutz (2003a, 2003b). There are two countries: the "home country", D, and the "foreign country", F. There are two firms: "domestic firm," located in the home country, and the foreign firm, located in the foreign country. Each firm produces a single variety of a

vertically differentiated good.<sup>3</sup> We assume that the hedonic attributes of this good are summarized by a scalar measure  $q$  we call quality.<sup>4</sup> The higher is  $q$  the better the good is from the point of view of all the consumers. The quality is assumed to be able to take any value in the interval  $[0,1]$ . When the qualities provided by the firms differ, they are referred to as “high” (h) quality and “low” (l) quality, respectively. Both firms have the same constant marginal cost of production, which is normalized to zero. However, before starting production each firm has to incur a “cost of developing quality.” These costs are increasing, convex functions of quality. We start with assuming them to be symmetric<sup>5</sup> and equal to  $\frac{q^2}{2}$ .

Markets are assumed to be regionally segmented.

Each consumer may purchase at most one unit of a product.

Consumers in both countries are assumed to have identical preferences and differ only in their income. Populations can be ordered according to an “income parameter”  $\theta$ .

Countries are symmetric and in each country parameter  $\theta$  is uniformly distributed over the interval  $[0,1]$ <sup>6</sup>. The income parameter  $\theta$  represents the inverse of consumers’ marginal rate of substitution between income and quality. The higher  $\theta$  corresponds to the lower marginal utility of income. So the wealthier consumers prefer higher quality

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<sup>3</sup> By saying that the good is vertically differentiated we mean that all consumers in both countries have the same ordering preferences over the mix of the characteristics this good can possess. For more details see Tirole (1993).

<sup>4</sup> Such measure of quality was suggested by Mussa and Rosen (1978) and now is commonly used. The logic behind comparing differentiated products on the basis of their fundamental measurable attributes has been discussed in Rosen (1974).

<sup>5</sup> We also plan to consider the case when the firms in different countries face different costs of developing quality.

<sup>6</sup> We also plan to consider the case when the countries have different market sizes.

products. We can use  $\theta$  when we refer to a single consumer or to the segment of consumers.

Consumers in each country know the quality of the good produced by the local firm, but are uncertain about the quality of the good produced by the foreign firm. They believe that if the quality of the imported good is said to be  $q_j$  the its true quality is uniformly distributed over the interval  $[0, q_j]$ . However, if there is a minimum quality standard  $\gamma$  recognized by the domestic government, consumers in the home country would believe that the true quality of the foreign firm's product said to be of quality  $q_j$  is uniformly distributed over the interval  $[\gamma, q_j]$ .

Let  $s$  denote the perception of the product's quality by a consumer. For the good of quality  $q_i$  produced at home  $s_i = q_i$ . For the imported good of quality  $q_j$ , in the absence

of the minimum quality standard  $s_j = \frac{q_j}{2}$  and with a minimum quality standard  $\gamma > 0$ ,

recognized by the domestic government,  $s_j = \frac{q_j + \gamma}{2}$ .

Consumers in both countries are assumed to be risk neutral.

Expenditure on the product (product's price  $p$ ) is small relative to income.

Then, consumer  $i$ 's preference can be represented by<sup>7</sup>:

$$U = \begin{cases} \theta_i s - p & \text{if one unit of the good which expected quality for consumer } i \text{ is } s \\ & \text{is purchased at price } p, \\ 0 & \text{otherwise.} \end{cases}$$

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<sup>7</sup> For more details see Tirole (1993, pp.296-297)

In the first stage, firms choose the qualities they will produce. In the second stage, firms compete in prices taking their choices as given.

### 2.3 Unregulated Equilibria.

We look only for subgame perfect equilibria in pure strategies.

Since markets are segmented the firms set the price in one market independently of the prices they set in another one.

At each market equilibrium price of the product perceived by the consumers in this

market as a high quality product is  $p_h = \frac{2s_h(s_h - s_l)}{(4s_h - s_l)}$ ,

while the equilibrium price of the product perceived by the consumers in this market as a

low quality product is  $p_l = \frac{s_l(s_h - s_l)}{(4s_h - s_l)}$

For derivation see appendix.

Given the equilibrium prices depicted above, we can express the demand for the product perceived by the consumers in this market as a high quality product and the demand for the product perceived by the consumers in this market as a low quality product in terms of the expected qualities of the product. Then we can represent the revenues at this market of the firm producing “high quality” product and the firm producing “low quality” product as functions of the expected qualities of the products. (See appendix)

Firm  $i$ 's revenue is a sum of its revenues in the domestic and the foreign market. The properties of the revenue functions are presented in the appendix.

Firm  $i$ 's profit is a sum of its revenues from the domestic sales and revenues from exports minus the cost of developing quality:

$$\Pi_i = R_i^D + R_i^F - C_i,$$

$$\text{where } C_i = \frac{q_i^2}{2}.$$

Firm  $i$ 's profit as a function of its own quality  $q_i$  consists of three segments, the segment in which the quality of the firm's product is perceived as low in both markets (L-L segment), the segment in which the quality of the firm's product is perceived as high in the domestic market and as low in the foreign market (H-L segment) and the segment in which the quality of the firm's product is perceived as high in both markets (H-H segment). In the absence of regulation firm  $i$ 's profit is

$$\Pi_i = \frac{4b_i^2 q_i^2 (q_i - q_j/2)}{(4q_i - q_j/2)^2} + \frac{4b_j^2 (q_i/2)^2 (q_i/2 - q_j)}{(4(q_i/2) - q_j)^2} - cq_i^2 \quad \text{for } q_i > 2q_j;$$

$$\frac{4b_i^2 q_i^2 (q_i - q_j/2)}{(4q_i - q_j/2)^2} + \frac{b_j^2 (q_i/2) q_j (q_j - q_i/2)}{(4q_j - q_i/2)^2} - cq_i^2 \quad \text{for } \frac{1}{2}q_j < q_i < 2q_j;$$

$$\frac{b_i^2 q_i (q_j/2)(q_j/2 - q_i)}{(4(q_j/2) - q_i)^2} + \frac{b_j^2 (q_i/2) q_j (q_j - q_i/2)}{(4q_j - q_i/2)^2} - cq_i^2 \quad \text{for } q_i < \frac{1}{2}q_j.$$

L-L segment and H-L segments are connected at  $q_i = q_j/2$  and H-L segment and H-H segment are connected at  $q_i = 2q_j$ .

Note that for the moment we focus on the case when  $b_i = b_j = 1$ .

**Lemma 1.** Firm  $i$ 's profit as a function of its own quality  $q_i$  consists of three strictly concave segments, the segment in which the quality of the firm's product is perceived as low in both markets (L-L segment), the segment in which the quality of the firm's product is perceived as high in the domestic market and as low in the foreign market (H-L segment) and the segment in which the quality of the firm's product is perceived as high in both markets (H-H segment). L-L segment and H-L segments are connected at  $q_i = q_j / 2$  and H-L segment and H-H segment are connected at  $q_i = 2q_j$ . Each of these segments has a unique local maximum  $\Pi_{LL}^{\max}$ ,  $\Pi_{HL}^{\max}$ ,  $\Pi_{HH}^{\max}$ .

**Proof.**

The strict concavity of the segments of the profit function follows from the strict concavity of the revenues (see appendix for the properties of the revenue functions and the properties of the expected qualities) and the fact that the costs are convex. The existence and uniqueness of the local maximum for each segment follows from the Wierstrass theorem. QED

It is easy to see that as  $q_j$  approaches zero,  $\Pi_{LL}^{\max}$  and  $\Pi_{HL}^{\max}$  approach zero, while  $\Pi_{HH}^{\max}$  approaches monopoly profits. From the properties of the revenue functions presented in the appendix we can also see that as  $q_j$  increases  $\Pi_{HH}^{\max}$  and  $\Pi_{HL}^{\max}$  decrease while  $\Pi_{LL}^{\max}$  increases.

*The best response functions,  $q_i(q_j)$ , and possible equilibria in pure strategies will be discussed during presentation.*

Consumer surplus in the country  $i$  is measured as

$$CS_i = \int_{\tilde{\theta}_i}^1 (ts_{hi} - p_{hi}) dt + \int_{\theta_{0i}}^{\tilde{\theta}_i} (ts_{li} - p_{li}) dt = \frac{s_{hi}^2 (2s_{hi} + 3s_{li})}{(4s_{hi} - s_{li})^2}.$$

For some properties of the consumer surplus see appendix.

Social welfare in the country  $i$  is measured as  $W_i = CS_i + R_i^D + R_i^F - C_i$  (the sum as the sum of the domestic firm's profits and consumer surplus).

### 2.3 Minimum Quality Standards.

Lutz (2003a, 2003b) demonstrated that when consumers have complete information about qualities of all products traded at the market, national welfare of both countries can be improved comparing with unregulated equilibria outcomes through imposition of the binding minimum quality standard. In our case increasing one of the qualities or both of them also can increase social welfare in both countries.

**Lemma 2.** Given an unregulated quality equilibria, national welfare of both countries can be increased by increasing at least one of the qualities.

#### **Proof.**

For any equilibrium pair of qualities marginal profits of both firms are zero. Marginal consumer surplus with respect to both qualities is positive in both countries (see appendix for the properties of the consumer surplus). If the quality of the product which is perceived as being of high quality increases, the profits of the firm producing the product which is perceived as a low quality product will increase. If the quality of the product that is perceived as being of low quality increases the profit of rival firm will decrease. But

this decrease in profits will be lower than an increase in consumer surplus due to this change in qualities. Thus, by slightly increasing one of the qualities in country  $i$  (keeping  $s_{li} < 4s_{hi} / 7$ ) we can increase this country's welfare. QED.

An important implication of the consumers' uncertainty about the quality of the imported good, is that imposition of a minimum quality standard will change the social welfare even if this standard is not binding.

### **3. Outline for the future research.**

In the future I plan to extend the model introduced above to include standard-setting governments. Following Lutz (2003b) the model will be modified to incorporate a four-stage game with the governments of the two countries interacting in the first two stages and firms interacting in the third and the fourth stages.

In the first stage both governments simultaneously choose a standard setting procedure from the set of three alternative policies. These alternatives are:

- National Treatment (NT), when governments simultaneously set minimum quality standards for the domestic consumers;
- Mutual Recognition (MR), when governments simultaneously set minimum quality standards for the domestic producers and recognize each other's standard;
- Full Harmonization (FH), when government representatives or some kind of international organization set the same minimum quality standard for both countries.

The governments announce their choices. If the governments' choices coincide the particular standard policy will be applied, otherwise the default procedure is used.

Default procedure in Lutz (2003b) is the Mutual Recognition procedure, which is justified by both governments choosing MR being always a Nash equilibrium in the certainty case.

The governments' actions in the second stage depend on the outcome of the first stage of the game.

If both governments have chosen National Treatment, each government maximizes domestic social welfare by independently setting consumer standards at the home market.

If both governments have chosen Mutual Recognition, each government maximizes social welfare in the home country by independently setting domestic producer standards.

If both governments have chosen Full Harmonization, the representatives of the governments or some international organization maximize the some of the regional welfares by setting one uniform standard.

In the third stage firms simultaneously choose qualities of their respective products.

In the fourth stage firms compete in prices in two segmented markets.

Then we want to solve the game and find under which conditions which standard setting procedure is going to prevail. Derive the effects of different standard setting procedures on firms' decisions, national welfares, and pattern of trade and compare them with the results for the certainty case from Lutz (2003a, 2003b). We are interested in how our results would change if we change the cost structure by making the quality choice to affect variable costs.

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## Appendix.

Consider the market where parameter  $\theta$  is distributed uniformly on the interval  $[0,b]$ .

Note that for the moment we focus on the case when  $b = 1$ .

Let  $s_1$  be expected quality of the product produced by the firm 1.

Let  $s_2$  be expected quality of the product produced by the firm 2.

Without loss of generality assume that  $s_1 > s_2$ .

Consumer indifferent between buying from firm 1 and firm 2 is defined by

$$\tilde{\theta}s_1 - p_1 = \tilde{\theta}s_2 - p_2$$

$$\tilde{\theta} = \frac{p_1 - p_2}{s_1 - s_2}$$

Demand for the product of the firm 1 will be

$$X_1 = b - \frac{p_1 - p_2}{s_1 - s_2}$$

Consumer indifferent between buying from firm 2 and not buying at all is defined by

$$\theta_0 s_2 - p_2 = 0$$

$$\theta_0 = \frac{p_2}{s_2}$$

Demand for the product of the firm 2 will be

$$X_2 = \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2}$$

Revenue for the firm 1 from this market will be

$$R_1 = X_1 p_1 = \left( b - \frac{p_1 - p_2}{s_1 - s_2} \right) p_1$$

Revenue for the firm 2 from this market will be

$$R_2 = X_2 p_2 = \left( \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2} \right) p_2$$

Optimal price to charge at this market:

Firm 1

F.O.C.

$$\frac{\partial R_1}{\partial p_1} = b - \frac{2p_1 - p_2}{s_1 - s_2} = 0$$

The above implies

$$p_1 = \frac{1}{2} p_2 + \frac{1}{2} b(s_1 - s_2)$$

Firm 2

F.O.C.

$$\frac{\partial R_2}{\partial p_2} = \frac{p_1 - 2p_2}{s_1 - s_2} - \frac{2p_2}{s_2} = 0$$

The above is equivalent to

$$\frac{p_1 s_2 - 2p_2 s_2 - 2p_2 s_1 + 2p_2 s_2}{(s_1 - s_2)s_2} = 0$$

and implies

$$p_2 = \frac{1}{2} p_1 \frac{s_2}{s_1}.$$

Note that since  $s_1 > s_2$ ,  $p_2 < \frac{1}{2} p_1$ .

$$p_1 = \frac{1}{4} p_1 \frac{s_2}{s_1} + \frac{1}{2} b(s_1 - s_2)$$

$$(4s_1 - s_2)p_1 = 2bs_1(s_1 - s_2)$$

$$p_1 = \frac{2bs_1(s_1 - s_2)}{(4s_1 - s_2)}$$

$$p_2 = \frac{1}{2}p_1 \frac{s_2}{s_1} = \frac{bs_2(s_1 - s_2)}{(4s_1 - s_2)}$$

$$p_1 - p_2 = \frac{b(2s_1 - s_2)(s_1 - s_2)}{(4s_1 - s_2)}$$

$$\tilde{\theta} = \frac{b(2s_1 - s_2)}{(4s_1 - s_2)}$$

$$\theta_0 = \frac{b(s_1 - s_2)}{(4s_1 - s_2)}$$

$$X_1 = b - \frac{b(2s_1 - s_2)}{(4s_1 - s_2)} = b \left( 1 - \frac{2s_1 - s_2}{4s_1 - s_2} \right) = b \left( \frac{4s_1 - s_2 - 2s_1 + s_2}{4s_1 - s_2} \right) = \frac{2bs_1}{4s_1 - s_2}$$

$$X_2 = \frac{b(2s_1 - s_2)}{(4s_1 - s_2)} - \frac{b(s_1 - s_2)}{(4s_1 - s_2)} = \frac{b(2s_1 - s_2 - s_1 + s_2)}{(4s_1 - s_2)} = \frac{bs_1}{(4s_1 - s_2)}$$

Revenues are

$$R_1 = \frac{4b^2s_1^2(s_1 - s_2)}{(4s_1 - s_2)^2}$$

$$R_2 = \frac{b^2s_1s_2(s_1 - s_2)}{(4s_1 - s_2)^2}$$

### Properties of the Revenue Functions.

Let  $R_i$  and  $MR_i$  denote firm's  $i$ 's revenue and marginal revenue functions, respectively, where  $t = h$  if in the market we consider the product provided by the firm  $i$  is expected to be of high quality and  $t = l$  if the product provided by the firm  $i$  is expected to be of low quality.

$$\frac{\partial R_h}{\partial s_i} = \frac{4b^2 s_i (4s_i^2 - 3s_i s_j + 2s_j^2)}{(4s_i - s_j)^3} \geq \frac{4b^2 s_i (4s_i^2 - 3s_i^2 + 2s_j^2)}{(4s_i - s_j)^3} = \frac{4b^2 s_i (s_i^2 + 2s_j^2)}{(4s_i - s_j)^3} \geq 0$$

$$\frac{\partial R_l}{\partial s_i} = \frac{b^2 s_j^2 (4s_j - 7s_i)}{(4s_j - s_i)^3} \geq 0 \text{ for } s_i \leq \frac{4}{7} s_j$$

$$\frac{\partial R_h}{\partial s_j} = -\frac{4b^2 s_i^2 (2s_i + s_j)}{(4s_i - s_j)^3} < 0$$

$$\frac{\partial R_l}{\partial s_j} = \frac{b^2 s_i^2 (2s_j + s_i)}{(4s_j - s_i)^3} > 0$$

$$\frac{\partial MR_h}{\partial s_i} = -\frac{8b^2 s_j^2 (5s_i + s_j)}{(4s_i - s_j)^4} < 0$$

$$\frac{\partial MR_l}{\partial s_i} = -\frac{2b^2 s_j^2 (7s_i + 8s_j)}{(4s_j - s_i)^4} \leq 0$$

$$\frac{\partial MR_h}{\partial s_j} = \frac{8b^2 s_i s_j (5s_i + s_j)}{(4s_i - s_j)^4} > 0$$

$$\frac{\partial MR_l}{\partial s_j} = \frac{2b^2 s_i s_j (7s_i + 8s_j)}{(4s_j - s_i)^4} > 0$$

### Properties of the expected qualities.

$\frac{\partial s_i}{\partial q_i} = \frac{\partial q_i}{\partial q_i} = 1$  if we consider the market in the country where firm  $i$  is located.

$\frac{\partial s_i}{\partial q_i} = \frac{\partial \frac{q_i + \gamma}{2}}{\partial q_i} = \frac{1}{2}$  if we consider the market at which firm  $i$  is exporting.

$\frac{\partial s_i}{\partial q_j} = 0$  always.

Properties of the consumer surplus in either country.

$$\frac{\partial CS}{\partial s_h} = -\frac{s_h(-8s_h^2 + 6s_h s_l + 5s_l^2)}{(4s_h - s_l)^3}$$

$$\frac{\partial CS}{\partial s_l} = \frac{s_h^2(28s_h + 5s_l)}{2(4s_h - s_l)^3} > 0$$

$$\frac{\partial^2 CS}{\partial s_h^2} = \frac{s_l^2(52s_h + 5s_l)}{(4s_h - s_l)^4} > 0$$

$$\frac{\partial^2 CS}{\partial s_l \partial s_h} = -\frac{s_h s_l(52s_h + 5s_l)}{(4s_h - s_l)^4} < 0$$