

## PROTECTION BY REGULATORY STANDARDS: AN EXAMPLE WITH FORCED EXIT

*The recent extensive study of vertical product differentiation models has allowed for the analysis of international trade issues in the presence of country asymmetries in terms of product qualities, technology, costs, market size and income. In the presence of such asymmetries, national industries will either be market leaders or be lagging behind in the international market place in terms of their product qualities. The resulting asymmetry in profits creates powerful incentives for lagging industries as well as their national governments to reverse this situation to their advantage, i. e. to promote leadership in terms of product qualities. This note presents an example where a minimum quality standard facilitates increased product quality by the domestic firm as well as exit of the foreign firm.*

### 1. Introduction

Issues of globalization, trade liberalization and regionalism are currently especially important to transitional countries. This is particularly the case for trade between transitional countries, where asymmetric conditions and imperfect competition are present. However, the conceptual economic framework to analyze these questions is rather fragmentary at this time, despite the fact that the recent studies of trade models under imperfect competition have allowed for impressive theoretical advances.

The usage of static vertical product differentiation models allows for modelling country asymmetries in terms of market size, income, and technology/costs. In the presence of such asymmetries, national industries will either be market leaders or be lagging behind in the international market place in terms of their product qualities. The resulting asymmetry in profits creates powerful incentives for lagging industries as well as their national governments to reverse this situation to their advantage, i. e. to induce "Leapfrogging" in terms of product qualities (LF). LF occurs when a national/regional industry that formerly produced a good qualitatively inferior to its international rivals' goods will change to produce the qualitatively superior good. This switch in competitive stance can, e. g., be induced by direct foreign investment into backward industries (e. g. as in East Germany and some transformation economies) or by government measures such as subsidies, quotas or standards. This note presents an example where a minimum quality standard facilitates Leapfrogging as well as exit of the foreign firm.

For our example, we utilize a benchmark model of vertical product differentiation that has been extensively applied in the literature. One domestic and one foreign firm face quality-dependent fixed costs and constant marginal production costs. They compete in quality and price in a single domestic market. Demand is such that an uncovered market results for all

possible outcomes. Since increased differentiation in terms of quality decreases competition between rival products, higher quality products will coexist with lower quality products, even if both firms were identical. However, in the presence of technological differences, it is possible that high-quality products will be provided by the national industry with high costs. This results in inefficient production, since costs are increasing and convex in quality.

The basic features of our model have been well-known for some time. Gabszewicz and Thisse (1979) developed a framework for quality preferences where consumers with identical tastes but different income levels demand different quality levels. They analyzed the Cournot-duopoly equilibrium and showed its dependence on the income distribution and quality parameters. Shaked and Sutton (1982) showed that in the case of duopolists that first choose quality and then compete in price, the equilibrium will include both firms entering with distinct quality levels enjoying positive profits, i. e., they demonstrated how quality differences relax price competition. Ronnen (1991) uses Shaked and Sutton's framework to demonstrate cases where quality standards improve welfare. He concludes that there exists a binding minimum quality standard such that all consumers are weakly better off, both firms have positive profits, and total welfare is increased. Our model is based on the framework of Shaked/Sutton and Ronnen<sup>1</sup>. As in Ronnen, the effects of quality standards on industry competition are primarily driven by their influence on price competition and the qualities produced. Due to the duopoly situation and the nature of price and quality competition, an unregulated equilibrium results in qualities being too low, prices being too high and quality differentiation being too low when com-

<sup>1</sup> See also Lutz (2000) as well as Lutz, et al. (2000). Related research on the effects of minimum quality standards has been forwarded, e. g., by Boom (1995), Crampes/Hollander (1995) and Das/Donnenfeld (1989).

pared to a welfare-maximizing solution. When qualities produced become more similar, price competition intensifies. In response to a quality standard that is binding for the low-quality producer, qualities rise, quality differentiation is reduced, and prices adjusted for quality fall. High quality rises also because qualities are strategic complements due to the effect of quality differentiation on price competition. Reduced quality differentiation results because increasing quality is increasingly costly. With a high standard, profits of both firms are reduced or one firm is forced out of the market<sup>1</sup>.

In our example, a more efficient domestic firm and a less efficient foreign firm operate in a single domestic market. The foreign firm initially produces and sells a product of higher quality. This initial situation could be the outcome of the foreign firm being longer in the market than the domestic firm, so that the foreign firm operated as a Stackelberg-leader towards the domestic firm in the past. Since the domestic firm could make higher profits by offering the higher quality, there is an incentive for the domestic government to facilitate this outcome by some policy. In the absence of a facilitating policy, however, the domestic firm cannot credibly leapfrog, since the current outcome represents a Nash-equilibrium. We show that the domestic government can choose a standard such that the domestic firm: (1) cannot have nonnegative profits as the low-quality firm; and (2) can set a quality such that the foreign firm cannot have nonnegative profits as either the low-quality or the high-quality firm; and (3) domestic welfare is increased. Hence, the standard facilitates Leapfrogging as well as exit of the foreign competitor<sup>2</sup>.

## 2. The Model

There are two firm  $s$ , the domestic firm  $d$  and the foreign firm  $f$ , both competing in the domestic market. If both firms remain in the market, then they produce distinct goods, sold at prices  $pd$  and  $pf$ , respectively. The two products carry a single quality attribute denoted by  $sd$  and  $sf$ , respectively. Either firm faces production costs that are increasing, convex (quadratic) functions of quality, the exact level of which depending on quality chosen and a quality cost parameter  $b$ . Total costs of firm  $i$  are then:

$$c_i = b s_i^2, \quad (1)$$

In the domestic market, there is a continuum of consumers distributed uniformly over the interval  $[0, T]$  with unit density. Each consumer purchases at most one unit of either firm  $d$ 's product or firm  $f$ 's product. The higher a consumer's income parameter  $t$ , the higher is her (his) reservation price. Consumer  $t$ 's

<sup>1</sup> Related research on entry/exit has been forwarded, e. g., by Donnenfeld/Weber (1992, 1995) and Hung/Schmitt (1988).

<sup>2</sup> The analysis of Leapfrogging in a vertical product differentiation framework has only recently been addressed by Herguera/Kujal/Petrakis (1995), Motta/Thisse/Cabrales (1995), and Lutz (1996). None of this literature covers the usage of standards to induce Leapfrogging.

utility is given by equation (2) if good  $i$  is purchased<sup>3</sup>. Consumers who do not purchase receive zero utility.

$$u_i = s_i t - p_i. \quad (2)$$

Firms  $d$  and  $f$  play a two-stage game<sup>4</sup>. In the first stage, firms determine qualities to be produced and incur costs  $c_i$  ( $i = d, f$ ). In the second stage, firms choose prices simultaneously<sup>5</sup>.

### Price Competition

To solve the game, consider first the demand faced by the high-quality and low-quality firm, respectively. Let  $h$  and  $o$  stand for high and low quality, respectively. These demands are then given by<sup>6</sup>:

$$\begin{aligned} q_h &= T - \frac{p_h - p_o}{s_h - s_o}, \\ q_o &= \frac{p_h - p_o}{s_h - s_o} - \frac{p_o}{s_o}. \end{aligned} \quad (3)$$

Let  $i = h, o$ ; let  $j \neq i$ . The profit function for firm  $i$  is given by  $\Pi_i = p_i q_i(p_h, p_o, s_h, s_o) - c_i(s_i)$ . Taken both qualities as given, the price reaction functions in each market are given as the solutions to the first order conditions. Solving the resulting equations for both prices, equilibrium prices are then given as:

$$p_h = \frac{2T s_h (s_h - s_o)}{4s_h - s_o}, \quad p_o = \frac{T (s_h - s_o) s_o}{4s_h - s_o}. \quad (4)$$

Note that for all  $s_h > s_o$ ,  $T > t_h > t_o > 0$  will hold, i. e., equation (4) is in fact an unconstrained price equilibrium.

Given the price equilibrium depicted above, demands and thus profits can be expressed in terms of qualities. For positive qualities  $s_i$  ( $i = h, o$ ), these profit functions are:

$$\Pi_h = \frac{4T^2 s_h^2 (s_h - s_o)}{(4s_h - s_o)^2} - b_h s_h^2, \quad (5a)$$

$$\Pi_o = \frac{T^2 s_h^2 (s_h - s_o) s_o}{(4s_h - s_o)^2} - b_o s_o^2. \quad (5b)$$

<sup>3</sup> Consumers who do not purchase receive zero utility.

<sup>4</sup> In this formulation, firm  $i$  not entering the market is equivalent to firm  $i$  choosing  $s_i = 0$ . The entry decision by firms is made simultaneously when choosing quality.

<sup>5</sup> To derive solutions, we will use the concept of subgame-perfect equilibrium, computing the solutions for each stage in reverse order. Both firms choose their respective product quality from the same interval  $[0, \infty)$ . The resulting market equilibria will include some consumers in the lower segment of the interval  $[0, T]$  not valuing quality enough to buy any product. This guarantees an interior solution of the price game.

<sup>6</sup> Let  $t_h = (p_h - p_o)/(s_h - s_o)$  and  $t_o = p_o/s_o$ . Consumers with  $t = p_o/s_o$  will be indifferent between buying the low-quality product and not buying at all. Consumers with  $t = (p_h - p_o)/(s_h - s_o)$  will be indifferent between buying either the high-quality or the low-quality product. Consumers with  $T \geq t > t_h$  will buy high quality, consumers with  $t_h > t > t_o$  will buy low quality, and consumers with  $t < p_o/s_o$  will not buy at all.

Similarly, consumer surplus <sup>1</sup> can be expressed in the following way:

$$CS = \frac{T^2 s_h^2 (4s_h + 5s_o)}{2(-4s_h + s_o)^2}. \quad (6)$$

### Quality Competition

To derive the firms' quality best responses, we investigate each firm's profit function, given the other firm's quality choice, and taking into account the behavior in the price-setting subgame. Given the order of qualities, the profit functions in equations (5) are concave in the respective firm's own quality. The profit-maximizing choices form a Nash-equilibrium in qualities, where both marginal profit functions evaluate to zero. The first order conditions for the high and low quality firm, respectively, are then given as:

$$4T^2 s_h (4s_h^2 - 3s_h s_o + 2s_o^2) / (4s_h - s_o)^3 = 2b_h s_h, \\ T^2 s_h^2 (4s_h - 7s_o) / (4s_h - s_o)^3 = 2b_o s_o. \quad (7)$$

From the properties of the revenue functions and the slopes of the quality best responses depicted in the Appendix, it is easy to see that the two qualities are strategic complements. Furthermore, a forced increase of the low quality will reduce product differentiation and increase price competition.

The resulting equilibrium qualities for identical firms (i. e.  $b_h = b_o = b$ ) are then <sup>2</sup>:

$$s_h = 0.126655 T^2 / b \text{ and } s_o = 0.0241192 T^2 / b.$$

However, for our example, we assume the low-quality producing home firm to have a cost advantage such that  $b_h = 1.5 b_o = 1.5 b$  <sup>3</sup>. Hence, the resulting equilibrium is <sup>4</sup>:

$$s_h = 0.08533 T^2 / b \text{ and } s_o = 0.02133 T^2 / b. \quad (8)$$

Due to the foreign high-quality firm's cost disadvantage, its quality is now substantially lower than in the symmetric case. Therefore, the home firm's quality is lower, too. However, since the home firm has a cost advantage, quality differentiation is lower.

The resulting domestic Welfare and Profit are:

$$W_d = 0.00978 T^4 / b \text{ and } \Pi_o = 0.00068 T^4 / b. \quad (9)$$

<sup>1</sup> Consumer surplus is defined as  $\{(t \cdot s_h - p_h)dt + (t \cdot s_o - p_o)dt\}$  where the first integral goes from 4 to  $T$  and the second goes from  $t_o$  to  $t_h$ .

<sup>2</sup> The exact procedure to find the analytical solution is described in the Appendix. Note that  $T^2/b$  enters in a multiplicative way and therefore does not affect the calculations.

<sup>3</sup> Of course, the parameter choice for the cost advantage is arbitrary. However, the qualitative result prevails as long as an initial unregulated equilibrium exists where the low-cost firm offers low quality.

<sup>4</sup> It is easy to check that the domestic firm has no incentive to provide high quality given the foreign firm's quality in equation (7). This is done by calculating the domestic firm's profits as high-quality firm given that low quality is equal to the foreign firm's quality in (7) and maximizing with respect to quality.

To keep the following example simple, we assume that both firms have to incur costs of providing quality per period, i. e. the quality chosen in the period before does not matter.

### 3. A Standard Facilitating Leapfrogging and Exit

In this section, we will demonstrate an example where the domestic government can increase welfare as well as domestic profits by an appropriately chosen standard which will induce the domestic firm to choose a quality higher than its initial quality and the formerly chosen foreign quality while the foreign firm is induced to exit the market. Hence, this is an example of policy-induced Leapfrogging with exit.

The domestic government chooses a standard such that the following conditions are satisfied:

- 1) The domestic firm cannot make positive profits as the low-quality firm.
- 2) The domestic firm can choose a quality such that the foreign firm cannot have positive profits as either the low-quality firm or the high-quality firm.
- 3) Domestic welfare and profits are increased.

Condition 1) requires a standard greater than or equal to the quality level at which the domestic low-cost firm makes zero profits given that the foreign high-cost firm provides high quality at its quality best response. This requires that the standard  $s_m$  be set such that  $s_m \geq 0.04275 T^2/b$ . (All calculations are shown in the Appendix.)

Given such a standard, entry by the foreign firm is effectively blocked. This means that the domestic firm can set its uncontested monopoly choice  $s_d = 0.125 T^2/b$  at which Condition 2) is satisfied. This is verified by calculating the foreign firm's best response profits as the low-cost firm and the high-cost firm, respectively, setting the other quality equal to  $0.125 T^2/b$ . Both calculations yield negative results.

Condition 3) is also satisfied as can be seen by calculating domestic welfare and profits given  $s_d = 0.125 T^2/b$  and  $s_f = 0$ . The example is summarized below.

$$s_m = 0.04275 T^2/b, s_d = 0.125 T^2/b, W_d = 0.03125 T^4/b \text{ and } \Pi_o = 0.015625 T^4/b. \quad (10)$$

Since welfare is the sum of consumer surplus and profits, we can see immediately that domestic consumers surplus rises <sup>5</sup>. Since the foreign firm cannot make profits, the foreign country as a whole is worse off. This means that the policy includes international profit-shifting and can therefore be qualified as strategic trade policy.

<sup>5</sup> However, although quality sold rises, not all consumers win since market coverage is reduced.

#### 4. Discussion

The purpose of the example shown above is to illustrate that domestic policies such as standards might have strategic trade effects that are not marginal but entail a complete restructuring of the international market in question. In this example, a standard that was nonbinding for the foreign firm ultimately led to the exit (or non-entry) of the foreign firm. This standard also enabled the domestic firm to act exactly like a monopolist without the threat of entry. In doing this, the domestic firm chose a quality that was not bound by the standard, higher than the quality it would have chosen without a standard, and higher than the quality the foreign firm would have chosen without the standard (potential "Leapfrogging").

However, we do not generally argue for the application of such policies, even though this example entails welfare increases for the domestic country. Since several examples can be constructed where the outcomes are quite different, this suggests that policy makers should be aware of the possibility of rather radical and detrimental effects of domestic policies. The possibility of "Leapfrogging" arises generally when a policy changes an industry's potential profits as the high-quality provider relative to its profits as the low-quality provider. It follows that a general analysis of "Leapfrogging" necessitates the analysis of firms' strategic best responses and profits. The example presented is a first step in that direction.

#### Appendix

(All calculations are available upon request.)

#### Properties of the Revenue Functions

Let  $R_i$  denote firm  $i$ 's revenue function. Let  $h$  and  $o$  denote high and low quality, respectively.

$$\frac{\partial R_h}{\partial s_h} \geq 0; \quad \frac{\partial R_o}{\partial s_i} = \frac{t^2(7s_i - 4s_j)s_j^2}{(s_i - 4s_j)^3} \geq 0 \text{ for } s_i \leq \frac{4s_j}{7};$$

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

$$\frac{\partial R_o}{\partial s_j} = \frac{t^2s_i^2(s_i + 2s_j)}{(-s_i + 4s_j)^3} > 0;$$

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

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

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

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

#### Slopes of Firms' Quality Best Responses

The slopes of the high and low quality firms' quality best responses can be calculated (using the implicit function theorem) as

$$ds_i/ds_j = -(\partial(\Pi_i/\partial s_i)/\partial s_j)/(\partial(\Pi_i/\partial s_i)/\partial s_i),$$

where  $i$  is either high or low quality and  $j$  is the other quality. Both slopes are positive, but less than one.

#### Properties of the Consumer Surplus Functions

Let  $CS_I$  ( $I = D, F$ ) denote region  $I$ 's consumer surplus function. Firms' qualities are denoted by  $s_h$  and  $s_o$  for high and low quality, respectively.

$$\frac{\partial CS_I}{\partial s_h} > 0 \text{ for } s_o < \frac{4s_h}{5}; \quad \frac{\partial CS_I}{\partial s_o} > 0;$$

$$\frac{\partial^2 CS_I}{\partial s_h^2} = \frac{t^2s_o^2(52s_h + 5s_o)}{(-4s_h + s_o)^4} > 0;$$

$$\frac{\partial^2 CS_I}{\partial s_o^2} = \frac{t^2s_h^2(52s_h + 5s_o)}{(-4s_h + s_o)^4} > 0;$$

$$\frac{\partial^2 CS_I}{\partial s_o \partial s_h} = -\frac{t^2s_h s_o (52s_h + 5s_o)}{(-4s_h + s_o)^4} < 0.$$

#### Calculation Procedure for the Quality Equilibria in Section 2

Divide the first order conditions given in (7), rearrange and write  $s_h = r s_o$  and  $b_o = a b_h$  to obtain:

$$\frac{4(2 - 3r + 4r^2)}{4r^2 - 7r} = \frac{r}{a}.$$

For  $a = 1$  (i. e.  $b_h = b_o = b$ )  $r = 5.25123$  while for  $a = 2/3$  (i. e.  $b_h = 1.5 b_o = 1.5b$ )  $r = 4.0$ . Using  $r$  to express  $s_h$  in terms of  $s_o$  and substituting for  $s_h$  in the first equation of (7) allows for calculating the equilibrium qualities for any given value of  $T$  and  $b$ . (However, the ratio of cost parameters  $a$  must be fixed.)

#### Calculations for the Example of Section 3

Calculation of a standard such that the domestic firm makes zero-profits as low-quality provider. The standard would bind the domestic firm. Take equations (5a) and (5b) with ( $b_h = 1.5b$ ,  $b_o = b$ ). Solve simultaneously:

$$\{\partial \Pi_h / \partial s_h = 0 \text{ and } \Pi_o = 0\} \text{ to obtain } \{s_h = 0.091728 T^2/b, s_o = 0.0427526 T^2/b\}.$$

In this solution,  $s_o$  represents the binding standard on the domestic firm.

Calculation of the uncontested monopoly choice of the domestic firm. Take equation (5a) with ( $b_h = 1$ ,  $s_o = 0$ ). Solve:

$$\partial \Pi_h / \partial s_h = 0 \text{ to obtain } s_h = 0.125 T^2/b.$$

Here,  $s_h$  is the uncontested monopoly choice of the domestic firm.

Given the domestic firm's quality choice in equation (A.5b), the calculations below show that the foreign firm cannot make positive profits.

Take equation (5a) with ( $b_h = 1.5b$ ). Solve simultaneously:

$$\{\partial \Pi_h / \partial s_h = 0 \text{ and } P_{i_h} = 0\} \text{ to obtain } \{s_h = 0.0972222 T^2/b, s_o = 0.0555556 T^2/b\}.$$

In this solution,  $s_o$  represents the minimum domestic quality such that the foreign firm cannot make positive profits as the high-quality provider. This quality is less than the chosen domestic quality of  $0.125 T^2/b$ .

Take equation (56) with

$$(b_o = 1.5b, s_h = 0.125 T^2/b).$$

Solve:

$$\Pi_o = 0 \text{ to obtain } s_o = 0.034746 T^2/b.$$

This solution represents the maximum foreign quality such that the foreign firm can make nonnegative profits as the low-quality provider. It is less than the standard of  $0.0427526 T^2/b$ .

1. *Boom, A.* (1995). Asymmetric International Minimum Quality Standards and Vertical Differentiation, *Journal of Industrial Economics*, Vol. 43(1), pp. 101-119.
2. *Crampes, C. and A. Hollander* (1995). Duopoly and Quality Standards, *European Economic Review*, Vol. 39, pp. 71-82.
3. *Das, S. P. and S. Donnenfeld* (1989). Oligopolistic Competition and International Trade: Quantity and Quality Restrictions, *Journal of International Economics*, Vol. 27(3-4), pp. 299-318.
4. *Donnenfeld, S. and S. Weber* (1995). Limit Qualities and Entry Deterrence, *Rand Journal of Economics*, Vol. 26(1), pp. 113-130.
5. (1992). Vertical Product Differentiation With Entry, *International Journal of Industrial Organization*, Vol. 10, pp. 449-472.
6. *Gabszewicz, J. J. and J.-F. Thisse* (1979). Price Competition, Quality and Income Disparities, *Journal of Economic Theory*, Vol. 20, pp. 340-359.
7. *Herguera, I., Kujal, P. and E. Petrakis* (1995). Endogenous Quality, Non-Credible Policies and Leapfrogging, mimeo., Universidad Carlos III de Madrid.
8. *Herguera, I. and S. Lutz* (1996). Minimum Quality Standards as Facilitating Devices: An Example With Leapfrogging and Exit, CEPR Discussion Paper N 1384.
9. *Hung, N. M. and N. Schmitt* (1988). Quality Competition and Threat of Entry in Duopoly, *Economics Letters*, Vol. 27, pp. 287-292.
10. *Lutz, S.* (2000). Trade Effects of Minimum Quality Standards with and without Deterred Entry, *Journal of Economic Integration*, Vol. 15(2), pp. 314-344.
11. *LMfe, S., Lyon, T. P. and John W. Maxwell* (2000). Quality Leadership when Regulatory Standards are forthcoming, *Journal of Industrial Economics*, Vol. 48(3), pp. 331-344.
12. *Motta, M., Thisse, J.-F. and A. Cabrales* (1995). On the Persistence of Leadership or Leapfrogging in International Trade, CEPR Discussion Paper N 1106.
11. *Ronnen, U.* (1991). Minimum Quality Standards, Fixed Costs, and Competition, *Rand Journal of Economics*, Vol. 22(4), pp. 490-504.
- 1A. *Shaked, A. and J. Sutton* (1982). Relaxing Price Competition Through Product Differentiation, *Review of Economic Studies*, Vol. 49, pp. 3-13.

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### ПРОТЕКЦІОНІЗМ ШЛЯХОМ РЕГУЛЮВАННЯ: ПРИКЛАД ВИМУШЕНОГО ВИХОДУ

*Останнє деталізоване дослідження моделей вертикальної диференціації продукції дало змогу провести аналіз питань міжнародної торгівлі за умов наявності асиметрії країн у якості продукції, технологи, цін, розмірів ринку та продуктів. За наявності подібної асиметрії національні індустрії будуть або ринковими лідерами, або ж пастимуть задніх на міжнародному ринку через якість своєї продукції. Реальна асиметрія прибутків створює потужний стимул для відсталих індустрій, а також дає можливість місцевій владі використати цю ситуацію на свою користь, наприклад, сприяти лідерству з якості продукції. Це ситуація, за якої мінімальні стандарти якості полегшують підвищення якості продукції місцевими фірмами, а також витіснення іноземних фірм.*