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Regulatory Standards Can Lead to Predation

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I present a model of vertical product differentiation and exit where a domestic and a foreign firm face fixed setup costs and quality-dependent costs of production and compete in quality and price in the domestic market. Quality-dependent costs are quadratic in qualities, but independent of the quantities produced. The domestic government may impose a minimum quality standard binding for both foreign and domestic firms. In the presence of an initial cost advantage of the domestic firm, a sufficiently high minimum quality standard set by the domestic government will enable the domestic firm to induce exit of the foreign firm, i.e. to engage in predation. However, the same standard would lead to predation by the foreign firm, if the foreign firm had the initial cost advantage!

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1. Introduction

This note presents a case where a minimum quality standard facilitates predation, i.e. the domestic firm is enabled to force exit of the foreign firm. For this case, I use a benchmark model of vertical product differentiation that has been extensively applied in the literature. One domestic and one foreign firm face quality-dependent product development 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

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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 the model utilized here 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.[1] 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 compared to a welfare-maximizing

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Center for European Integration Studies (ZEI), Bonn. I am thankful to Jim Gaisford for suggesting to me the possibility of predation induced by trade regulation.

[1] See also Lutz (2000), Lutz, et.al. (2000), and Lutz/Baliamoune-Lutz (2003). Related research on the effects of minimum quality standards has been forwarded, e.g., by Das/Donnenfeld (1989), Boom (1995), Crampes/Hollander (1995) Ecchia/Lambertini (1997), Constatatos/Perrakis (1998), Scarpa (1998), Valletti (2000), Jinji/Toshimitsu (2004).

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.[2]

In the case presented, 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 monopoly profits if it was alone in the market, there is an incentive for the domestic government to facilitate this outcome by some policy. In the absence of a facilitating policy (or a prohibitive entry cost), however, the domestic firm cannot credibly prevent entry or effect exit of the foreign firm, 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 predation by the domestic firm, i.e. forcing exit of the foreign competitor.[3]

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[2] Related research on entry/exit has been forwarded, e.g., by Hung/Schmitt (1988), Donnenfeld/Weber (1995, 1992), Lutz (1997), and Siebert (2003).

[3] This could also be interpreted as a quality reversal induced by the standard. Quality reversals in a vertical product differentiation framework have been previously addressed by Herguera/Kujal/Petrakis (1995, 2001), Motta/Thisse/Cabrales (1997), and Herguera/Lutz (1996, 1998, 2002).

2. The Model

There are two firms, 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 p_d and p_f, respectively. The two products carry a single quality attribute denoted by s_d and s_f, 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:

$$c_i = b_i \, s_i^2 \tag{1}$$

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 utility is given by equation (2) if good i is purchased.[4] Consumers who do not purchase receive zero utility.

$$u_t = s_i \, t - p_i \tag{2}$$

Firms d and f play a two-stage game[5]. 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.[6]

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[4] Consumers who do not purchase receive zero utility.

[5]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.

[6]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, ∞). 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.

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:[7]

$$q_h = T - (\frac{p_h - p_o}{s_h - s_o}),\ q_o = \frac{p_h - p_o}{s_h - s_o} - \frac{p_o}{s_o} \qquad (3)$$

Let i = h, o; let j ≠ i. The profit function for firm i is given by $\Pi_i = p_i q_i(p_i, p_j, s_i, s_j) - c_i(s_i)$. 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:

$$p_h = \frac{2Ts_h(s_h - s_o)}{4s_h - s_o},\quad p_o = \frac{T(s_h - s_0)s_o}{4s_h - s_o} \qquad (4)$$

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:

$$\Pi_h = \frac{4T^2 s_h^{\,2}(s_h - s_0)}{(4s_h - s_0)^2} - b_h s_h^{\,2} \qquad (5a) \qquad\qquad \Pi_o = \frac{T^2 s_h(s_h - s_o)s_o}{(4s_h - s_o)^2} - b_o s_o^{\,2} \qquad (5b)$$

Similarly, consumer surplus[8] can be expressed in the following way:

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

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[7]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.

[8]Consumer surplus is defined as $\{\int(t{*}s_h - p_h)dt + \int(t{*}s_o - p_o)dt\}$ where the first integral goes from t_h to T and the second goes from t_o to t_h.

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:

$$4T^2 s_h (4{s_h}^2 - 3 s_h s_o + 2{s_o}^2 -) / (4s_h - s_o)^3 = 2 b_h s_h$$

$$T^2 {s_h}^2 (4s_h - 7s_o) / (4s_h - s_o)^3 = 2 b_o s_o \qquad (7)$$

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:[9]

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

However, for our example, we assume the low-quality producing home firm to have a cost advantage such that $b_h = 1.5\ b_o = 1.5\ b$.[10] Hence, the resulting equilibrium is[11]

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

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[9]The exact procedure to find the analytical solution is decribed in the Appendix. Note that t^2/b enters in a multiplicative way and therefore does not affect the calculations.

[10]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.

[11]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.

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:

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

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 Quality Standard Facilitating Predation

In this section, we will develop a case 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 a case of policy-induced predation.

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 blockaded. 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 result is summarized below.

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

Since welfare is the sum of consumer surplus and profits, we can see immediately that domestic consumer surplus rises.[12] 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.

5. Foreign Domination Instead of Domestic Predation

If the domestic firm has a cost advantage, a quality standard that is set "too low", i.e. too close to the low-quality level without regulation, may lead to a situation where the foreign firm can only survive as the high-quality supplier in the market. Given enough time and without a persistence of quality leadership, this could lead to a quality reversal where the domestic industry is not driven out of the market, but ends up as the low-quality supplier despite of its cost advantage.

Let the home cost advantage be again such that $b_o = 1.5\ b_h = 1.5$ b. Be minimum quality standard greater than or equal to 0.0349322 T^2/b, but not much greater than that, will remove the foreign firm's ability to make profits as a low-quality supplier.[13] Consequently, only one Nash-equilibrium remains once the one-shot market game is played again. This will be the

[12] However, although quality sold rises, not all consumers win since market coverage is reduced.

[13] The critical value for the standard is calculated by simultaneously solving the first-order condition for the high-quality firm with b_h=b and the zero-profit condition for the low-quality firm with b_o=1.5 b for s_h and s_o.

one with the foreign firm providing high quality despite, or here because, of its cost disadvantage.

5. When the Standard Invites Foreign Predation

If the foreign firm has the cost advantage rather than the domestic firm, then the domestic standard would lead to predation by the foreign firm and exit of the domestic firm. This follows immediately by analogy from the arguments presented in the previous section. Note, though, that domestic welfare would still rise since the increase in consumer surplus would be higher than losing the domestic firm's low-quality profits.

To illustrate this, assume for simplicity (and without much loss of generality) that the foreign firm has an advantage such that $b_h = 1.5\ b_o = 1.5\ b$. Note that again, the domestic firm provides low quality. Now the same minimum quality standards enables the foreign firm to set monopoly quality while the domestic firm's best response is to exit. The resulting situation is summarized as:

$$s_m = 0.04275\ T^2/b,\ s_f = 0.125\ T^2/b,\ W_d = CS_d = 0.015625\ T^4/b \text{ and } \Pi_d = s_d = 0 \quad (11)$$

Still domestic welfare could be improved by the standard, but at the cost of market exit of the domestic industry.

6. Discussion

The purpose of the case 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 the case presented, a standard that was nonbinding for the foreign firm ultimately lead to the exit of the foreign firm. This standard also enabled the domestic firm to act exactly like a monopolist without the threat of further 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.

However, we do not generally argue for the application of such policies, even if they lead to welfare increases for the domestic country. On the contrary, policy makers should simply be aware of the possibility of rather radical and detrimental effects of domestic policies. The possibility of predation arises generally when a policy leads to negative profits for some subset of an industry's best response choices. In addition, the final effects of such a policy and the resulting predation are rather sensitive to the exact standard chosen as well as to the magnitude and direction of cost differences between competing industries.

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.

$$\frac{\partial R_h}{\partial s_h} \geq 0; \quad \frac{\partial R_0}{\partial s_o} \geq 0 \text{ for } s_o \leq \frac{4s_h}{7}; \quad \frac{\partial R_h}{\partial s_o} < 0, \quad \frac{\partial R_o}{\partial s_h} > 0;$$

$$\frac{\partial^2 R_h}{\partial s_h{}^2} \leq 0; \qquad \frac{\partial^2 R_o}{\partial s_o{}^2} \leq 0; \qquad \frac{\partial^2 R_h}{\partial s_h \partial s_o} > 0; \qquad \frac{\partial^2 R_o}{\partial s_o \partial s_h} > 0.$$

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

$$\frac{\partial CS_I}{\partial s_h} > 0 \text{ for } s_o < \frac{4s_h}{5}; \qquad \frac{\partial CS_I}{\partial s_o} > 0; \quad \frac{\partial^2 CS_I}{\partial s_h^2} > 0; \quad \frac{\partial^2 CS_I}{\partial s_o^2} > 0; \quad \frac{\partial^2 CS_I}{\partial s_o \partial s_h} < 0.$$

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. $b_h = 1.5\, b_o = 1.5\, b$) 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 Case 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 = 1.5 b, b_o = b). Solve simultaneously:

$\{\partial \Pi_h/\partial s_h = 0$ and $Pi_o = 0\}$ 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:

$\partial \Pi_h/\partial s_h = 0$ 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 = 1.5 b). Solve simultaneously:

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

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 (5b) with (b_o = 1.5 b, 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.

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