

”Innocuous” Minimum Quality Standards

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Abstract

The present note shows that ”innocuous” Minimum Quality Standards, namely *below* the lowest quality in a market, may have effects on equilibrium outcomes. Such a MQS reduces the incentive to invest in R&D by the quality-leading firm.

JEL: L0, L5

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1. Introduction

So far the role of Minimum Quality Standards (MQS) has received little attention in the theory of oligopoly. After Ronnen (1991), however, a small number of papers (for instance Crampes and Hollander 1995, Ecchia and Lambertini (1997), Scarpa 1998) have analyzed the effects of MQS in markets with differentiated products. Usually, the analysis is confined to standards that lie between the lowest and highest quality and it is almost always built upon vertical differentiation models. In no place has been mentioned the possibility that standards *below* the lowest quality in the market may have any impact on the industry. I shall term such standards ”innocuous”, due to their *nonbinding* appearance. In a duopoly, if a ”leading” firm is able to invest resources in cost reducing technologies, an innocuous MQS may lead to lower investment of this sort. This result hinges upon qualities being strategic substitutes, in a model where the firms’ need to differentiate is already satisfied by horizontal features. To be precise, qualities are substitutes also in the pure vertical differentiation model of Gabszewicz and Thisse (1979) and of Shaked and Sutton (1982), since if the rival chooses a high (low) quality a firm chooses a low (high) quality. However, *given a pre-ordering* on qualities, marginal revenue from quality upgrading can be increasing in the rival’s quality (Choi and Shin 1992 and, for positive costs of quality, Ronnen 1991). Strictly speaking, however, such pre-ordering does not allow the definition of substitutes or complements to apply globally. As examples of marginal revenue from quality upgrades decreasing in the rival’s quality, Eales and Binkley (2003) suggest to interpret persistent advertising and complementary information associated to baking mix product Bisquick as a quality attribute, to contrast it with no-advertising-strategy by Chelsea Milling’s for its Jiffy

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product, aimed to induce a low quality perception by consumers.¹ Similarly, British Airways response to no-frills air companies has been to cut frills². The ability of sellers of unbranded goods to attract new consumers through improvements in quality may inversely vary with the quality of branded goods in the market, and the other way round.

Reduced incentives to invest are also found in Maxwell (1998), where firms anticipate a regulator to raise standards *above* the realized quality, after R&D occurs. The example below is a variant of Garella (2003) with a duopoly differentiated horizontally and vertically. In a different context, of political economy, it has been stressed the role of "quality leaders" (Lutz, Lion and Maxwell (2000)). In the present paper the quality "leader" is defined as the *only* firm that innovates, while the competitor is not able to innovate. This is an extreme case of asymmetry in R&D abilities. A general case would obtain if both firms could invest in R&D with different abilities. Unfortunately, this proves algebraically irksome and would become tractable only at the cost of special assumptions.

The model below is a modified Hotelling (1929) city, with firms at the two opposite endpoints, with an added quality dimension. The stages of the *basic game*, played in the absence of regulation and of investments are the following. At the first firms choose qualities, at the second, prices. This game is analyzed only as a background to sketch the main argument. The *regulation game* is a shortcut to avoid a fully dynamic game: a regulator is called to decide whether to use or not a MQS, based upon the observed unregulated qualities, as after an investigation by experts. The modified game is the following. Firms inherit their qualities from the situation with no R&D investment and no regulation. At stage 0, the regulator's choice is restricted to a binary choice, for the sake of the argument: it can either set a MQS equal to the lowest produced quality (innocuous standard) or no MQS. At stage 1 Firm 1 invests in R&D. Then, the second and third stages parallel those of the basic game. A comparison between the decision to have no standard and that of introducing an innocuous standard reveals that with no standard the investment in R&D by firm 1 is higher. The low quality firm is transformed in a constrained player and, if it could choose the MQS appropriately, would do it as a first mover that can commit to a given quality level. Commitment, one may speculate, could improve its equilibrium profits.³

The one-shot interpretation of the investment in quality is one possibility. A second possibility would be that of a per-period investment, leading to fixed costs, determining the quality in each period (quality would drop down without investments).

2. Unregulated industry

There are two firms, 1 and 2. Products are horizontally differentiated, are "located" at the opposite endpoints of a Hotelling linear city (Hotelling 1929), and each embodies a vertical quality dimension, θ . The production cost for the quantity q_1 for firm 1 is $C_1(q_1, \theta_1) = cq_1 + \theta_1^2/2$, where $c > 0$ is independent of θ . For firm 2, $C_2(q_2, \theta_2) = cq_2 + \alpha\theta_2^2/2$, where $\alpha > 1$ is a parameter for 2. Quality only affects fixed costs.

¹ An interpretation of advertising as a complementary product, increasing utility from consuming a good, has been pioneered by Becker and Murphy (1993).

² See Piercy 2000.

³ Non binding *quantity* restraints that change investments in a trade model are found in Herguera, Kujal and Petrakis (2000).

Consumers have an address $x \in [0, 1]$, and are uniformly distributed, with unit mass. When buying at location $i - 1$, for $i = 1, 2$, a consumer's utility is decreased of the amount ("transportation cost") $t|x - (i - 1)|$. Given p_1, p_2 , the utility from one unit of good i is

$$u_i(x, \theta_i) = v + \theta_i - t|x - (i - 1)| - p_i, \text{ for } i = 1, 2. \quad (2.1)$$

Where $v > 0$ is a utility parameter, identical across consumers.

The basic game without regulation and R&D is: at stage 1 firms simultaneously choose qualities, θ_1 and θ_2 ; at stage 2 firms simultaneously choose prices.

Assumption 1. (i) $t > 2/9$, (ii) $1 < \alpha < 2$

Assumption 2. $v > 2t + c$.

A.1 ensures that equilibrium quality levels be positive and A.2 ensures that the market is entirely served.

The address, \tilde{x} , such that $u_1(x, \theta_1) = u_2(x, \theta_2)$ is:

$$\tilde{x}(p_1, p_2; \theta_1, \theta_2) = \max \left\{ 0, \min \left\{ 1, \frac{1}{2} + \frac{(p_2 - p_1) + (\theta_1 - \theta_2)}{2t} \right\} \right\}. \quad (2.2)$$

The demand functions are: $D_1(p_1, p_2; \theta_1, \theta_2) = \tilde{x}$ and $D_2(p_1, p_2; \theta_1, \theta_2) = 1 - \tilde{x}$. Then, when $\tilde{x}(p_1, p_2; \theta_1, \theta_2) \in (0, 1)$, the firm 1 program at stage 2 is:

$$\max_{p_1} (p_1 - c) \left[\frac{1}{2} + \frac{(p_2 - p_1) + (\theta_1 - \theta_2)}{2t} \right] - \frac{\theta_1^2}{2}.$$

This provides the best replies

$$\tilde{p}_i(p_j) = \max \left[\frac{p_j}{2} + \frac{(\theta_i - \theta_j) + t + c}{2}, 0 \right], \text{ for } i, j = 1, 2; i \neq j. \quad (2.3)$$

If $\theta_2 \leq \theta_1 - 3(t + c) \equiv \theta_2^0$, then 2 is priced out and equilibrium prices are $p_2 = 0$, and $p_1 = p_1^m$, where p_1^m is the monopoly price for firm 1. Similarly, firm 1 can be priced out⁴. We shall exclude that either firm uses a quality so low as to be priced out, so that the analysis of the case where $\theta_2 \leq \theta_2^0$ (or $\theta_1 \leq \theta_1^0$) shall not be pursued. The study of a game where either firm can use a high quality so as to gain monopoly is out of the scope of the present work. Then, it is easy to calculate the Nash prices, p_1^* and p_2^* , as:

$$p_i^*(\theta_1, \theta_2) = t + c + (-1)^{i-1} [(\theta_1 - \theta_2)/3], \text{ for } i = 1, 2. \quad (2.4)$$

Note that $p_1^*(\theta_1, \theta_2) - p_2^*(\theta_1, \theta_2) = (2/3)(\theta_1 - \theta_2) > 0$ for $\theta_1 > \theta_2$.

Now, solving⁵ for θ 's at stage 1, the best reply functions in qualities, are

$$\theta_1(\theta_2) = \frac{3t - \theta_2}{9t - 1}, \quad \theta_2(\theta_1) = \max \left\{ \frac{3t - \theta_1}{9\alpha t - 1}, \theta_1 - 3(t + c) \right\}. \quad (2.5)$$

⁴Namely if $\theta_1 \leq \theta_2 - 3(t + c) \equiv \theta_1^0$.

⁵The equilibrium demand functions are $D_i^*(\theta_1, \theta_2) = (1/2) + (-1)^{(i-1)} [(\theta_1 - \theta_2)/(6t)]$. The reduced form profits, used to solve the first stage, are $\pi_i^*(\theta_1, \theta_2) = \frac{[3t + (-1)^{(i-1)}(\theta_1 - \theta_2)]^2}{18t} - \frac{\alpha^{(i-1)}(\theta_i)^2}{2}$.

Qualities are strategic substitutes. As noted, firm 2 cannot choose $\theta_2 < \theta_1 - 3(t + c)$: this explains the V-shape of its best reply (obviously also the best reply of firm 1 is V-shaped, as firm 1 cannot choose $\theta_1 < \theta_2 - 3(t + c)$, but the best replies are pictured so as to simplify the exposition).

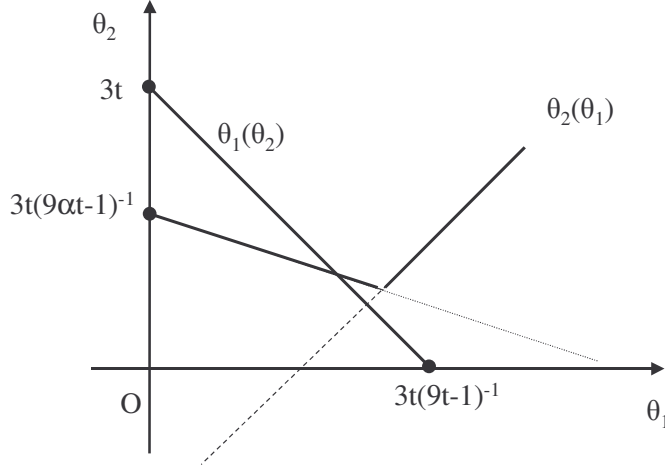


Figure 1: quality best replies

If the best reply functions cross where they slope downward⁶ then the Nash qualities are

$$\theta_1^* = \frac{9\alpha t - 2}{3(9\alpha t - \alpha - 1)}; \quad \theta_2^* = \frac{9t - 2}{3(9\alpha t - \alpha - 1)}, \quad (2.6)$$

where $\theta_2^* > 0$ from (A.1); if they cross where the best reply of 2 is increasing, this firm is priced out, and 1 remains a monopoly (since $\alpha < 2$ is assumed in A.1, this case is excluded). Prices and demands at equilibrium, are

$$p_i^* = t + c + (-1)^{i-1} \left(\frac{t(\alpha - 1)}{9\alpha t - \alpha - 1} \right), \quad D_i^* = \frac{1}{2} + (-1)^{i-1} \left(\frac{\alpha - 1}{2(9\alpha t - \alpha - 1)} \right) \quad (2.7)$$

Further, it can be checked that $D_2^* > 0$ and $p_2^* > 0$ for $t > 2/9$. Therefore, under (A.1) the best replies in qualities cross where they are both downward sloping. The equilibrium demand for 2, $\alpha(9t - 2)/(9\alpha t - \alpha - 1)$, is positive for $\alpha > 1$.

⁶The upward sloping parts are parallel and cannot cross therefore.

Profits are

$$\pi_1^u = \left(\frac{9t-1}{18}\right) \left(\frac{9\alpha t-2}{9\alpha t-\alpha-1}\right)^2 \quad \text{and} \quad \pi_2^u = \alpha \left(\frac{9t-1}{18}\right) \left(\frac{9t-2}{9\alpha t-\alpha-1}\right)^2, \quad (2.8)$$

with $\pi_1^u > \pi_2^u > 0$.

3. Incentives to Invest and MQS

The regulator can set a MQS, defined by a real number, Θ . For the sake of the argument, the regulator's choice is assumed to be restricted such that either $\Theta = \theta_2^*$ ("innocuous standard") or $\Theta = 0$ (no MQS). This decision is taken at stage "0" of the regulation game, given $(\theta_1, \theta_2) = (\theta_1^*, \theta_2^*)$ as in (2.6). At stage 1 of the regulation game, firm 1 invests the sum x , so as to reduce the cost of quality improvement. Firm 2 cannot invest, as a simplifying assumption.

In particular, $C_1(q, \theta_1, x) = cq + g(x)[\theta]^2/2 + x$: investing $x \geq 0$, reduces fixed costs of quality according to the function $g(x)$, where: $g'(x) < 0$, $g''(x) < 0$, for all $x \geq 0$, and $g(0) = 1$.

In terms of best replies in **Figure 1**, an increase in x leads to an outward rotation of the reaction function $\theta_1(\theta_2)$, with the point $(0, 3t)$ on the vertical axis, as a pivot.

Under no regulation, namely with $\Theta = 0$, the problem of 1 at the quality stage is

$$\max_{\theta_1} \frac{[3t + (\theta_1 - \theta_2)]^2}{18t} - g(x) \frac{[\theta_1]^2}{2} - x. \quad (3.1)$$

This leads to the best reply

$$\theta_1(\theta_2, x) = \frac{3t - \theta_2}{9g(x)t - 1}. \quad (3.2)$$

Clearly $\theta_1(\theta_2, x)$ increases in x . Recalling that the best reply of 2 is $\theta_2(\theta_1) = (3t - \theta_1)/(9\alpha t - 1)$, if there is no standard, the Nash qualities, denoted θ_i^0 , are

$$\theta_1^0 = \frac{9\alpha t - 2}{3(9\alpha t g(x) - \alpha - g(x))} \quad \text{and} \quad \theta_2^0 = \frac{9gt - 2}{3(9\alpha t g(x) - \alpha - g(x))}. \quad (3.3)$$

Notice that when $g = 1$, ($x = 0$), the values of θ_1^0 and θ_2^0 coincide with θ_1^* and θ_2^* of section 2.

Without a standard, firm 2 would lower quality⁷ below θ_2^u , namely $\theta_2^0 < \theta_2^u$, implying that a lower g leads to a lower value for θ_2 .

The R&D investment by firm 1 results from

$$\max_x \pi(x) = \frac{[3t + (\theta_1(x) - \theta_2)]^2}{18t} - g(x) \frac{[\theta_1(x)]^2}{2} - x. \quad (3.4)$$

It is apparent that marginal net return to invest x , decreases with θ_2 . Therefore, since θ_2 is forced to remain at its pre-standard level, firm 1 will invest less in R&D under a "innocuous" MQS.

⁷Indeed $\frac{d\theta_2^0}{dg} = \frac{9\alpha t - 2}{3(9\alpha t g - \alpha - g)^2} > 0$.

Proposition 1. *Provided the function $\pi(x)$ is concave, in a game where a MQS equal to the lowest quality in the market prevails the level of cost-reducing R&D investment, x , by the high quality firm 1 is lower than in a game where there is no standard.*

Proof: Let $\pi(x) = [3t + (\theta_1(x) - \theta_2^*)]^2 / (18t) - (g(x)/2) [\theta_1(x)]^2 - x$. Furthermore, let $\theta'(x)$ denote the derivative of $\theta_1(x)$ with respect to x . Note first that $\theta'(x)$ is positive for $x \geq 0$. Then the first order condition for a maximum of $\pi(x)$ is $\pi'(x) = 0$, where $\pi'(x) = \theta_1'(x) [(3t + \theta_1 - \theta_2^*) / (9t)] - g'(x) [\theta_1(x)]^2 (1/2) - g(x) \theta_1'(x) \theta_1(x)$. The second order condition, under the hypothesis that $\pi(x)$ is concave, implies that $\pi''(x) < 0$. Then, differentiating the first order condition with respect to θ_2^* and x gives

$$\frac{dx}{d\theta_2^*} = \frac{\theta_1'(x)}{\pi''(x)} < 0, \text{ for } x \geq 0,$$

which completes the proof.

By continuity arguments, a MQS slightly below the lowest quality level has the same effects.

4. Conclusion

That Minimum Quality Standards *below* the minimum produced quality bear effects on the industry outcome is the only issue of the present note. In particular, there is no indication here that MQS be a "wrong" policy, since the optimal level of R&D from the social point of view is not discussed. A welfare analysis requires a more general model. The main result has to be interpreted as a counter-example to the notion of innocuous standards. More work is needed to assess the general effects of MQS on R&D.

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