Full vs Partial Market Coverage with Minimum Quality Standards[¤]

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Abstract

The consequences of the adoption of quality standards on the extent of market coverage is investigated by modelling a game between regulator and low-quality …rm in a vertically di¤erentiated duopoly. The game has a unique equilibrium in the most part of the parameter range. There exists a non-negligible range where the game has no equilibrium in pure strategies. This result questions the feasibility of MQS regulation when …rms endogenously determine market coverage.

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1 Introduction

The regulation of industries where consumers are willing to pay higher prices for higher qualities takes often the form of minimum quality standards (MQSs), aiming at increasing social welfare through a reduction of the price/quality ratio prevailing in those industries. The rationale behind these interventions is that governments, either for paternalistic reasons or for the recognition of the presence of externalities, believe that the qualities offered by firms are too low. The car industry and the pharmaceutical industry are two examples of industries where MQSs are commonly adopted (for a more detailed discussion, see Viscusi et al., 1995).

The literature dealing with Minimum Quality Standards (MQSs) is still relatively small. A few papers deal with the problem of regulating a vertically differentiated monopolist (Spence, 1975; Besanko, Donnenfeld and White, 1987 and 1988), although many other relevant contributions analyse the kind of distortion introduced by a multiproduct monopolist under vertical differentiation, without explicitly discussing the issue of correcting such a distortion (Mussa and Rosen, 1978; Itoh, 1983; Maskin and Riley, 1984; Gabszewicz, Shaked, Sutton and Thisse, 1986; Champsaur and Rochet, 1989, inter alia).

In the case of oligopolistic markets, three issues have been dealt with so far, namely (i) the introduction of MQSs in a duopoly where quality improvements involve a fixed cost technology (Ronnen, 1991, and Scarpa, 1997); (ii) the introduction of an MQS and its long-run competitive effects in a duopoly where quality improvements are obtained through an increase in variable costs, under full market coverage (Crampes and Hollander, 1995; Ecchia and Lambertini, 1997). Crampes and Hollander consider the level of the MQS is treated as an exogenous parameter, while in Ecchia and Lambertini its derivation is completely endogenous, and this allows to shrink significantly the set of possible results. Moreover, in the latter paper it is shown that the adoption of the MQS can also have some positive effects in the long run, in that it reduces the likelihood that firms behave collusively in the price stage; (iii) the effects of MQSs in an open economy with intraindustry trade (Motta and Thisse, 1993; Boom, 1995).

To our knowledge, the issue of setting an MQS in a situation where firms can endogenously determine the extent of market coverage has not been addressed so far in the literature. Here we extend the analysis carried out in Crampes and Hollander (1995) and Ecchia and Lambertini (1997) to account for this possibility. To this aim, we first investigate the endogenous determination of market coverage in an unregulated duopoly market, to be used as a benchmark in the remainder of the paper. It appears that the choice whether or not to cover the entire market belongs to the low-quality firm, and the incentive to opt for full market coverage exists above a critical threshold of consumers' marginal willingness to pay for quality. Then we determine the optimal level of the MQS in each alternative setting, and we evaluate the feasibility of such a policy vis à vis the low-quality firm's decision concerning market coverage. This is done by envisaging a noncooperative one-shot game between the regulator choosing the MQS as a Stackelberg leader, and the low-quality firm determining market coverage as a follower. The main result is that such a game has a unique Nash and Stackelberg equilibrium in pure strategies, unambiguously identifying both the regulatory policy and market coverage, only in a range where marginal willingness to pay takes intermediate values. Outside that range, (i) when marginal willingness to pay is low, there are multiple Nash equilibria, but only one Stackelberg equilibrium; (ii) when marginal willingness to pay is high, the game has neither a Nash nor a Stackelberg equilibrium in pure strategies. This result seems to put into question the feasibility of an MQS policy in markets where the marginal willingness to pay of consumers is considerably high.

The paper is structured as follows. The unregulated market setting is presented in section 2. Optimal MQSs under alternative choices by the low-quality firm concerning market coverage are derived in section 3. Then, section 4 describes the interaction between the regulator and the low-quality firm, and derives the subgame perfect equilibrium. Concluding comments are provided in section 5.

2 The unregulated duopoly

Here we describe a model of unregulated duopoly under complete information, presented in several contributions (Cremer and Thisse, 1994; Crampes and Hollander, 1995; Lambertini, 1996; Ecchia and Lambertini, 1997). Each firm produces a vertically differentiated good, with $q_H \geq q_L$, and then compete in prices against the rival. There exists a continuum of consumers indexed by their marginal willingness to pay for quality $\theta \in [\theta_0; \theta_1]$; with $\theta_0 = \theta_1 - 1$. The distribution of consumers is uniform, with density $f(\theta) = 1$, so that the total mass of consumers is also 1. Each consumer buys one unit of the product that yields the highest net surplus $U = \theta q - p$.

The logical sequence of decisions is as follows. First, the low-quality firm decides whether to serve the consumer with the lowest marginal willingness to pay, i.e., θ_0; or not, in order to maximize her profits.[1] This decision must be taken before firms start competing in qualities and prices. Thus, we can consider two alternative cases. The first refers to the situation where the low-quality firm decides at the outset that θ_0 is going to be served. In the remainder, we refer to this case as the ex ante full market coverage situation. The second is the setting where the low-quality firm may or may not find it profitable to serve θ_0. If, at

[1] Given consumer surplus, the individual identified by θ_1 is always served, so that only the low-quality firm's decision is relevant as to market coverage.

equilibrium, the poorest consumer is actually served, we are in a situation of ex post full market coverage. Otherwise, we obtain partial market coverage. We investigate first the behaviour of the unregulated duopolists under ex ante full market coverage.

2.1 Ex ante full market coverage

Suppose the low-quality firm has decided to serve θ_0. Given generic prices and qualities, the "location" of the consumer indifferent between the two varieties is $h = (p_H - p_L)/(q_H - q_L)$, so that market demands are $x_H = \theta_1 - h$ and $x_L = h - (\theta_1 - 1)$.

Production technology involves variable costs, which are convex in the quality level and linear in the output level:

$$C_i = q_i^2 x_i \quad i = H, L. \tag{1}$$

Hence, firm i's profit function is

$$\pi_i = (p_i - q_i^2)x_i. \tag{2}$$

Consumer surplus in the two market segments is defined as follows:

$$CS_L = \int_{\theta_0}^{h} (\theta q_L - p_L)d\theta; \quad CS_H = \int_{h}^{\theta_1} (\theta q_H - p_H)d\theta; \tag{3}$$

social welfare corresponds to the sum of consumer surplus and firms' profits, $SW = CS_H + CS_L + \pi_H + \pi_L$.

Competition between firms is fully noncooperative and takes place in two stages. In the first, firms set their respective quality levels; then, in the second, which is the proper market stage, they compete in prices. The solution concept applied is the subgame perfect equilibrium by backward induction. From the first order conditions (FOCs henceforth) at the second stage, the following equilibrium prices obtain:

$$p_H = \frac{(q_H - q_L)(\theta_1 + 1) + 2q_H^2 + q_L^2}{3}; \quad p_L = \frac{(q_H - q_L)(2 - \theta_1) + 2q_L^2 + q_H^2}{3} \tag{4}$$

Substituting and rearranging, we get the profit functions defined exclusively in terms of qualities, $\pi_i(q_H, q_L)$. The subgame perfect quality levels are

$$q_H = \frac{4\theta_1 + 1}{8}; \quad q_L = \frac{4\theta_1 - 5}{8}; \tag{5}$$

which entails the general constraint $\theta_1 \geq 9/4$, in order for the poorest consumer to be in a position to buy the low-quality product. The corresponding equilibrium profits are $\pi_H = \pi_L = 3/16$, and equilibrium demands are $x_H = x_L = 1/2$. The welfare level is $SW = (16\theta_1^2 - 16\theta_1 - 1)/64$. Consumer surplus in each segment of the market is $CS_H = (16\theta_1^2 - 8\theta_1 - 27)/128$, and $CS_L = (16\theta_1^2 - 24\theta_1 - 19)/128$. Observe that the socially preferred qualities would be the first and third quartiles of the interval $[\theta_0/2, \theta_1/2]$, which obtains from the calculation of the preferred varieties for the richest and the poorest consumer in the market, if such varieties were sold at marginal cost. This implies that (i) qualities are set, respectively, too low and too high as compared to the social optimum; and (ii) this model shares its general features with the model of spatial competition with quadratic transportation costs.[2]

2.2 Partial (or ex post full) market coverage

Consider now the case where the low-quality firm decides not to include θ_0 from the outset in her own demand function. We retain the set of assumptions introduced above, except that now there exists a consumer who is indifferent between buying the low-quality good and not buying at all. His location along the spectrum of the marginal willingness to pay is given by the ratio $k = p_L/q_L$, so that now market demands are $x_H = \theta_1 - h$ and $x_L = h - k$. Given the cost function (1), the profit function of firm i remains defined as in (2).

Again, proceeding backwards, the FOCs for noncooperative profit maximization are

$$\frac{\partial \pi_H}{\partial p_H} = \theta_1 - \frac{2p_H - p_L + q_H^2}{q_H - q_L} = 0; \qquad (6)$$

$$\frac{\partial \pi_L}{\partial p_L} = \frac{p_H q_L - 2p_L q_H + q_H q_L^2}{q_L(q_H - q_L)} = 0; \qquad (7)$$

yielding

$$p_H = \frac{q_H(2\theta_1 q_H + 2q_H^2 - 2\theta_1 q_L + q_L^2)}{4q_H - q_L}; \quad p_L = \frac{q_L(\theta_1 q_H + q_H^2 - \theta_1 q_L + 2q_H q_L)}{4q_H - q_L} \qquad (8)$$

as the equilibrium prices. Substituting and simplifying, we get the following expressions defining the firms' profit functions at the quality stage:

$$\pi_H = \frac{q_H^2(q_H - q_L)(2\theta_1 - 2q_H - q_L)^2}{(4q_H - q_L)^2}; \quad \pi_L = \frac{q_H q_L(q_H - q_L)(\theta_1 + q_H - q_L)^2}{(4q_H - q_L)^2}. \qquad (9)$$

[2] It can be shown that the spatial model with quadratic transportation costs is actually a special case of a vertical differentiation model with quadratic costs of quality improvement (Cremer and Thisse, 1991). Moreover, the symmetry of the model suggests that regulation could take place through symmetric rules, rather than an MQS (see Cremer and Thisse, 1994; Lambertini, 1997).

The corresponding FOCs are:

$$\frac{\partial \pi_H}{\partial q_H} = \frac{q_H}{(4q_H - q_L)^3}(16\theta_1^2 q_H^2 - 64\theta_1 q_H^3 + 48q_H^4 - 12\theta_1^2 q_H q_L + 48\theta_1 q_H^2 q_L - 20q_H^3 q_L + 8\theta_1^2 q_L^2 - 12\theta_1 q_H q_L^2 - 12q_H^2 q_L^2 - 8\theta_1 q_L^3 + 9q_H q_L^3 + 2q_L^4) = 0; \quad (10)$$

$$\frac{\partial \pi_L}{\partial q_L} = \frac{q_H}{(4q_H - q_L)^3}(4\theta_1^2 q_H^2 + 8\theta_1 q_H^3 + 4q_H^4 - 7\theta_1^2 q_H q_L - 30\theta_1 q_H^2 q_L - 23q_H^3 q_L + 24\theta_1 q_H q_L^2 + 36q_H^2 q_L^2 - 2\theta_1 q_L^3 - 19q_H q_L^3 + 2q_L^4) = 0; \quad (11)$$

whose solution gives the unregulated Nash equilibrium qualities, $q_H^* = 0.40976\theta_1$ and $q_L^* = 0.199361\theta_1$.[3] Equilibrium prices are $p_H^* = 0.2267\theta_1^2$; $p_L^* = 0.075\theta_1^2$, outputs are $x_H^* = 0.2792\theta_1$; $x_L^* = 0.3445\theta_1$; while profits amount to $\pi_H^* = 0.0164\theta_1^3$; $\pi_L^* = 0.0121\theta_1^3$. Finally, consumer surplus is, respectively, $CS_H^* = 0.03515\theta_1^3$ in the high-quality range and $CS_L^* = 0.01183\theta_1^3$ in the low-quality range, so that total welfare amounts to $SW^* = 0.07554\theta_1^3$.

The equilibrium values pertaining to social welfare, as well as firm's profit and consumer surplus in the low-quality range are acceptable if total equilibrium demand is at most equal to one, i.e., $k \geq \theta_0$, which implies the constraint $\theta_1 \leq 1.6032$. Otherwise, the marginal willingness to pay of the consumer supposedly indifferent between buying the low-quality good and not buying at all falls below the lower bound of the interval assumed for θ. If this is the case, i.e., $\theta_1 > 1.6032$, then given the above equilibrium prices and qualities, we have to compute both the profits accruing to the low-quality firm and the consumer surplus in the low-quality segment of the market taking into account that the demand for the low-quality good is $\overline{x}_L^* = 1 - x_H^* = h - (\theta_1 - 1) = h - \theta_0$ instead of $h - k$, where the bar indicates that the market is fully covered ex post. This yields $\overline{\pi}_L^* = 0.03526(1 - 0.2792\theta_1)\theta_1^2$ and $\overline{CS}_L^* = 0.12435\theta_1^2 - 0.09968\theta_1 - 0.02695\theta_1^3$, respectively. Consumer surplus in the high-quality segment and the profits of the high-quality firm are obviously unchanged, so that social welfare amounts to $\overline{SW}^* = 0.01476\theta_1^3 + 0.15962\theta_1^2 - 0.09968\theta_1$. It remains to be established the parameter range in which the low-quality firm's output is strictly positive. It turns out that $\overline{x}_L^* > 0$ for all $\theta_1 \in [1, 3.58166)$. This implies that, for $\theta_1 \geq 3.58166$, the low-quality firm must choose ex ante full market coverage, in order to survive.

The discussion carried out in this section leads to the following remark:

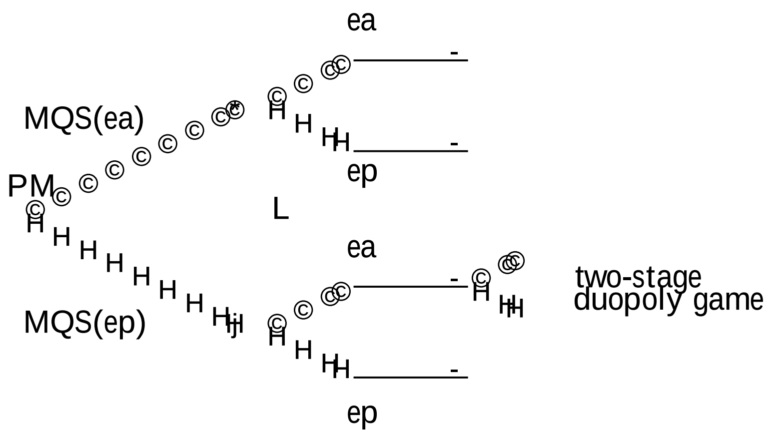
Remark 1 In the unregulated setting, the market is partially covered if $\theta_1 \in [1, 1.6032)$, and is fully covered if $\theta_1 \geq 1.6032$. Full market coverage obtains (i) only ex post if $\theta_1 \in [1.6032, 9/4)$; (ii) either ex ante or ex post if $\theta_1 \in [9/4, 3.58166)$; (iii) only ex ante if $\theta_1 \geq 3.58166$.

[3] This can be verified through numercal calculations, initially performed by normalizing θ_1 to 1. Then, increasing the latter shows that the relationship between equilibrium qualities and θ_1 is linear.

3 The optimal MQS

In this section, we explicitly calculate the optimal levels of the MQS, as well as their consequences on the relevant equilibrium magnitudes, under the alternative choices by the low-quality …rm concerning market coverage. We assume the following game structure. First, the policy maker sets the optimal MQS in order to maximize social welfare, taking into account the subsequent …rms' decisions. More explicitly, the policy maker announces either the MQS which is optimal if the low-quality …rm adopts ex ante full market coverage, or the MQS which is optimal under partial (or ex post full) market coverage. This amounts to saying that the policy maker enjoys a …rst-mover advantage w.r.t. the low-quality …rm. The optimal level of the MQS is obtained as a result of the Nash equilibrium in quality levels of a game where the regulator simulates to play simultaneously against the high-quality …rm, having q_L as the control variable as social welfare as the objective function, given the pair of prices that duopolists are going to choose in the ensuing price stage. It can be shown (see Ecchia and Lambertini, 1997) that the regulator does not …nd it convenient to use the best reply function of the high-quality …rm at the quality stage. Then, once the policy maker has …xed the MQS, the remainder of the game is as in the previous section, namely, the low-quality …rm makes a decision concerning market coverage, and …nally two-stage duopolistic interaction takes place. The game tree is illustrated in …gure 1.

Figure 1. The game tree



Legenda: ea = ex ante full market coverage; ep = ex post partial or full market coverage; PM = policy maker; L = low-quality …rm.

3.1 The optimal MQS under ex ante full market coverage

The derivation of the optimal MQS under ex ante full market coverage coincides with the analysis presented in Ecchia and Lambertini (1997). The resulting MQS is

$$q_L^S = \frac{20\theta_1 - 34 + 9\sqrt{6}}{40}. \tag{12}$$

Given q_L^S and its equilibrium price, ex ante full market coverage is possible if and only if $\theta_1 \geq 2.23926$. Observe that the introduction of the standard slightly loosens such a constraint as compared to the unregulated setting. The new level of the high quality is the best reply of the high-quality firm to the MQS:

$$q_H^S = \frac{20\theta_1 + 2 + 3\sqrt{6}}{40}. \tag{13}$$

The new equilibrium profits are

$$\pi_L^S = 0.22153; \quad \pi_H^S = 0.06714. \tag{14}$$

As a result of the adoption of the MQS, the degree of differentiation decreases (since both qualities increases, but the reaction of the high quality is weaker) and the demand for the high quality decreases while the demand for the low quality increases. Moreover, notice the drastic reduction in the high-quality firm's profits. Since the increase observed in the profit accruing to the low-quality firm is lower, total industry profits are considerably decreased as compared to the unregulated equilibrium.

Social welfare amounts to $SW^* = [200\theta_1(\theta_1 - 1) + 18\sqrt{6} - 13]/800$, which is obviously higher than that observed in the unregulated setting. The increase in welfare is due to two effects: (i) the increase in both quality levels; (ii) the increase in price competition, due to a reduced degree of product differentiation. However, the effect of the MQS on consumer surplus is not identical across consumers. The MQS increases the surplus of consumers purchasing the low quality for all acceptable values of θ_1, while it decreases the surplus of consumers patronizing the high quality if θ_1 is sufficiently high. Summing up, under ex ante full market coverage it appears that the MQS policy, provided it is designed to maximize welfare regardless of its redistributive effects, trades off the losses suffered by the agents (firm and consumers) dealing with the high quality with the gains enjoyed by the other agents.

3.2 The optimal MQS under partial (or ex post full) market coverage

Consider now the setting where firms' interaction determines either partial or ex post full market coverage. As in the previous case, we assume that the regulator simulates to play simultaneously against the high-quality firm in the quality stage, maximising social welfare w.r.t. q_L, given prices chosen by firms in the market stage. The main result is stated in the following proposition:

Proposition 1 The optimal MQS under partial or ex post full market coverage is $q_L^S = 0.28162\theta_1$. The corresponding best reply by the high-quality firm is $q_H^S = 0.45537\theta_1$.

Proof. Since prices are given by (8), the duopolists' profit functions pertaining to the quality stage are as in (9). Hence, the high-quality firm's reaction function is implicitly defined by her FOC w.r.t. q_H, given by expression (10). In turn, the social planner's reaction function is implicitly determined by the following FOC for welfare maximization w.r.t. q_L,

$$\frac{\partial SW}{\partial q_L} = \frac{1}{2(4q_H - q_L)^3}(96\theta_1 q_H^3 - 64q_H^3 - 16\theta_1^2 q_H^3 - 32q_H^4 + 16\theta_1 q_H^4 + 32q_H^5 + 48q_H^2 q_L -$$

$$- 24\theta_1 q_H^2 q_L - 26\theta_1^2 q_H^2 q_L - 120q_H^3 q_L + 48\theta_1 q_H^3 q_L - 118q_H^4 q_L - 12q_H q_L^2 + 48q_H^2 q_L^2 +$$

$$+ 48\theta_1 q_H^2 q_L^2 + 36q_H^3 q_L^2 + q_L^3 - 4q_H q_L^3 - 4\theta_1 q_H q_L^3 - 35q_H^2 q_L^3 + 4q_H q_L^4) = 0. \quad (15)$$

Solving the system (10-15) yields[4]

$$q_H^S = 0.45537\theta_1; \quad q_L^S = 0.28162\theta_1; \quad (16)$$

where q_L^S is the optimal level of the MQS. ■

As a result, equilibrium prices are $p_H^S = 0.24886\theta_1^2$; $p_L^S = 0.11661\theta_1^2$, independently of the extent of market coverage. However, all remaining equilibrium magnitudes are affected by the extent of market coverage. As in the previous section, we have to determine a condition on θ_1 which discriminates between partial market coverage and ex post full market coverage. If total equilibrium demand is at most equal to one, i.e., $k \geq \theta_0$, which implies the constraint $\theta_1 \leq 1.70663$, we are in the situation where the market is partially covered. Then, it can be shown that outputs are $x_H^S = 0.23884\theta_1$; $x_L^S = 0.3471\theta_1$, while profits amount to $\pi_H^S = 0.0099\theta_1^3$; $\pi_L^S = 0.0129\theta_1^3$. Finally, the consumer surplus is, respectively, $CS_H^S = 0.03633\theta_1^3$ in the high-quality range and $CS_L^S = 0.01696\theta_1^3$ in the low-quality range, so that total welfare amounts to $SW^S = 0.07616\theta_1^3$.

Otherwise, the market is ex post fully covered if the marginal willingness to pay of the consumer supposedly indifferent between buying the low-quality good and not buying at all falls below the lower bound of the interval assumed for θ. If this is the case, i.e., $\theta_1 > 1.70663$, then given the above equilibrium prices and qualities, we have to compute both the profit accruing to the low-quality firm and the consumer surplus in the low-quality segment of the market taking into account that the demand for the low-quality good is $\overline{x}_L^S = 1 - x_H^S = h - (\theta_1 - 1) = h - \theta_0$ instead of $h - k$, where, again, the bar indicates that the market is being fully covered ex post. This yields $\overline{\pi}_L^S = 0.037298(1 - 0.23884\theta_1)\theta_1^2$ and $\overline{CS}_L^S = 0.16501\theta_1^2 - 0.14081\theta_1 - 0.03138\theta_1^3$, respectively. Both the consumer surplus in

[4] Second order conditions are also satisfied, but are omitted for the sake of brevity.

the high-quality segment and the pro…ts of the high-quality …rm remaining unchanged, social welfare corresponds to $\overline{SW}^S = 0{:}00596\mu_1^3 + 0{:}20231\mu_1^2$ ¡ $0{:}14081\mu_1$: Finally, $\overline{x}_L^S > 0$ if μ_1 2 [1; 4:1869): This implies that, for μ_1 ¸ 4:1869; the low-quality …rm must switch to ex ante full market coverage, in order to survive.

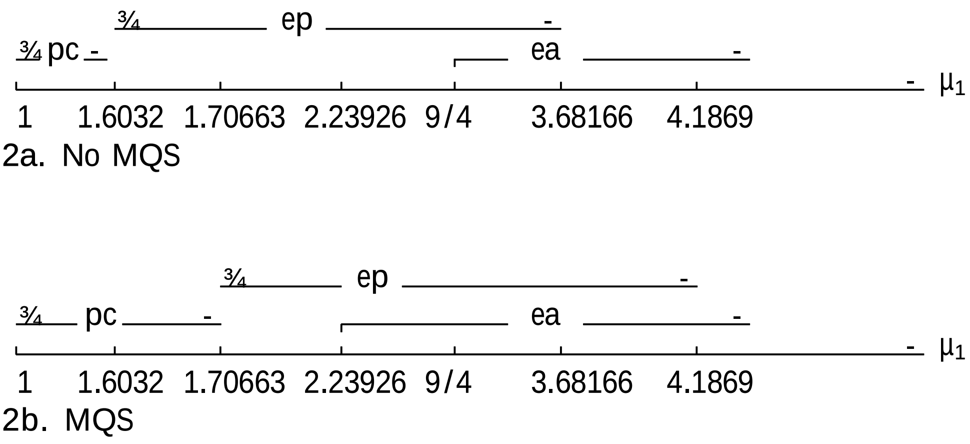
The above discussion can be summarized in the following remark:

Remark 2 In the regulated setting, the market is partially covered if μ_1 2 [1; 1:70663); and conversely if μ_1 ¸ 1:70663. Full market coverage obtains (i) ex post if μ_1 2 [1:70663; 2:23926); (ii) either ex ante or ex post if μ_1 2 [2:23926; 4:1869); (iii) ex ante if μ_1 ¸ 4:1869:

4 MQS and market coverage in equilibrium

In the previous section we have determined the outcomes associated with the introduction of the optimal MQS given the alternative hypotheses on market coverage. Going backwards, we are now in a position to investigate the interaction between the regulator and the low-quality …rm. Before duopolistic competition takes place, the policy maker has to decide whether to intervene in the market or not. In the former case, he announces the optimal MQS, acting as a Stackelberg leader, and the low-quality …rm reacts to the announcement by choosing the appropriate market coverage policy. In the absence of regulation, the game develops as in section 2.

Figure 2. Alternative settings



Legenda: ea = ex ante full market coverage; ep = ex post full market coverage; pc = partial market coverage.

In order to verify whether the regulator …nds it convenient to intervene, consider …gure 2, where the extent of market coverage as μ_1 grows is described, in the two alternative settings where firms' behaviour is unregulated (figure 2a), or they must adjust to the MQS (figure 2b). It should be remembered that for $\theta_1 < 2.23926$; the MQS can only be determined under either partial or ex post full market coverage. For $\theta_1 \geq 2.23926$; the MQS can be determined under either ex post or ex ante full market coverage.

We are now in a position to discuss the interaction between firms' choices concerning market coverage and the policy maker's decisions about the introduction of the optimal MQS, over the viable range of θ_1. When $\theta_1 \in]1; 1.6032[$; market coverage is partial in both regimes. When $\theta_1 \in [1.6032; 1.70663[$; the market is ex post covered without MQS, while it is only partially covered with MQS. When $\theta_1 \in [1.70663; 2.23926[$; the market is ex post covered both with and without MQS. When $\theta_1 > 9/4$; the market might be ex ante covered, depending on whether the low-quality firm finds it profitable to do so. Hence, it remains to be assessed what happens in the intervals $[2.23926; 9/4]$ and $(9/4; 4.1869)$. Consider the former. Here, the market is ex post covered without MQS, while it can be ex ante covered with MQS, so it should be assessed whether the adoption of the optimal MQS under ex post partial or full market coverage may generate a problem for the policy maker if, after the announcement, the low-quality firm were induced to adopt the regime of ex ante full market coverage. It can be quickly shown that this is not the case.

Consider first the preferences of the low-quality firm, if, alternatively, qualities are fixed at

(a) $q_L^S = 0.28162\theta_1$; $q_H^S = 0.45537\theta_1$ (ex post full market coverage);

and

(b) $q_L^S = (20\theta_1 - 34 + 9\sqrt{6})/40$; $q_H^S = (20\theta_1 + 2 + 3\sqrt{6})/40$ (ex ante full market coverage).

In the remainder, we adopt the following notation, regarding profits and social welfare. Let $\pi_L^S(ea; ep)$ define the profit accruing to the low-quality firm when she covers the market ex ante, and the policy maker adopts the MQS which would be optimal under ex post partial or full market coverage. Accordingly, define as $SW^S(ea; ep)$ the corresponding level of social welfare. The remaining cases are defined accordingly. Hence, in general, the first term in parenthesis defines the behaviour of the low-quality firm, while the second refers to the choice of the policy maker.

Consider first $\theta_1 \in [2.23926; 9/4]$. Simple numerical calculations are needed to prove that, under (a) and (b), respectively:

$$\text{(a) } \pi_L^S(ea; ep) < \pi_L^S(ep; ep); \quad \text{(b) } \pi_L^S(ea; ea) > \pi_L^S(ep; ea); \qquad (17)$$

$$\forall \theta_1 \in [2.23926; 9/4].$$

The inequalities in (17) show that the low-quality firm never finds it convenient to change the type of her coverage policy after the introduction of the standard.

Consider now the standpoint of the government. Specifically, compare the levels of social welfare attained when the optimal MQS is introduced, under the alternative choices concerning market coverage. We get the following inequalities:

$$SW^S(ep;ep) > SW^S(ep;ea); \quad SW^S(ea;ea) > SW^S(ea;ep); \tag{18}$$

$$\forall\theta_1 \in [2.23926; 9/4].$$

The interaction between the low-quality firm and the policy maker can be described as a non-cooperative Stackelberg game between a policy maker setting the MQS which is optimal under either ex post or ex ante market coverage and the low-quality firm which decides between the first or the second market coverage rule. The game is depicted in matrix 1.

		Policy Maker	
		MQS(ep)	MQS(ea)
Firm L	ep	$\pi_L^S(ep;ep); SW^S(ep;ep)$	$\pi_L^S(ep;ea); SW^S(ep;ea)$
	ea	$\pi_L^S(ea;ep); SW^S(ea;ep)$	$\pi_L^S(ea;ea); SW^S(ea;ea)$

Matrix 1

On the basis of (17) and (18), the game exhibits two Nash equilibria, namely, $(ep;ep)$ and $(ea;ea)$. Notice that $SW^S(ep;ep) > SW^S(ea;ea)\ \forall\theta_1 \in [2.23926; 9/4]$. Hence, since the regulator announces the MQS before the low-quality firm decides about the extent of market coverage, the Stackelberg equilibrium is unique and defined by $(ep;ep)$.

Consider now $\theta_1 \in (9/4; 4.1869)$. Here, the low-quality firm's preferences are summarized as follows. In the regulated setting where qualities are $q_L^S = 0.28162\theta_1$ and $q_H^S = 0.45537\theta_1$,

$$\pi_L^S(ea;ep) < \pi_L^S(ep;ep) \quad \forall\theta_1 \in (9/4; 3.41867); \tag{19}$$

$$\pi_L^S(ea;ep) > \pi_L^S(ep;ep) \quad \forall\theta_1 \in (3.41867; 4.1869). \tag{20}$$

When instead qualities are $q_L^S = (20\theta_1 - 34 + 9\sqrt{6})/40$ and $q_H^S = (20\theta_1 + 2 + 3\sqrt{6})/40$, we obtain

$$\pi_L^S(ea;ea) > \pi_L^S(ep;ea) \quad \forall\theta_1 \in (9/4; 2.70577); \tag{21}$$

$$\pi_L^S(ea;ea) < \pi_L^S(ep;ea) \quad \forall\theta_1 \in (2.70577; 4.1869). \tag{22}$$

The ranking of welfare levels is analogous to (18). Moreover, $SW^S(ep;ep) > SW^S(ea;ea)$ and $\pi_L^S(ea;ea) > \pi_L^S(ep;ep)$, $\forall\theta_1 \in (9/4; 2.70577]$.

Again, we can refer to matrix 1 for the discussion of the game. It is easy to verify that:

1) the game has two Nash equilibria, $(ep; ep)$ and $(ea; ea)$; $\forall \theta_1 \in (9/4; 2.70577)$; the Stackelberg equilibrium is $(ep; ep)$;
2) the game has a unique Nash equilibrium, that coincides with the Stackelberg equilibrium, $(ep; ep)$, $\forall \theta_1 \in [9/4; 3.41867)$;
3) the game has no Nash equilibrium in pure strategies if $\theta_1 \in (3.41867; 4.1869)$. As a consequence, neither a Stackelberg equilibrium exists.[5]

Finally, when $\theta_1 > 4.1869$, the only option for the low-quality firm consists in choosing to cover the whole market ex ante. In such a case, the policy maker sets the MQS at $q_L^S = (20\theta_1 - 34 + 9\sqrt{6})/40$.

The analysis carried out in this section can be summarized in the following

Proposition 2 The game between the regulator and the low-quality firm has (i) two Nash equilibria, $(ep; ep)$ and $(ea; ea)$; and a unique Stackelberg equilibrium, $(ep; ep)$; $\forall \theta_1 \in (9/4; 2.70577)$; (ii) a unique Nash (and Stackelberg) equilibrium, $(ep; ep)$, $\forall \theta_1 \in [2.70577; 3.41867)$; (iii) no Nash equilibrium in pure strategies if $\theta_1 \in (3.41867; 4.1869)$. As a consequence, neither a Stackelberg equilibrium exists in such an interval.

The above proposition can be interpreted as follows. Consider first the interval $\theta_1 \in (9/4; 2.70577)$. In this range, given that all consumers are served, the policy maker prefers $(ep; ep)$ to $(ea; ea)$ since social welfare is higher in the former case. This is due to the fact that the higher level of consumer surplus in the former case more than compensates the lower profits accruing to firms. In order to compare the levels of consumer surplus in the two cases, just notice that the consumer characterized by θ_0 enjoys a positive surplus under $(ep; ep)$, whereas his surplus is driven to zero under $(ea; ea)$. From the standpoint of the low-quality firm, the choice of the equilibrium strategy is affected by the trade-off between her ability to extract surplus from poor consumers by raising the price (surplus extraction effect), and her ability to steal demand from the rival by reducing the price (demand effect). In the range we are considering, consumers are relatively poor, so that the low-quality firm would prefer to include θ_0 in her demand function from the outset. However, given the first mover advantage by the policy maker, she has to adopt ep. In the second interval, where $\theta_1 \in [2.70577; 3.41867)$, there is a unique equilibrium where full market coverage obtains ex post. As θ increases, ea is no longer attractive to the policy maker, in that ep allows for lower prices and, hence, a higher consumer surplus. At the same time, the low-quality firm prefers ep because the trade-off between the demand effect and the surplus extraction effect is in favour of the former. Finally, the intuition behind the non-existence of an equilibrium when the marginal willingness to pay is relatively high ($\theta_1 \in (3.41867; 4.1869)$) is the following. To interpret this

[5] Clearly, a Nash equilibrium exists in mixed strategies.

result, observe …rst that MQS(ep) < MQS(ea) for all μ_1 2 (3:41867; 4:1869) and remember that, ceteris paribus, a higher MQS favours the low-quality …rm vis à vis her rival. Suppose players consider the strategy combination (ep; ep): The low-quality …rm would deviate to ea because the demand e¤ect guaranteed by MQS(ep) is dominated by the surplus extraction e¤ect. For the policy maker, the best reply is obviously to adopt MQS(ea): In (ea; ea); the low-quality …rm would deviate to ep to exploit completely the demand e¤ect o¤ered by a higher standard. At this point the regulator would prefer to set MQS(ep): This shows that any arbitrary strategy combination cannot candidate as an equilibrium.

In summary, the above discussion suggests two general observations. First, it is shown that, when at least one pure strategy equilibrium exists, the optimal MQS never distorts the choice of low-quality …rm concerning market coverage. Second, the above results imply that the MQS is not a feasible policy to regulate quality in a non-trivial range of the relevant parameter μ; due to the lack of compatibility between the incentives of the regulator and the low-quality …rm.

5 Concluding remarks

In the foregoing analysis, we have investigated the regulation through MQSs of a vertically di¤erentiated duopoly where the extent of market coverage is the result of …rms' choices. We have characterized the optimal MQS when the marginal consumer is identi…ed ex post as a result of strategic interaction between …rms. Together with previous results (Ecchia and Lambertini, 1997) concerning the regulation of a market where ex ante it is known that all consumers are going to be served, the paper presents a completely endogenous analysis of the interaction between policy maker and …rms. In particular, the decision concerning the extent of market coverage is taken by the low-quality …rm. Hence, the announcement of the policy maker is a¤ected by the subsequent choice of the low-quality …rm, which is driven by the trade-o¤ between a surplus extraction e¤ect, and a demand e¤ect. When the …rst e¤ect prevails, full market coverage emerges ex ante. Otherwise, the low-quality …rm prefers to exploit the demand e¤ect by lowering the price and stealing customers from the rival. The main conclusion we have reached is that the equilibrium con…guration of such a setting is univocally determined for most of the admissible parameter values. However, for a non-negligible interval, the game has no equilibria in pure strategies. Given the MQS announced by the policy maker, the above trade-o¤ induces the low-quality …rm to deviate from the socially optimal choice. This, in turn, induces a deviation by the policy maker, so that the choices of the regulator and the low-quality …rm are never compatible.

On policy grounds, it appears that the MQS may not always be a feasible instrument of regulation in vertically di¤erentiated markets, due to a con‡ict of incentives between regulator and …rms. This result shows that the e¤ectiveness of a given policy instrument may depend on consumers' a- uency, and this fact opens the way to the issue of a comparative evaluation of the tools available to the policy maker.

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