E C O N O M I C S B U L L E T I N

Is a Minimum Quality Standard Socially Optimal?

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Abstract

This paper explores the role of a minimum quality standard when the quality choice is discrete. A minimum quality standard is never a socially optimal policy under Bertrand and Cournot competition. Conversely, it is often optimal to subsidize or tax the high quality in order to implement different firms' choices corresponding to a situation of welfare maximization.

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1. Introduction

Even if the economics literature generally underlines that firms do not always make socially optimal quality choices, there are still uncertainties about the social impact of Minimum Quality Standard (MQS).

Industries and services often face up to a limited number of technical alternatives regarding safety or quality. This is for instance the case with the regulatory choice between single-hulled ships (corresponding to a low-quality vessel) and double-hulled ships (corresponding to a high-quality vessel). Indeed, several oil tanker spills have rekindled debates over the MQS of sea-faring vessels. Recent international regulations said single-hulled ships will be banned from ports and replaced by double-hulled ships after 2010 (IMO, 2003).

Even with a limited number of quality/safety alternatives for a product, the selection of a MQS may induce a difficult understanding. We seek to answer the following questions: Is the MQS optimal? Are there better policies compared to a MQS?

This paper explores the role of a MQS when the quality choice made by firms is discrete. In a very simple model, two firms choose whether or not to select costly high-quality products. Under the alternative choice, only low-quality products are selected at zero cost. In this context, the regulator has the possibility to select a mandatory MQS imposing high quality with which all sellers should comply and/or a tax/subsidy mechanism linked to the quality effort. The regulation is selected by a regulator seeking to maximize welfare defined by the sum of the firm's profits and consumers' surplus.

From a social point of view, we show that a MQS is never a socially optimal policy under Cournot and Bertrand competition. The MQS under duopoly or monopoly via the exit of one competitor is never selected. Moreover, for a relatively low cost of quality improvement under Cournot competition, the MQS is ineffective (but never welfare decreasing), since there is a high-quality overinvestment by one firm. Conversely, it is often optimal to subsidize or tax the high-quality effort in order to implement different firms' choices corresponding to a situation of welfare maximization. These regulatory tools favour diversity regarding the quality choices selected by firms.

The results of this paper differ from the literature on MQS pointing toward a difference between Bertrand and Cournot competition. In particular, when quality is selected on a continuous range of values, the MQS is socially optimal under Bertrand competition (Ronnen, 1991), but is not used under Cournot competition since it reduces welfare (Valletti, 2000). Conversely, in our paper, we show that the MQS is not used whatever the type of competition, namely Bertrand or Cournot. Instead of a mandatory tool, the regulator in our paper favours subsidies or taxes linked to the quality effort for providing incentives to one firm to offer high-quality, while the other one offers low-quality. This issue was overlooked in the literature.

The paper is organized as follows. The next section introduces the stylized model. Following that, both market equilibrium and regulatory choices are successively detailed. The last section presents some conclusions.

2. The Model

In this stylized framework, trade occurs in a single stage, with two firms able to produce the

good. Each firm offers either high- or low-quality products. High-quality k_H entails a sunk cost *C*. Under the alternative choice, low quality k_L that costs zero is selected. For simplicity, the marginal cost is zero whatever the quality.

Consumers want to purchase only one unit of the good under perfect information. For a quality of producer 1, k_1 , consumers have a willingness to pay equal to θk_1 (and θk_2 for producer 2), where the parameter $\theta \in [0,1]$ is uniformly distributed (see Mussa and Rosen, 1978). Before purchasing, a consumer who wants to buy one unit of this product at a price of p_1 has an indirect utility equal to $\theta k_1 - p_1$. The mass of those consumers is normalized at 1.

The timing of this game is divided into three stages. In stage 1, the regulator chooses whether or not to select a mandatory MQS imposing high-quality products, along with a subsidy or/and a tax linked to the choice of high-quality products. The policy is selected by a regulator searching to maximize welfare defined by the sum of the firms' profits and consumers' surplus. For simplicity, the regulator may perfectly observe the quality choices and the firms spending equal to *C* or zero. It is assumed that, when tax and/or subsidy are necessary, only the lowest levels of tax and/or subsidy are selected by the regulator searching to reach its regulatory aim and cap monetary transfers. No policy is imposed if private choices by firms without regulation are equivalent to choices maximizing total welfare.

In stage 2, each firm may exit the market before any quality/quantity choice, which means that the quality is zero. Each firm in the market selects the quality level. Each firm also complies with the regulation and incurs the sunk cost *C* if the high-quality is voluntary selected or imposed by the regulator. The firms choose the quantity (or price) in stage 3. We start with Cournot competition before presenting the results under Bertrand competition.

3. The Firm's Decisions under Cournot competition

In stage 1, the regulation is defined by taking into account the quality decision in stage 2 and the quantity decision in stage 3 (i.e., subgame Nash equilibrium).

In stage 2, qualities are selected. Depending on the quality choices k_1 and k_2 by firms 1 and 2, the demands are the following. With $k_1 > k_2$, the consumer's indifference between buying a product offered by firm 2 at price p_2 and buying nothing is identified by the preference parameter $\overline{\theta} = p_2 / k_2$ (such that $\overline{\theta} k_2 - p_2 = 0$). The consumer's indifference between buying a product offered by firm 2 at price p_2 and buying a product offered by firm 1 at a price p_1 is identified by the preference parameter $\tilde{\theta} = (p_1 - p_2)/[k_1 - k_2]$ (such that $\tilde{\theta} k_2 - p_2 = \tilde{\theta} k_1 - p_1$). With a uniformly distributed parameter $\theta \in [0,1]$, the demands for firms 1 and 2 are respectively $x_1 = (1 - \tilde{\theta})$ and $x_2 = (\tilde{\theta} - \overline{\theta})$ (recall that the mass of consumers normalized at 1). The inverse demands are equal to $p_1(x_1, x_2) = k_1 (1 - x_1) - k_2 x_2$ and $p_2(x_1, x_2) = k_2 (1 - x_1 - x_2)$.

Under Cournot competition in stage 3, both firms' gross profits (namely, net of sunk cost incurred at stage 2) are $p_1(x_1, x_2) x_1$ and $p_2(x_1, x_2) x_2$. The maximization of these gross profits are given by the first order conditions $p_1(x_1, x_2) + x_1 \partial p_1(x_1, x_2) / \partial x_1 = 0$ and

$p_2(x_1,x_2)+x_2\partial p_2(x_1,x_2)/\partial x_2=0$. By solving these two conditions, the equilibrium quantities are $x_1^C=(2k_1-k_2)/(4k_1-k_2)$ and $x_2^C=k_1/(4k_1-k_2)$. The equilibrium gross profit for firms are given by $\pi_1(k_1,k_2)=p_1(x_1^C,x_2^C)x_1^C$ and $\pi_2(k_1,k_2)=p_2(x_1^C,x_2^C)x_2^C$. With consumers' preference parameters $\overline{\theta}^C=p_2(x_1^C,x_2^C)/k_2$ and $\tilde{\theta}^C=[p_1(x_1^C,x_2^C)-p_2(x_1^C,x_2^C)]/(k_1-k_2)$. The equilibrium consumers' surplus is $cs(k_1,k_2)=\int_{\overline{\theta}^C}^{\tilde{\theta}^C}(\theta k_2-p_2(x_1^C,x_2^C))d\theta+\int_{\tilde{\theta}^C}^{1}(\theta k_1-p_1(x_1^C,x_2^C))d\theta$. The equilibrium gross profits for firms, consumer's surplus are respectively equal to

$$\begin{cases}\pi_1(k_1,k_2)=\dfrac{k_1(2k_1-k_2)^2}{(4k_1-k_2)^2}\\ \pi_2(k_1,k_2)=\dfrac{(k_1)^2k_2}{(4k_1-k_2)^2}\\ cs(k_1,k_2)=\dfrac{k_1(4(k_1)^2+k_1k_2-(k_2)^2)}{2(4k_1-k_2)^2}.\end{cases}\quad(1)$$

The gross welfare (net of the sunk costs) is defined by $w(k_1,k_2)=\pi_1(k_1,k_2)+\pi_2(k_1,k_2)+cs(k_1,k_2)$ Note that when $k_1=k_2$, then profits are equal to $\pi_1(k_2,k_2)=\pi_2(k_2,k_2)=k_2/9$. The monopoly allocation is given by the case $k_2=0$. The overall profits and the overall welfare include the sunk cost and the transfer *T* coming from the tax (*T>0*) and/or subsidy (*T<0*) linked to the choice of high-quality products. The tax/subsidy does not depend on quantity at the optimum.[1] Indeed, they are a transfer between firms incurring *T* and taxpayers receiving *T*, so it does not impact the welfare in the absence of opportunity cost of public fund (which is an assumption made for simplicity).

In stage 2, the quality choice is determined by taking into account the decisions in stage 3. If both firms select the high quality, k_H, then the firm's overall profit is $\Pi_1=k_H/9-C-T$ and the overall welfare is $W_1=4k_H/9-2C$. If one firm selects the high-quality and the other one the low-quality, then the overall profit is $\overline{\Pi}_2=\pi_1(k_H,k_L)-C-T$ for the firm with high-quality products and $\underline{\Pi}_2=\pi_2(k_H,k_L)$ with the low-quality products. The overall welfare is $W_2=w(k_H,k_L)-C$. If both firms select the low-quality, k_L, then the firm's overall profit is $\Pi_3=k_L/9$ and the overall welfare is $W_3=4k_L/9$.

We first assume the absence regulation (no MQS and *T=0*) at stage 1 for characterizing private choices. When no regulation is decided at stage 1, each firm compares the possible profits for choosing quality. The selection of high-quality products by both firm is a subgame perfect equilibrium, if $\Pi_1>\underline{\Pi}_2$. In this case, no firm has an incentive to deviate for choosing low-quality products, leading to a profit $\underline{\Pi}_2$. The selection of high-quality products by one firm and the other one only selecting the low-quality products is a subgame perfect equilibrium, if

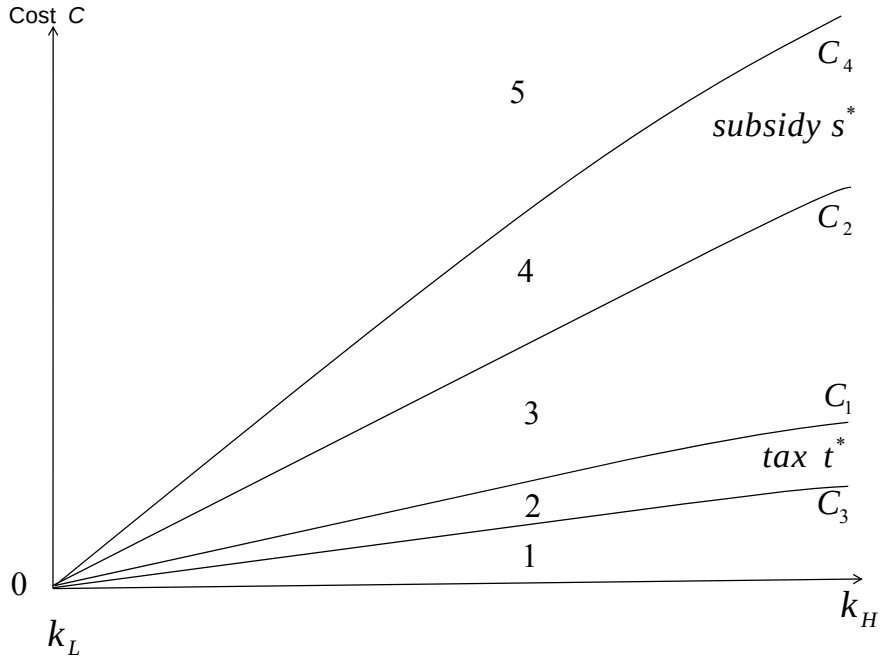
[1] Only a fixed tax or a fixed subsidy not depending on quantity is selected at the optimum. Such a tax does not influence selected quantities (and the resulting prices) in stage 3 and is better than a per-unit tax that would entail positive quantity distortions and a welfare reduction.

$\overline{\Pi}_2 > \Pi_3$ and $\underline{\Pi}_2 > \Pi_1$. The selection of low-quality products is the equilibrium, if $\overline{\Pi}_2 < \Pi_3$, since no firm has an incentive to offer high-quality products.

Figure 1 is useful for illustrating the private choices by firms under the absence of regulation. The high-quality, k_H, is located along the horizontal axis starting at k_L, and the high-quality cost, *C*, is located along the vertical axis. The quality spread ($k_H - k_L$) that is exogenously given influences the firm's optimal strategy.

In regions 1 and 2, namely for a cost $C < C_1$, the high-quality products are selected by both sellers, because of a relatively low cost of high-quality. In region 3, namely for a cost $C_1 < C < C_2$, the high-quality products are selected by only one seller with the other one selecting low-quality products. In regions 4 and 5, namely for a cost $C > C_2$, the low-quality products are selected by both sellers.

Figure 1: Private and public choices under Cournot competition



4. Regulator's Choices under Cournot competition

In stage 1, the policy is determined by taking into account the effort decision in stage 2 and the quantities decisions in stage 3. The regulator maximizes welfare by taking into account the firms' profits and the consumers' surplus. In our context, a MQS consists in imposing high-quality products to all firms and/or a tax (*T>0*) and/or subsidy (*T<0*) linked to the choice of high-quality products. Regulation may lead to a monopoly situation in period 2, if it is not compatible with a duopoly, namely for $\Pi_1 < 0$.

Figure 1 allows us to characterize firms' choices maximizing the welfare. Values of

welfare under various situations, W_1 , W_2 and W_3 are compared. In region 1, namely for a cost, $C < C_3$, the choice of high-quality products by both sellers maximizes the welfare. In regions 2, 3 and 4, namely for a cost, $C_3 < C < C_4$, a situation with high-quality products selected by only one seller with the other one selecting low-quality products maximizes the welfare. In region 5, namely for a cost, $C > C_4$, a situation with low-quality products selected by both sellers maximizes the welfare.

Private and social choices differ in areas 2 and 4. Indeed, the sunk cost *C*, incurred by a firm, is not passed on to consumers in the price in stage 3, leading to private choices further removed from socially optimal choices. There is a high-quality overinvestment by one firm in area 2. In area 4, there is a high-quality underinvestment by one firm. In regions 2 and 4, the regulator will try to select regulatory tools leading to firms' choices compatible with the welfare maximization. The optimal regulatory choice for determining the policy is presented in proposition 1.

Proposition 1. *The optimal choice for a regulator is:*

(i) *the absence of intervention in regions* 1, 3 and 5,

(ii) *a tax* $t^* = k_H / 9 - C - \pi_2(k_H, k_L)$ *on the quality effort in region 2,*

(iii) *a subsidy* $s^* = k_L / 9 + C - \pi_1(k_H, k_L)$ *linked to the quality effort in region 4.*

Proof: The MQS imposing high-quality is useless for areas 2 and 4. In area 2, both firms voluntarily chooses high-quality and a MQS does not impede one firm to select high-quality products. In area 4, the MQS imposing high-quality products lead to the exit of one firm, since $k_H / 9 < C$ for $C > C_2$. The welfare equal to $w(k_H, 0) - C = 3k_H / 8 - C$ under monopoly is (*i*) strictly lower than the welfare W_2 under duopoly for $C_2 < C < C_4$ and (*ii*) strictly lower than the welfare W_3 under duopoly for $C > C_4$.

For area 2 (with $C_3 < C < C_1$), the tax $T = t^*$ linked to the selection of high-quality products leads to different qualities selected by firms and to the maximum welfare equal to W_2 . The tax is such that $\Pi_1 \leq \underline{\Pi}_2$. The lowest level of tax $T = t^*$ is given by $\Pi_1 = \underline{\Pi}_2$. For this level $T = t^*$, one firm pays t^* and selects high quality products since $\overline{\Pi}_2 > \Pi_3$.

For area 4 (with $C_2 < C < C_4$), the subsidy $-T = s^*$ linked to the high-quality selection leads to different qualities selected by firms and to the maximum welfare equal to W_2 . The subsidy is such that $\overline{\Pi}_2 \geq \Pi_3$. The lowest level of subsidy $-T = s^*$ is given by $\overline{\Pi}_2 = \Pi_3$. For this level of subsidy, the other firm has no incentive to select the high quality since the inequality $\Pi_1 < \underline{\Pi}_2$ is satisfied for $-T = s^*$.

□

Proposition 1 means that tools exist for getting situations with a maximized welfare. It is optimal to subsidize or tax the quality effort, in order to implement different firms' choices corresponding to a situation of welfare maximization. These regulatory tools favour diversity

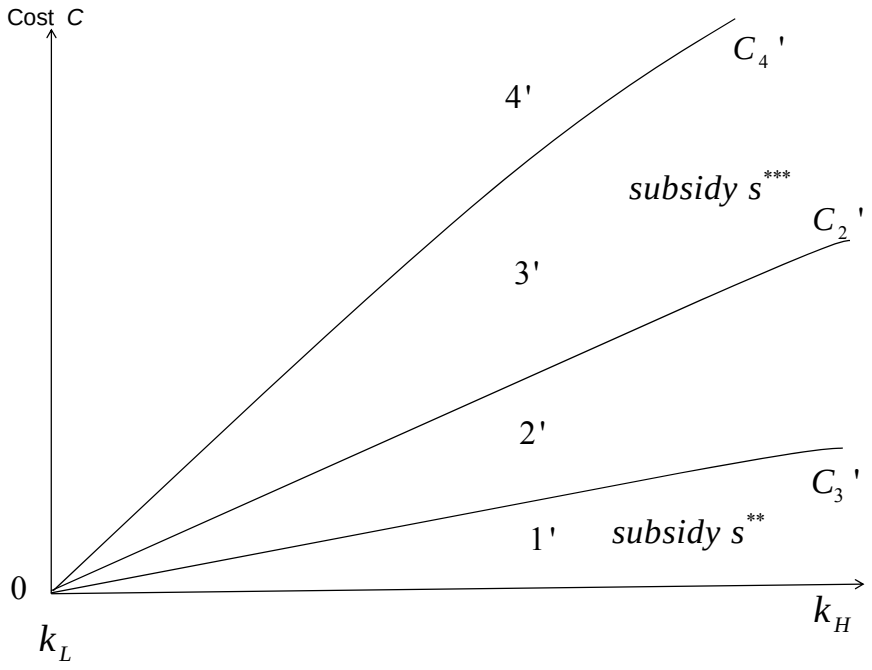
regarding the quality choices selected by firms. In region 2, the high-quality overinvestment for one seller is thwarted by a tax, t^* leading one firm to select low-quality. In this case, the MQS is ineffective (but never welfare decreasing), since there is a quality overinvestment by one firm. When the cost of high-quality is large (region 4), the regulator selects a subsidy s^* leading to the high-quality selection by only one seller. Consumers benefit from high-quality products selected by one seller. The MQS imposing high quality and/or leading to monopoly via the exit of one competitor is never selected since it would reduce competition and product diversity.

4. Bertrand competition

We briefly turned to the Bertrand competition at stage 3 (results are not detailed but can be provided upon request). The main difference compared to the previous Cournot case comes from the zero profit when firms choose the same quality level, $k_1 = k_2$ because of a more intense price competition. The incentive for differentiating products with a respective quality choice k_H and k_L by each firm is higher than under Cournot competition.

Figure 2 is useful for illustrating private and public choices by firms. In regions 1' and 2', namely for a cost, $C < C_2'$, high-quality products are selected by only one firm with the other one selecting low-quality products under the absence of regulation. In regions 3' and 4', only low-quality is selected under the absence of regulation. From a public perspective, the welfare maximization favours the selection of high-quality by both firms in area 1', the selection of different qualities by both firms in areas 2' and 3' and the selection of low quality products by both firms in area 4'.

Figure 2: Private and public choices under Bertrand competition



In regions 1' and 3', the regulator will try to select regulatory tools leading to firms' choices compatible with the welfare maximization. In area 1' (for $C < C_3'$), the subsidy $s^{**} = C + \pi_2(k_H, k_L)$ leads both firms to select high-quality profits. The MQS is ineffective to enforce the high-quality choice by both firms, because of firms' losses under duopoly leading to firm's exit.[2] In area 3' (for $C_2' < C < C_4'$), the subsidy $s^{***} = C - \pi_1(k_H, k_L)$ leads one firm to select high-quality profits, while the other one selects low-quality products. The MQS is ineffective for implementing the socially optimal allocation, since one firm will exit the market with the MQS, while the society values product diversity with the presence of both high and low quality products.

5. Conclusion

Using a very stylized framework, we showed that regulation is often necessary for correcting firms' quality choices. However, the MQS is dominated by alternative monetary tools, which is an important result. This simple model sheds light on the thorny task regarding the policy implementation. It suggests that it is especially imperative for governments to examine firms' profitability and incentive when quality policies are selected.

In order to focus on the main economic mechanisms and to keep the mathematical aspects as simple as possible, the analytical framework was admittedly simple. In order to fit different problems coming from various contexts, some extensions could be integrated into the model presented here. As the analysis was performed under duopoly, this paper can be a starting point for future research on the same issue in an oligopoly context with many firms. Another simplifying assumption was the discrete quality choice linked to an effort costing *C*. One possible extension would consist to consider a continuous choice of quality k at the beginning of stage 2 with a quadratic sunk cost given by k^2. Only numerical solutions are possible with this previous assumption (Valletti, 2000), but the regulatory choice could be extended by comparing a MQS and a tax/subsidy mechanism. Eventually, the opportunity cost of public funds could be taken into account, which would reduce the social benefits to intervene with tax or subsidies.

References

IMO (2003). International Maritime Organisation. "IMO meeting adopts accelerated single-hull tanker phase-out, new regulation on carriage of heavy fuel oil." December 4th 2003. Available October 2008 at http://www.imo.org/Safety/mainframe.asp?topic_id=758&doc_id=3341.

Mussa, M., and S. Rosen (1978) "Monopoly and Product Quality." *Journal of Economic Theory,* **18**, 301-317.

Ronnen, U. (1991). "Minimum Quality Standards, Fixed Costs, and Competition," *Rand Journal of Economics,* **22**, 490-504.

Valletti, T. M. (2000). "Minimum Quality Standards under Cournot Competition." *Journal of Regulatory Economics*, **18**, 235-245.

[2] The MQS is ineffective to enforce the high-quality choice by both firms. As the cost for high-quality is sunk in period 3, only one firm is able to cover the sunk cost with MQS, which would lead to a systematic monopoly price. Thus, one firm would exit the market in stage 2 and only the situation of a single firm offering products can be a subgame perfect equilibrium. The welfare under monopoly is strictly dominated by the welfare under duopoly.