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

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Earlier versions of this paper have been presented at the University of Mannheim and the Annual Conferences of the International Institute of Public Finance, Helsinki and the European Association for Research in Industrial Economics, Dublin. We would like to thank the participants there, and in particular Andreas Irmen and Paolo Panteghini for valuable discussions and hints. The usual disclaimer applies.
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Price Ceilings and Quality Competition

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Abstract

This paper investigates the quality implications of an upper limit on product prices in a vertically differentiated duopoly. It is shown that a price ceiling diminishes the incentives for strategic product differentiation, thereby improving average quality in the market.

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1. Introduction

Upper limits on product prices can be observed for a number of goods including, e.g., housing, food, drugs or utilities. While such regulations are often justified by the desire to prevent customers from paying 'too' high prices, there is also widespread belief that this comes at the cost of deteriorating product quality.[1]

It is the purpose of this article to revisit this belief in the framework of a vertically differentiated duopoly. We show that price ceilings appear in a somewhat different light, when their strategic implications are taken into account. As commonly known (d'Aspremont, Gabszewicz and Thisse, 1979; Shaked and Sutton 1982), the laissez-faire equilibrium in first-quality-then-price games displays maximal quality differentiation, as this allows firms to charge highest prices. However, the imposition of an effective price ceiling hinders firms from achieving these prices, which in turn diminishes the incentives to provide differing qualities. In particular, the low-quality firm is shown to enhance its quality compared to laissez-faire, whereas the choice of the high quality firm remains unaffected. As a consequence, an upper limit on product prices improves average quality in the market.

To the best of our knowledge, prior research has devoted no attention to a theoretical investigation of price ceilings on product quality in an oligopolistic setting. Previous studies have shed light on either monopolistic (Besanko, Donnenfeld and White, 1987) or competitive markets (Raymon, 1986), where the strategic interaction between firms is absent. Focussing on the repercussion of price regulation on product quality, our approach differs also distinctively from models of minimum quality standards (see, e.g., Ronnen, 1991), where quality is directly affected by regulatory constraints.

The paper is organized as follows. The next section outlines the basic features of the model and establishes the effects of price ceilings on equilibrium qualities. Section 3 concludes.

1 See, e.g., Albon and Stafford (1987) in the context of rent ceilings.

2. The model

Consider a model of a vertically differentiated market inspired by Shaked and Sutton (1982) and Tirole (1988) with two firms $i = 1, 2$, where $j \neq i$ denotes the competitor. Each firm produces a good of quality $s_i \in [s^-, s^+]$. The profit of firm i is: $\Pi_i = p_i D_i$, where p_i and D_i denote price and demand of its product.[2] Demand for each firm is determined by the choices of consumers, their total number being normalized to 1. The utility of a consumer buying a product from firm i amounts to $U_i(\theta) = \theta s_i - p_i$, where θ, the marginal utility of quality, differs among individuals. To simplify matters, we assume that θ is uniformly distributed in the interval $[\theta^-, \theta^+]$, with $1 > \theta^- > 0$ and $\theta^+ = \theta^- + 1$. Furthermore, we assume that every consumer buys exactly one unit, and makes a mutually exclusive choice between the two firms.[3]

The sequence of events is as follows. At stage 1, firms decide simultaneously on the quality s_i of their product. At stage 2, they set the corresponding prices p_i. At stage 3, consumers make their choice.

Looking for the subgame perfect Nash equilibrium, we first derive the demand functions by considering the consumers' problem at stage 3. Prices and qualities are fixed then, so one can easily determine the condition for the type $\tilde{\theta}$, indifferent between both products $\tilde{\theta} s_1 - p_1 = \tilde{\theta} s_2 - p_2$, giving:

$$\tilde{\theta} = \begin{cases} \theta^- & : \ \frac{p_2 - p_1}{s_2 - s_1} \leq \theta^- \\ \frac{p_2 - p_1}{s_2 - s_1} & : \ \theta^- < \frac{p_2 - p_1}{s_2 - s_1} < 1 + \theta^- \\ 1 + \theta^- & : \ \frac{p_2 - p_1}{s_2 - s_1} \geq 1 + \theta^-. \end{cases}$$

Without loss of generality, we assume $s_2 \geq s_1$. Thus, whenever firms supply different qualities, firm 2 is the high-quality and firm 1 is the low-quality firm. Demand results as $D_2 = 1 + \theta^- - \tilde{\theta}, D_1 = \tilde{\theta} - \theta^-$.

At stage 2, firms engage in price competition and maximize profits by choosing p_i, subject to the premise that product prices must not exceed an exogenously imposed level $\bar{p} > 0$. Product qualities are fixed at this stage. This leads to the following

2 As usual in the referring literature, production costs are neglected. We discuss this assumption in the conclusions section.

3 This is another common assumption in the literature (Tirole, 1988; Cremer and Thisse, 1991). An exception is Wauthy (1996).

reaction functions:

$$p_2(p_1) = \begin{cases} \min\left\{\frac{p_1}{2} + \frac{(1+\theta^-)\triangle s}{2}, \bar{p}\right\} & : \quad p_1 \leq (1-\theta^-)\triangle s, \\ \min\left\{p_1 + \theta^-\triangle s, \bar{p}\right\} & : \quad p_1 > (1-\theta^-)\triangle s, \end{cases}$$

$$p_1(p_2) = \begin{cases} 0 & : \quad p_2 < \theta^-\triangle s \\ \min\left\{\frac{p_2}{2} - \frac{\theta^-(s_2-s_1)}{2}, \bar{p}\right\} & : \quad \theta^-\triangle s \leq p_2 \leq (2+\theta^-)\triangle s \\ \min\left\{p_2 - (1+\theta^-)\triangle s, \bar{p}\right\} & : \quad p_2 > (2+\theta^-)\triangle s, \end{cases}$$

and equilibrium prices and demands:

$$(p_1^*, p_2^*) = \begin{cases} \left(\frac{\triangle s}{3}(1-\theta^-), \frac{\triangle s}{3}(2+\theta^-)\right) & : \quad \bar{p} \geq \frac{\triangle s}{3}(2+\theta^-) \\ \left(\frac{\bar{p}-\theta^-\triangle s}{2}, \bar{p}\right) & : \quad \frac{\triangle s}{3}(2+\theta^-) > \bar{p} > \theta^-\triangle s \\ (0, \bar{p}) & : \quad \theta^-\triangle s \geq \bar{p}, \end{cases} \quad (1)$$

$$D_2(p_1^*, p_2^*) = \begin{cases} \frac{2+\theta^-}{3} & : \quad \bar{p} \geq \frac{\triangle s}{3}(2+\theta^-) \\ 1 + \frac{\theta^-}{2} - \frac{\bar{p}}{2\triangle s} & : \quad \theta^-\triangle s < \bar{p} < \frac{\triangle s}{3}(2+\theta^-) \\ 1 & : \quad \bar{p} \leq \theta^-\triangle s, \end{cases}$$

$$D_1(p_1^*, p_2^*) = 1 - D_2(p_1^*, p_2^*).$$

Equation (1) shows that the effectiveness of the price regulation is governed by the quality differential $\triangle s = (s_2 - s_1)$, with the ceiling becoming effective only if qualities differ sufficiently: $\triangle s > \frac{3\bar{p}}{(2+\theta^-)}$. See Figure 1 for an equilibrium with such a binding price limit. At this stage, two things are worth noting: First, the price limit imposes a direct upper bound only for firm 2 as firm 1 must charge a lower price in order to attract any consumers. Nevertheless, a tighter price ceiling reduces also p_1, due to the strategic complementarity in prices. Second, the price ceiling modifies the price effects of the quality differential. With an ineffective regulation, product differentiation allows both firms to increase prices. However, when the ceiling is binding, a higher quality differential does not affect the decision of firm 2, but reduces the price set by the lower quality firm.

Taking these repercussions into account, firms choose qualities at the first stage. Maximizing $\Pi_2(s_1, s_2) = p_2^* D_2(p_1^*(s_1, s_2), p_2^*(s_1, s_2), s_1, s_2)$, firm 2 faces the following

first-order condition:

$$\frac{\partial \Pi_2}{\partial s_2} = \underbrace{p_2^* \frac{\partial D_2}{\partial s_2}}_{\text{direct effect}} + \underbrace{p_2^* \frac{\partial D_2}{\partial p_1} \frac{dp_1^*}{d\triangle s} \frac{d\triangle s}{ds_2}}_{\text{strategic effect}} = \begin{cases} \frac{(2+\theta^-)^2}{9} & : \quad s_2 \leq s_1 + \frac{3\bar{p}}{2+\theta^-} \\ \frac{\bar{p}^2}{2(\triangle s)^2} & : \quad s_1 + \frac{\bar{p}}{\theta^-} \geq s_2 \\ & \quad > s_1 + \frac{3\bar{p}}{2+\theta^-} \\ 0 & : \quad s_2 > s_1 + \frac{\bar{p}}{\theta^-}. \end{cases}$$

leading to:

$$s_2(s_1) = \left\{ s_2 \mid s_2 \in \left[s_1 + \frac{\bar{p}}{\theta^-}, s^+ \right] \right\}. \tag{2}$$

The first-order condition reveals that the choice of quality is influenced by both a direct and a strategic effect. The direct effect $p_2^* \frac{\partial D_2}{\partial s_2}$, the influence of the change in firm 2's quality on its demand, is positive, creating an incentive to increase quality. However, the sign of the strategic effect, measuring how a change in own quality affects demand through changing the competitor's price via the quality differential, depends on whether the price ceiling is effective or not: With an ineffective regulation, firm 1 responds to a higher quality differential by charging a higher price. Then, the strategic effect is positive. The opposite holds when the price ceiling is binding, for firm 1 cuts its price in such a situation. However, the direct effect always dominates the strategic effect, thus choosing the highest possible quality is always worthwhile for firm 2, as illustrated in Figure 2, where for ease of exposition, the quality bounds s^-, S^+ have been omitted.[4]

Firm 1 faces a similar problem. Returns from increasing quality are:

$$\frac{\partial \Pi_1}{\partial s_1} = \underbrace{p_1^* \frac{\partial D_1}{\partial s_1}}_{\text{direct effect}} + \underbrace{p_1^* \frac{\partial D_1}{\partial p_2} \frac{dp_2^*}{d\triangle s} \frac{d\triangle s}{ds_1}}_{\text{strategic effect}} = \begin{cases} -\frac{(1-\theta^-)^2}{9} & : \quad s_1 \geq s_2 - \frac{3\bar{p}}{2+\theta^-} \\ \frac{\bar{p}^2}{4(\triangle s)^2} - \frac{\theta^{-2}}{4} & : \quad s_2 - \frac{3\bar{p}}{2+\theta^-} > s_1 \\ & \quad \geq s_2 - \frac{\bar{p}}{\theta^-} \\ 0 & : \quad s_1 < s_2 - \frac{\bar{p}}{\theta^-}. \end{cases}$$

As can be seen from Figure 3, firm 1 profits from decreasing quality as long as the quality differential is so low that the ceiling is ineffective.[5] This holds because the loss in demand incurred by providing lower quality at given prices (direct effect) is lower

4 Firm 2 is indifferent between all s in the interval $\left[s_1 + \frac{\bar{p}}{\theta^-}, s^+ \right]$, because for every $s_2 > s_1 + \frac{\bar{p}}{\theta^-}$ both the direct and the strategic effect become zero, for firm 1 is driven out of the market. Thus, there exists a continuum of profit maximizing qualities.

5 Again, the technological quality bounds are not drawn into the figure.

than the demand gained by inducing firm 2 to set a higher price (strategic effect). However, providing an even lower quality it is not advantageous for the strategic effect vanishes when the ceiling is effective: $\frac{dp_2^*}{d\triangle s} = 0$. No additional demand can be gained as firm 2 cannot increase its price $\bar{p}$. Thus, we get the reaction function:

$$s_1(s_2) = \max\left\{s^-, s_2 - \frac{3\bar{p}}{2+\theta^-}\right\}. \tag{3}$$

Solving (2) and (3) for the equilibrium qualities gives (see also Figure 4):

$$(s_1^c, s_2^c) = \begin{cases} (s^-, s^+) & : \quad \bar{p} \geq \frac{s^+ - s^-}{3}(2+\theta^-) \\ \left(s^+ - \frac{3\bar{p}}{2+\theta^-}, s^+\right) & : \quad \bar{p} < \frac{s^+ - s^-}{3}(2+\theta^-). \end{cases}$$

When the price ceiling is high enough such that it is ineffective in equilibrium (laissez-faire competition), the market displays maximal differentiation (d'Aspremont, Gabszewicz and Thisse, 1979; Shaked and Sutton 1982). That is, in order to relax price competition and to prevent the Bertrand zero-profit outcome, firms have an incentive to differentiate themselves as much as possible with respect to quality. A tighter ceiling diminishes these incentives, leading to the following

Proposition. *The imposition of a binding price ceiling increases the quality provided by the low-quality firm compared to laissez-faire price competition. The quality chosen by the high-quality firm remains unaffected. Thus, the ceiling increases average quality in the market.*

3. Conclusion

We have addressed the question how a price ceiling affects product quality. In contrast to previous research we have incorporated strategic behavior both in prices and qualities in a vertical differentiation duopoly model. Altering the strategic effects, an upper limit on prices is found to improve average product quality. In particular, the strategic effect is eliminated for the low-quality firm.[6]

The fact that firms differentiate themselves to a lower extent than under laissez-faire competition is reminiscent of the loss of product diversity in models of horizontal differentiation when price competition becomes absent (Hotelling, 1929; d'Aspremont,

6 This fact leads us to conclude that a similar quality-enhancing effect of price ceilings arises also for non-uniform distributions of consumer preferences.

Gabszewicz and Thisse, 1979). As Cremer and Thisse (1991) have pointed out, some classes of vertical and horizontal differentiation models are equivalent. However, our model does not fulfill their equivalence condition. Furthermore, there exists a general difference between horizontal and vertical differentiation models in terms of price regulation. Contrary to a horizontally differentiated duopoly, where both firms choose identical equilibrium prices, price ceilings affect firms asymmetrically in vertical differentiation models. This is, roughly speaking, due to the fact that for identical prices consumers' choices differ among products in horizontal differentiation models, whereas they coincide in vertical differentiation models. Consequently, the low-quality firm has to charge lower prices than the high-quality firm and the ceiling becomes binding only for the latter. This effect, which is absent in Hotelling-type models, is responsible for our quality improvement result.

In accordance with much of the literature (see, e.g., Tirole, 1988, Wauthy, 1996), we have highlighted the strategic ramifications by abstracting from costs of quality choice. Obviously, when such costs are considered, firms have to weigh them against direct and strategic effects in their quality choices. However, as long as quality is not too costly and the ceiling is not too tight, an upper limit on prices has still a positive impact on the average quality of products in the market.

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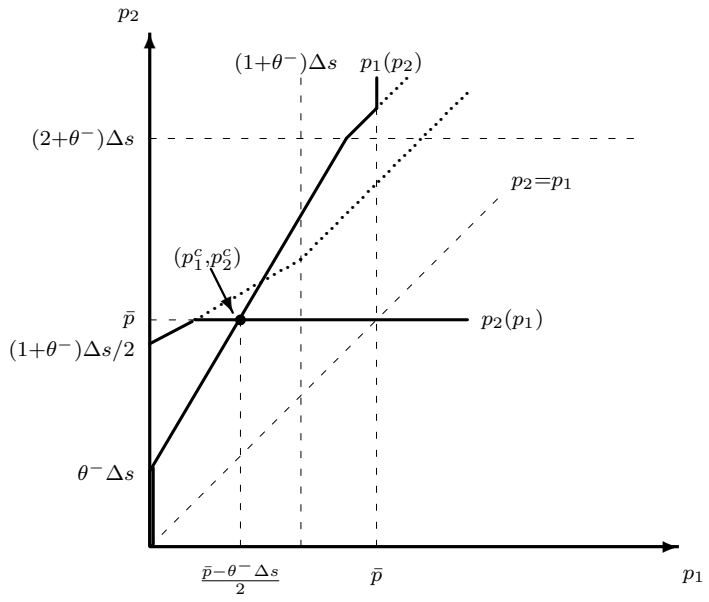

Figure 1: Price equilibrium under a binding price ceiling

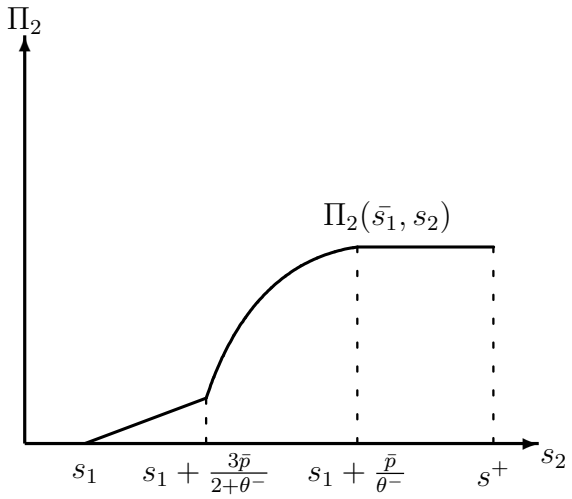

Figure 2: Profit as a function of quality for firm 2

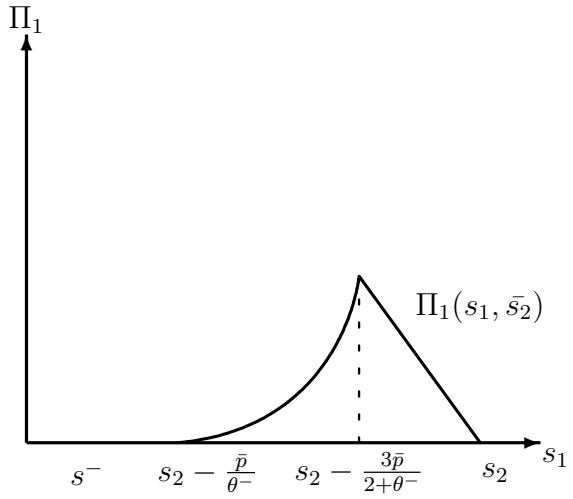

Figure 3: Profit as a function of quality for firm 1

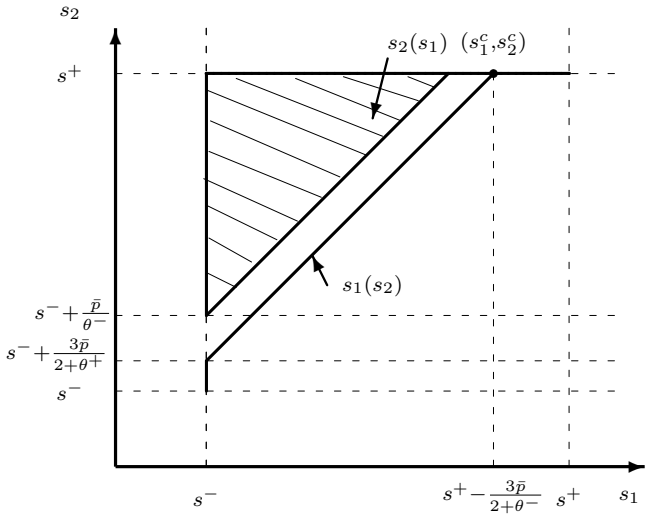

Figure 4: Equilibrium qualities