Strategic pricing and entry deterrence under price cap regulation

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Abstract

This paper shows that dynamic price cap regulation allows the regulated firm to deter entry. Under dynamic price cap regulation, the allowed prices in each period are an increasing function of the prices set in the previous period. By setting a low price before entry, the regulated firm can commit itself to charge a low price in the event of entry. If this price is sufficiently low with respect to the potential entrant's fixed cost, entry does not occur. Whether the regulated firm prefers to deter or accommodate entry depends on the level of the entry cost for the prospective entrant, on the tightness of the price cap and on the degree of market power of the competing firms in case of entry. (JEL classification: L13, L50. Key words: Price cap regulation, entry deterrence.)

1 Introduction

Price cap regulation, first introduced in the UK in the 1980s, is a regulatory scheme widely used for utilities across the world. Basically, it entails a constraint on an index of prices set by the regulated firm. Its widespread use is the result of its very appealing properties; as analysed in the literature (see, for instance, Vogelsang and Finsinger [19], Bradley and Price [6], Brennan [7], Vogelsang [18] and Iozzi *et al.* [11]), price cap regulatory schemes perform very well with respect to both allocative and productive efficiency objectives when the regulated firm is a natural monopolist. Indeed, it can be shown that, together with optimal characteristics typical of fixed–price regulatory schemes with respect to productive efficiency, an appropriate definition of the price index guarantees that prices tend to converge to second best prices in the long–run equilibrium.[1]

These very desirable properties of price cap plans have been shown to hold when the regulated firm is a multi–product monopolist. This was the prevalent market struc-

[1]Second best prices are those prices, usually called Ramsey prices after the seminal paper by Ramsey [14] and analysed further by Boiteux [4] and Baumol and Bradford [3], which maximise the welfare of the society, provided that the monopolistic firm is able to obtain a given level of profits.

ture in regulated industries when price caps were first introduced. However, most if not all of these industries have recently undergone dramatic structural changes that have made the condition of natural monopoly that once characterised the whole industry applicable only to a subset of markets in the industry. The result has been the development of either actual or potential competition in some of the markets served by the regulated firm. In spite of these structural changes having affected most of the regulated industries, little attention has been devoted in the recent literature to the analysis of the effects of price caps in industries where the regulated firm faces actual or potential competition by other rivals.

This paper attempts to further our understanding of price cap regulation in industries where there is potential competition. In particular, the main focus of the paper is on the relationship between dynamic price cap regulation and entry deterrence. Under dynamic price cap regulation, a firm is required to set its prices in each period of time so that an index of these prices is weakly smaller than an index based on the prices set in the previous period. This implies that the lower the prices set by the firm in each period of time the tighter are the constraints the firm faces in the following periods.[2]

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[2] For a more general discussion of dynamic price cap mechanisms,

A typical example of dynamic price cap regulation is the Laspeyres–type price cap. It constrains the firm to set prices so that their weighted average is lower than the weighted average of previous period prices, with weights in both cases given by the previous period revenue shares.[3] This is basically the regulatory constraint which is imposed on many regulated firms across the world, such as British Telecom and the water companies in the UK as well as Telecom Italia and the motorways concessionaires in Italy. Another example of dynamic price cap has been used in the US to regulate AT&T since the beginning of the '90s. Under this constraint, the firm's average revenue is constrained not to exceed a specified cap, where average revenue is calculated using the quantities sold by the firm at previous period prices.[4]

In this paper, I study a very stylised example of a one–market two–period industry. An incumbent regulated firm is a monopolist in the first period and faces some potential competition in the second period. In this very simple set-

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see Armstrong *et al.* [2], pp. 79-85.

[3]More specifically, abstracting from any adjustments for inflation and productivity growth and assuming that the firm produces N goods, the typical formula for the Laspeyres–type price cap – also called *tariff basket* – is $\sum_{n=1}^{N} p_n^t q_n^{t-1} \leq \sum_{n=1}^{N} p_n^{t-1} q_n^{t-1}$.

[4]The stylised version of this formula is $\sum_{n=1}^{N} p_n^t q_n^{t-1} \leq \sum_{n=1}^{N} \overline{p} q_n^{t-1}$, where $\overline{p}$ is exogenously set by the regulator.

ting, the regulatory constraint that the dynamic price cap usually imposes on an index of the current prices relative to an index of the previous period prices simply reduces to a constraint on the level of the only current price relative to the equally unique previous period price. In other words, in this paper dynamic price cap constrains the regulated firm to set a price in each period lower than the price charged in the previous period.

This very simple set–up allows nonetheless to capture the essential feature of dynamic price cap regulation of making the economic environment faced by the regulated firm in each period dependent on the choices made by the firm in the previous period. This feature is crucial in creating the conditions that allow the regulated firm to deter entry. Indeed, the economic analysis of entry deterrence shows that for an incumbent firm to deter entry, it is necessary to take an action before entry which makes the equilibrium payoff of the potential entrant in the case of entry lower than its reservation level.[5] In creating a link between periods, a dynamic price cap allows the choices made by the firm at time $t-1$ to affect the economic environment at time t and, through this, the market equilibrium resulting from the choices made by the firm itself and by its poten-

[5] See, for instance, the seminal papers by Spence [17] and Dixit [8] and [9].

tial competitors. In the set–up adopted in this paper, the dynamic price cap implies that the allowed price today is an increasing function of the price yesterday. Therefore, when a potential competitor may enter at time t, the regulated incumbent may set a low price at time $t-1$ to commit itself to charge a low price also in the following period. Knowing the price set by the incumbent at time $t-1$ and anticipating its optimal choice in the following period, the potential entrant may find it optimal to stay out of the market.

The main finding of this paper is that, under dynamic price cap regulation, a regulated incumbent may find this entry deterring behaviour more profitable than entry accommodation. Not surprisingly, it is found that the incumbent prefers to deter entry when the level of the entry cost for the prospective entrant is high. As in the model under analysis the incumbent would not be able to deter entry in the absence of regulation, it is has to be emphasised that it is price cap regulation itself that allows the regulated incumbent to deter entry.

The paper also illustrates that the initial level of the price cap and the degree of market power enjoyed by the firms in case of entry affects the relative profitability of the two types of behaviour of the incumbent. As to the first issue, the tighter the price cap the more likely it is that the incumbent prefers to deter entry rather than to accommodate it. The reason for this is that a tight price cap causes the incumbent firm to obtain very small profits when it accommodates entry. As profits under entry deterrence do not depend on the level of the price cap, a tight cap makes entry deterrence relatively more profitable than entry accommodation. On the other hand, the closer substitute the goods produced by the incumbent and the entrant in case of entry, the more likely it is that the incumbent prefers to deter entry rather than to accommodate it. The reason for this result is that, when the competition after entry is particularly fierce, the profits for the incumbent's profits are low thus raising the potential gains from entry deterrence.

The possibility of strategic manipulation of the pricing decisions by a price capped firm is derived in a single market setting but easily extends to the case of a multi–product price capped firm. In this context, entry clearly depends only on the prices prevailing in the competitive markets after entry. However, the prices charged in these markets by a multi–product price capped firm depend both on the general level of the cap and on the prices charged in the other markets. This paper focuses on the first determinant. By taking the only price charged by the single–product firm analysed in this model as a stylised description of the average level of prices charged by a multi–product firm, the paper shows that a strategic manipulation of the price level today may reduce the likelihood of entry tomorrow. Indeed, a low (overall) price level today leads to a low (overall) price level tomorrow. This causes a low level also of the prices set by the regulated firm in the competitive markets and therefore reduces the likelihood of entry. As to the the relationship between entry and the structure of prices, in a companion paper (Iozzi [11]) I show that a multi–product firm regulated by a Laspeyres–type price cap which faces potential competition in some of the markets it serves may also want to manipulate strategically the price structure before entry. The firm strategically chooses the prices before entry in order to face a tighter constraint (i. e. higher weights in the price cap formula) on the prices of the competitive products in case of entry. Hence, this pre–entry strategic behaviour creates a commitment to an aggressive pricing in case of entry and may deter the potential entrant from entering the market.

The issue of strategic pricing under dynamic fixed–price regulatory schemes has attracted the attention of scholars since the first model of a regulatory scheme of this kind by Vogelsang and Finsinger [19]. The existing literature focuses on the analysis of purely monopolistic markets and on the possibility of strategical manipulation of the monopolist's choices to *soften* the future price constraints. Sappington [15] shows that the optimality properties of the long–run equilibrium prices under the Vogelsang–Finsinger mechanism can be altered by the strategic behaviour of the regulated firm, which may take advantage of welfare–reducing waste of resources in anticipation of regulation. Other papers have focused on the possibility of strategic manipulation of the price structure. Sappington and Sibley [16] show that the intertemporal linkages embodied in average revenue price cap regulation can provide incentives for the regulated firm to engage in strategic nonlinear pricing. Foreman [10] and Law [13] both show that, in a two–period two–market setting, a multi–product monopolist regulated by a Laspeyres–type price cap may find it profitable to make use of the first period choice variables to manipulate the weights attached to each price in the following periods and relax the constraint of the price formula. This strategic behaviour is shown to lower society's welfare and to occur when the regulator sets too tight a price cap.

Differently from this literature, this paper analyses the case of a price capped firm under an entry threat. This allows one to see that the regulated firm may find it profitable to choose its current price level to *tighten* the price constraints in the following periods. The dynamic features of the regulatory mechanism may then be used as a commitment device for an aggressive pricing behaviour in case of entry.

The effects of price cap regulation on the development of competition in regulated industries has already been analysed by Bös and Nett [5] and by Armstrong and Vickers [1]. Both papers use a single–period model, so that the regulated firm cannot strategically use its prices. Bös and Nett [5] study a duopoly game with quantity pre–committment where one of the firms is price capped. They find that the lower the cap the lower is the capacity and output of the entrant. However, regulation prevents entry only when the level of the price cap is too low to allow the entrant to cover its capacity costs, that is when it is the regulator which forces the potential entrant to stay out of the market. Armstrong and Vickers [1] analyse a different setup with a static two–market model and where there is potential competition in one of the markets. They show that average price cap regulation may adversely affect the development of competition. In particular, they show that average price cap regulation encourages a behaviour by the regulated incumbent which is more aggressive than the behaviour the firm would adopt if the different prices were capped separately. This is because the regulated firm may make up in the captive market the revenues it foregoes by setting a low price in the competitive market. Thus, average price cap regulation results in lower likelihood of entry or in entry at a smaller scale by the competitors.

The structure of this paper is as follows. Section 2 presents the model. Section 3 details the equilibrium of the game under analysis. Some concluding remarks are given in Section 4. All the proofs are relegated to Appendix A.

2 The model

Consumption occurs over periods 1 and 2. Firm i – referred to as the incumbent in the rest of the paper – operates in the industry over the two periods; a potential entrant – firm e – may enter in the second period. In case of entry, the two firms produce non–homogeneous goods and compete in prices. The incumbent is a price leader: this may be due to institutional reasons which restrict the pricing flexibility of this firm only. For instance, these may take the form of obligations to publish prices or requirements of authorization by the regulator for new prices.

In each period t (where $t = 1, 2$), the (inverse) market demand for each firm k is given by $p_t^k(q_t^k, q_t^m) = 1 - q_t^k - sq_t^m$, where $k, m = i, e$ and $k \neq m$. The taste parameter s is assumed to be such that $s \in (0, 1)$, which is equivalent to saying that the two firms produce (imperfectly) substitute goods. Clearly, in the first period and in the second period when entry does not occur, the (inverse) market demand faced by the incumbent reduces to $p_t^i(q_t^i, 0) = 1 - q_t^i$. Let $q_t^k(p_t^k, p_t^m)$ (where $k, m = i, e$ and $k \neq m$) denote the (direct) demand function faced by firm k at time t.[6]

Both firms produce with constant and identical marginal cost, which is normalised to zero without further loss of generality. In case of entry, the entrant has to bear an entry cost equal to $F = f^2$. A similar cost was borne by the incumbent in the past and, since it plays no role in the analysis, it is not formalised here. It is assumed that the two firms have zero discount rate.

The incumbent is subject to dynamic price cap regulation. This implies that the regulated firm is constrained to set in every period a price weakly lower than the price in the previous period. Formally, in every period t it faces a constraint $p_t^i \leq \overline{p_t}$ where $\overline{p_t} \equiv p_{t-1}^i$. In the first period, since no previous period exists, the price cap takes on an exogenous value $\overline{p_1}$, where it is assumed that $\overline{p_1} \in \left(0, \frac{1}{2}\right)$. This implies that the regulated firm is never allowed to

[6] The main results of the paper can be obtained also under different assumptions on the nature of the strategic interaction between firms in case of entry. Indeed, Iozzi [11] obtains the same results as in this paper assuming that the entrant is a price taker firm with an upward sloping supply function, while the incumbent operates along the residual demand curve. The crucial common feature of the two models is that the entrant's profits in case of entry are decreasing with the price set by the incumbent. Intuitively, this is the only condition on the nature of strategic interaction between firms which is necessary to show the possibility of strategic pricing under dynamic price cap regulation.

choose the monopoly price but it is never forced to produce at loss.

Insert Fig. 1 about here

The structure of the game I analyse is illustrated in Figure 1. At time 1, the incumbent firm sets $p_1^i \in [0, 1)$, under the constraint given by the price cap formula $p_1^i \leq \overline{p_1}$. At time 2, three sequential stages can be identified. In stage 2.a, the potential entrant decides whether or not to enter, choosing between In and Out and bearing fixed costs equal to f^2 in case of entry. Entry occurs when the potential entrant forecasts it can obtain strictly positive profits after entry.[7] In Figure 1, this decision is taken at node 2.a. In stage 2.b, the incumbent firm can find itself at the two different nodes 2.b.i and 2.b.ii, depending on the rival's previous choice on entry. It chooses $p_2^i \in [0, 1)$ under the constraint of a price formula $p_2^i \leq \overline{p_2} \equiv p_1^i$. In stage 2.c, if entry has occurred, the entrant sets its price $p_2^e \in [0, 1)$.

[7] If one sets to zero the level of the potential entrant's reservation profits, it is customary to assume that a forecast of weakly positive equilibrium profits is sufficient for the potential entrant to choose to enter. On the contrary, for technical reasons I assume that only a forecast of strictly positive profits convinces the potential entrant to enter.

It is assumed that players have perfect knowledge of the past history of the game at each stage in which they are taking an action. Because of this and of the structure of the game described above, the game is solved by backward induction.

Profits for the incumbent are given by

$$\begin{aligned}\Pi^i(p_1^i, p_2^i, p_2^e) &= \Pi_1^i(p_1^i) &&+ \Pi_2^i(p_2^i, p_2^e) \\ &= q_1^i(p_1^i) \cdot p_1^i &&+ q_2^i(p_2^i, p_2^e) \cdot p_2^i\end{aligned} \tag{1}$$

while profits for the entrant are given by

$$\Pi_2^e(p_2^e, p_2^i, f) = q_2^e(p_2^e, p_2^i) \cdot p_2^e - f^2. \tag{2}$$

3 The equilibrium of the game

This section characterises the equilibrium of game under the two alternative (and traditional) types of behaviour of *entry accommodation* and *entry deterrence* and derives the conditions under which the different types of behaviour are preferred by the incumbent.

Solving the game backwards, it is first necessary to characterise the equilibrium of the second period sub–games.

Consider first the sub–game in case of entry. At node 2.c, firm e chooses a price which is the best reply to the price set by the rival in the previous stage. Let $p_2^{e*}(p_2^i)$

be this price as a function of the rival's price. Using (2), $p_2^{e*}(p_2^i) = \frac{1}{2}(1 - s + sp_2^i)$. In the previous stage, the incumbent chooses its price to maximise $\Pi_2^i(p_2^i, p_2^{e*}(p_2^i))$, subject to the price cap constraint $p_2^i \leq \overline{p_2} \equiv p_1^i$. Denoting this price with $p_{2(In)}^i(p_1^i)$, it is easy to show that $p_{2(In)}^i(p_1^i) = \min\left\{p_1^i, \frac{2-s^2-s}{2(2-s^2)}\right\}$. In the first stage of this period, the entrant anticipates this equilibrium price and decides to enter if it forecasts obtaining strictly positive profits, that is if

$$\Pi_2^e(p_2^{e*}(p_{2(In)}^i), p_{2(In)}^i, f) = \frac{(1 - s + sp_{2(In)}^i)^2}{4(1 - s^2)} - f^2 > 0. \tag{3}$$

Note that the entrant decides to enter only if the level of the entry cost is sufficiently low relatively to the price set by the incumbent in the second period in case of entry.

Consider now the sub–game in case of no entry. Denoting by $p_{2(Out)}^i$ the optimal price set by the incumbent when it operates as a monopolist and faces the price cap constraint $p_2^i \leq \overline{p_2} \equiv p_1^i$, it is easy to show that $p_{2(Out)}^i(p_1^i) = p_1^i$.

Before proceeding with the analysis of the two–stage game, I make the following assumption on f:

$$\frac{1-s}{2\sqrt{1-s^2}} < f < \min\left\{\frac{1-s+s\overline{p_1}}{2\sqrt{1-s^2}}, \frac{\sqrt{1-s}(4+2s-s^2)}{4\sqrt{1+s}(2-s^2)}\right\}. \tag{4}$$

This assumption guarantees that entry is a profitable option for the entrant in the absence of entry deterring behaviour by the incumbent and, at the same time, that entry deterrence is a feasible option for the incumbent.

This assumption is justified by my focus on the relative profitability of the two types of behaviour – entry deterrence or entry accommodation – of the incumbent. Hence, I concentrate my analysis only on those parametric conditions under which, on the one hand, both types of behaviour are possible for the incumbent and, on the other hand, entry actually depends on the behaviour of the incumbent. More specifically, the condition given by the RHS inequality in (4) is motivated by the need to rule out the parametric conditions under which entry is blockaded. This would imply that entry does not occur in any event, as entry would be unprofitable for the entrant irrespective of the behaviour adopted by the incumbent. On the other hand, the condition given by the LHS inequality in (4) implies that entry deterrence is actually feasible. Indeed, the condition guarantees that the price that the incumbent has to set in the competitive market in the second period to deter entry is positive, i.e. it is above its marginal cost.

I turn now to analysing the whole two–stage game. The following Proposition characterises the optimal prices for the incumbent when it accommodates entry.

Proposition 1. *Let p_1^{iA} and p_2^{iA} be the optimal prices set by firm i in the first and second periods respectively when it accommodates entry. Then,*

$$p_1^{iA} = \overline{p_1}$$

and

$$p_2^{iA} = \min\left\{\overline{p_1}, \frac{2 - s^2 - s}{2(2 - s^2)}\right\}.$$

Setting the first period price equal to $\overline{p_1}$, the incumbent obtains the highest possible profits in the first period and, at the same time, makes the price cap constraint as slack as possible in the following period. This allows the firm to set in the second period a price high enough to accommodate entry. Note that, when the price cap is particularly high in the second period, the incumbent prefers to set a price such that the price cap is not binding. This is due to the presence of the entrant which lowers the optimal unconstrained price for the incumbent.

In principle, it could be the case that entry would not occur even if the incumbent accommodated entry. This could occur if the level of entry cost for the entrant were particularly high. However, using (3), it is easy to see that assumption (4) is sufficient to rule out this case.

Consider now the case when firm i deters entry. In order to deter entry, the incumbent has to choose a price in the first period such that, in the second period, the profit maximising price (in the event of entry) subject to the price cap constraint does not allow the entrant to make positive profits. Then,

Proposition 2. *Let p_1^{iD} and p_2^{iD} be the optimal prices set by firm i in the first and second periods respectively when it deters entry. Then,*

$$p_1^{iD} = p_2^{iD} = \frac{s - 1 + 2f\sqrt{1 - s^2}}{s}.$$

In order to understand the rationale behind this Proposition, note that, when the entrant optimally chooses its quantity, it makes positive profits if and only if $p^i_{2(In)} > \frac{s-1+2f\sqrt{1-s^2}}{s}$. Hence, when the incumbent wants to deter entry, it has to make it optimal to set a price just equal to $\frac{s-1+2f\sqrt{1-s^2}}{s}$ in the second period in the event of entry. The only first period choice that makes it optimal to charge such a price in the second period is to charge the same price also in the first period.

I can now turn to describing the equilibrium of the two–stage game. This is done in the following Proposition.

Proposition 3. *Let*

$$f^* \equiv \begin{cases} \frac{(2-s)\sqrt{1-s^2}-s\kappa_1}{4(1-s^2)} & \text{if } \overline{p_1} \leq \frac{2-s^2-s}{2(2-s^2)} \\ \frac{2(s^3-2s^2-2s+4)\sqrt{1-s^2}-s\kappa_2}{8(2-s^2)(1-s^2)} & \text{if } \overline{p_1} > \frac{2-s^2-s}{2(2-s^2)} \end{cases} \tag{5}$$

where

$$\kappa_1 \equiv \sqrt{(4-3s^2)\overline{p_1}^2 - (4-3s^2-s)\overline{p_1} + 1 - s^2};$$

$$\kappa_2 \equiv \sqrt{(\kappa_3\overline{p_1}^2 - \kappa_3\overline{p_1} - 3s^3 + 4 + 8s - s^2)(1-s)(2-s^2)}$$

and

$$\kappa_3 \equiv 8(2-s^2)(1+s).$$

The equilibrium of the game is given by the following sequence of actions:

- *when* $f < f^*$*:*

  Time 1: *incumbent sets* p_1^{iA}*;*

  Time 2: *entrant chooses* In*, incumbent sets* p_2^{iA}*, and entrant chooses* $p_2^{e*}(p_2^{iA})$*;*

- *when* $f > f^*$*:*

Time 1: *incumbent sets* p_1^{iD}*;*

Time 2: *entrant chooses Out, incumbent sets* p_2^{iD}.

The Proposition illustrates that the incumbent prefers to accommodate entry when the entry cost is smaller than the critical value f^*. The reason for this is the following. In order to deter entry, the incumbent sets a sub–optimal price before entry to make the price cap tight enough in the following period. In this way, it commits itself to charge in case of entry a price which is low enough to make entry unprofitable. The cost of this sub–optimal choice in the first period increases as the value of the entry cost for the potential entrant decreases. The reason for this is that profits when deterring entry negatively depend on f while they are independent of f under entry accommodation. Hence, the smaller the entry cost the higher is the relative cost of entry deterrence.

Also, I can state the following result:

Proposition 4. f^* *increases as* $\overline{p_1}$ *increases.*

The Proposition says that the tighter the initial price cap the more likely is entry deterrence to be the preferred behaviour by the incumbent. This is because the lower $\overline{p_1}$ the lower is the value of f^*, that is the smaller is the minimum value of the entry cost for the entrant which makes the incumbent prefer deterring entry. Hence, a given cost structure of the two firms may lead the incumbent to accommodate entry only for a sufficiently high value of $\overline{p_1}$. If $\overline{p_1}$ is set to a lower value, even with the same cost structure, the incumbent may prefer to deter entry instead.

The economic reason for this result is that a low $\overline{p_1}$ reduces the profits the incumbent can obtain when it accommodates entry. As profits under entry deterrence are independent of $\overline{p_1}$, a low cap also reduces the cost that the incumbent has to incur in deterring entry. Hence, *ceteris paribus*, deterring entry is relatively more profitable than entry accommodation the tighter is the level of the price cap.

Moreover,

Proposition 5. *f^* decreases as s increases.*

The Proposition says that the closer substitute the goods produced by the incumbent and the entrant in case of entry, the higher it is the value of the entrant's fixed cost that makes the incumbent indifferent between deterring and accommodating entry. The reason for this result is that, when the competition after entry is particularly fierce, the profits for the incumbent's profits are low. Hence, other things being equal, it is more likely that the incumbent prefers to deter entry because of the higher gains from being the only supplier in the market. The result given in the Proposition is also illustrated in Figure

2, which plots f^* against s when $\overline{p}_1 = 0.3$. The Figure also shows the lower and upper boundary of the interval within which f should fall for an equilibrium of the model to exist.

Insert Fig. 2 about here

In terms of policy indications, this result suggests that, if the regulator were able to reduce the competitiveness of the industry after entry (e.g. by an appropriate policy with respect to standard), this would facilitate entry. This recommendation echoes the usual argument that suggests that new entrants should be protected from competition to ease the development of competition. However, in the context of this paper, a reduction of the level of competitiveness in the market after entry affects the development of competition in so far as it increased the profits for the incumbent in case of entry, thus making relatively less profitable the choice of deterring entry.

4 Conclusions

This paper shows that the adoption of a dynamic price cap mechanism to regulate a monopolist may hamper the possibility of the development of competition in the industry. Using a very simple model, this paper shows that the regulated firm may deter entry by choosing strategically the price level before entry. Also, it shows that the tighter the price cap and the fiercer the competition in case of entry, the more likely it is that the regulated firm finds this anticompetitive behaviour more profitable.

In terms of policy implications, the paper suggests the downward flexibility under price cap regulation may be used by the regulated firm to limit the development of competition. Hence, prices below the cap should be closely monitored by the regulator (and/or the competition authority) to prevent this from occurring. Also, the paper indicates that the lifting of regulatory constraints should not just follow the development of competitive conditions in the regulated markets. Rather, it should occur at the same time as entrants have just committed to enter the regulated markets. The reason for this is that, in the presence of these regulatory constraints, the development of competition may not start at all.

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A Appendix

The derivation of most of the results of the paper, obtained by use of standard constrained maximisation techniques, is omitted here and is available from the author upon request.[8]

In particular, the proofs of Propositions 1 and 2 involve the simple application of backward induction solution methods and are omitted. I merely here a sketch of the proofs of Propositions 3 and 4.

Proof of Proposition 3. Let Π^{iA} and Π^{iD} be the incumbent's profits when it accommodates and deters entry respectively. Equilibrium profits under entry accommodation are given by

$$\Pi^{iA} = \begin{cases} (1-\overline{p_1})\overline{p_1} + \frac{(2-s-s^2+s^2\overline{p_1}-2\overline{p_1})\overline{p_1}}{2(1-s^2)} & \text{if } \overline{p_1} \leq \frac{2-s^2-s}{2(2-s^2)} \\ (1-\overline{p_1})\overline{p_1} + \frac{(2+s)^2(1-s)}{8(1+s)(2-s^2)} & \text{if } \overline{p_1} > \frac{2-s^2-s}{2(2-s^2)} \end{cases} \tag{6}$$

and

$$\Pi^{iD} = 2\left(1 - \frac{s-1+2f\sqrt{1-s^2}}{s}\right)\frac{s-1+2f\sqrt{1-s^2}}{s}. \tag{7}$$

[8]Details are provided in the Appendix B for the use of referees only.

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Assume now that $\overline{p_1} \leq \frac{2-s^2-s}{2(2-s^2)}$. Let $\Delta_1 \equiv \Pi^{iA} - \Pi^{iD}$. Using (6) and (7), I obtain

$$\Delta_1 = \frac{8(1-s^2)}{s^2} f^2 - \frac{4\sqrt{1-s^2}(2-s)}{s^2} f + \\ + \frac{\overline{p_1}(4 - 3s^2 - 4\overline{p_1} + 3s^2\overline{p_1} - s)}{2(1-s^2)} + 2\frac{1-s}{s^2}.$$

This is a convex second-degree equation in f, whose roots are

$$\underline{f_1} = \frac{(2-s)\sqrt{1-s^2} - s\kappa_1}{4(1-s^2)}$$

and

$$\overline{f_1} = \frac{(2-s)\sqrt{1-s^2} + s\kappa_1}{4(1-s^2)}$$

where $\kappa_1 \equiv \sqrt{(4-3s^2)\overline{p_1}^2 - (4-3s^2-s)\overline{p_1} + 1 - s^2}$. Note that $\underline{f_1}, \overline{f_1} \in \Re$ when $s \in (0,1)$.

Recall now that under the initial assumption on $\overline{p_1}$, from (4) it follows that all admissible values of f are such that $\frac{1-s}{2\sqrt{1-s^2}} < f < \frac{1-s+s\overline{p_1}}{2\sqrt{1-s^2}}$. Let $f^{min} \equiv \frac{1-s}{2\sqrt{1-s^2}}$ and $f_1^{max} \equiv \frac{1-s+s\overline{p_1}}{2\sqrt{1-s^2}}$.

It is easy to show that *i*) $\underline{f_1} > f^{min}$; *ii*) $\underline{f_1} < f_1^{max}$; and *iii*) $\overline{f_1} > f_1^{max}$. Hence $\Pi^{iA} > \Pi^{iD}$ iff $f < \underline{f_1} \equiv f^*$.

Assume now that $\overline{p_1} > \frac{2-s^2-s}{2(2-s^2)}$. Let $\Delta_2 \equiv \Pi^{iA} - \Pi^{iD}$. Using (6) and (7), I obtain

$$\Delta_2 = \frac{8(1-s^2)}{s^2} f^2 - \frac{4\sqrt{1-s^2}(2-s)}{s^2} f + \\ +(1-\overline{p_1})\overline{p_1} - \frac{s^5 - 13s^4 + 44s^2 - 32}{8s^2(1+s)(2-s^2)}.$$

This is a convex second-degree equation in f, whose roots are

$$\underline{f_2} = \frac{2(s^3 - 2s^2 - 2s + 4)\sqrt{1-s^2} - s\kappa_2}{8(2-s^2)(1-s^2)}$$

and

$$\overline{f_2} = \frac{2(s^3 - 2s^2 - 2s + 4)\sqrt{1-s^2} + s\kappa_2}{8(2-s^2)(1-s^2)},$$

where $\kappa_2 \equiv \sqrt{(\kappa_3\overline{p_1}^2 - \kappa_3\overline{p_1} - 3s^3 + 4 + 8s - s^2)(1-s)}$ $\sqrt{(2-s^2)}$ and $\kappa_3 \equiv 8(2-s^2)(1+s)$. Note that $\underline{f_2}, \overline{f_2} \in \Re$ when $s \in (0,1)$.

Recall now that under the initial assumption on $\overline{p_1}$, from (4) it follows that all admissible values of f are such that $\frac{1-s}{2\sqrt{1-s^2}} < f < \frac{\sqrt{1-s}(4+2s-s^2)}{4\sqrt{1+s}(2-s^2)}$. Let $f_2^{max} \equiv \frac{\sqrt{1-s}(4+2s-s^2)}{4\sqrt{1+s}(2-s^2)}$ and recall that $f^{min} \equiv \frac{1-s}{2\sqrt{1-s^2}}$.

Similarly to the previous case, it is easy to show that: *i)* $\underline{f_2} > f^{min}$; *ii)* $\underline{f_2} < f_2^{max}$; and *iii)* $\overline{f_2} > f_2^{max}$. Hence, $\Pi^{iA} > \Pi^{iD}$ iff $f < \underline{f_2} \equiv f^*$.

$\square$

Proof of Proposition 4. Trivial, by noting that

$$\frac{\partial \underline{f_1}}{\partial \overline{p_1}}, \frac{\partial \underline{f_2}}{\partial \overline{p_1}} > 0.$$

$\square$

Proof of Proposition 5. Because of the highly non–linear nature of f^* in s, it is not possible to prove the result analytically. Instead, this is done by means of numerical methods. Details are available from the author upon request.

$\square$