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PRICING AND INVESTMENT INCENTIVES UNDER PRICE CEILING REGULATION

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1. Introduction

For decades, public utilities have been regulated by a maximum allowed rate of return. This type of regulation has long been criticized as being outmoded for technologically dynamic industries like telecommunications. For example, it has been argued that rate of return regulation retards new product and service innovation and research and development. It has also been argued that this form of regulation does not encourage rates based on marginal costs.

The Federal Communications Commission (FCC) has proposed that a different form of regulation be examined as an alternative to rate-of-return regulation for the telecommunications industry and has adopted this form of regulation for AT&T.[1] This alternative is price ceiling regulation. Instead of constraining the overall rate of return a telephone company is allowed to earn on federally regulated services, price ceilings would put an upper bound on the aggregate average prices charged for a predetermined "basket" of services. The rate at which such average prices would be allowed to grow would also be constrained.

The allowed growth rate of aggregate prices under a price ceiling regulatory regime would probably be dependent on (1) the growth rate of the general price level in the overall economy, and (2) a "productivity offset." The "productivity offset" is a rate of expected growth for productivity in telecommunications. It is subtracted from the rate at which price ceilings would otherwise be allowed to grow. If the regulated telephone company can be more productive than the rate suggested by the "offset," it is allowed to keep the revenues from such efficiency.

Thus, the FCC proposed an indexed, aggregate price ceiling for a bundle of services that have historically been subject to rate-of-return regulation. The indexing means that the maximum prices allowed by the ceiling are allowed to

M. A. Einhorn (ed.), *Price Caps and Incentive Regulation in Telecommunications*

grow only at a prespecified rate, which incorporates changes in the purchasing power of money and expected changes in the productivity of the regulated firm.

One aspect of the economics of price ceiling regulation that has received little analytical attention is the way this new form of regulation affects the incentive of a regulated firm to engage in cost-reducing investment.[2] If a regulated firm is subject to price ceilings, how does this affect its decision to invest in new capital? Continued investment in cost reduction and the ability to recover that investment determines the long-term viability of the regulated firm. It is important, then, to examine the investment incentives of a firm subject to price ceiling regulation.

Our principal results are:

1. Given some level of profit earned by the firm, pricing under price ceiling regulation in general will not be second-best optimal.

2. A change to price ceiling regulation, with the ceiling set at the former rate-of-return regulated price, will lead to cost-reducing improvements in investment behavior.

3. The firm's incentive for cost minimization under price ceiling regulation is the same, regardless of the profit level. This is in contrast to rate-of-return regulation, where incentives for cost minimization are strongest when the firm is earning less than the allowed rate of return.

4. As the price ceiling constraint becomes more binding, the price ceiling regulated firm has a greater incentive than the unconstrained monopolist to develop, promote, and market its services to those customers whose demand is relatively inelastic.

2. Description of the Formal Model

The model employed in this article is similar to one used by Baumol (1971) in examining the optimal depreciation policy for the purchase of durable investment. This analytic framework allows the model to address a wide range of questions on investment decisions under price ceilings. It assumes the multiproduct regulated firm attempts to maximize the discounted value of profits (over a planning horizon it has chosen for the capital it has purchased), subject to compliance with price ceilings. In addition to the price ceilings, the model implicitly employs a set of capacity constraints that allow the model to address the incentives for cost-reducing investment over time. It is in this latter aspect that our model differs from those employed by other authors.

In this model, several assumptions are employed to avoid a needlessly complex formulation and to make it relevant to the telecommunications industry.

1. The underlying goal of regulators is to ensure that consumers pay "just and reasonable" prices for services for which the regulated firm has market power (and hence has the ability to raise prices above competitive levels).

2. The regulated firm maximizes profits subject to a regulatory price ceiling constraint.

3. The regulated firm is multiproduct in nature. We make no assumptions on scale economies, since our model will generalize to various formulations of returns to scale. Throughout the analysis, we assume the regulated firm is purchasing a piece of equipment in the first period of a planning horizon, with no further purchases of equipment. We do not address the case of sporadic investment.

4. Demands for the services produced by the regulated firm are assumed independent.

5. The level of quality is exogenous to the firm and determined by regulation.

6. The regulated firm has a common carrier obligation. It must supply all customers who want a service at the given price.

7. We abstract from all questions of uncertainty in the investment decision, that is, the model assumes there is perfect certainty when investment in capital is made.

8. Investment need not take place in lumpy increments.

2.1 Definition of Variables Used in the Model

Define the following variables, where i refers to product ($i = 1, ..., N$) and t refers to discrete time unit ($t = 1, ..., T$):

x_{it} = output quantity
x_t = N-vector of products, i.e., $(x_{1t}\, x_{2t} \ldots x_{Nt})$
p_{it} = price of x_{it}
y_t = capital purchased during t
r = per unit cost of acquiring capital
K_t = total capital accumulated through t
C_t = operating costs during t
$\delta = 1/(1 + d)$, where d is a discount rate
ω_i = weighting scheme of aggregate price ceiling
κ_0 = initial value of aggregate price ceiling
ν = price and productivity indices.

Also define

$$\varepsilon_i \equiv -\frac{\partial x_{it}}{\partial p_{it}} \frac{p_{it}}{x_{it}},$$

which is the own price elasticity for product i.

2.2 Maximization Problem

The regulated firm seeks to maximize the discounted stream of profits, subject to capacity limits and the price ceilings. Thus, the firm's programming problem is to maximize the following profit function with respect to the firm's choice variables: price (p_{it}), and investment (y_t), for $i = 1, ..., N$ and $t = 1, ..., T$:

$$\Pi = \sum_{i=1}^{N} \sum_{t=1}^{T} p_{it} x_{it}(p_{it}) \delta^t - \sum_{t=1}^{T} C_t(x_t, K_t) \delta^t - \sum_{t=1}^{T} r y_t \delta^t.$$

It is assumed that additional investment in K reduces both total and marginal costs, so that $C_K < 0$ and $C_{xK} < 0$. The firm is subject to a capital accumulation condition that holds in each period $t = 1, \ldots, T$:

$$K_t = K_{t-1} + y_t .$$

It is assumed here that capital is completely fungible so that a unit of capital can be used to produce a unit of any product. The fundamental results are not changed by assuming less than perfect substitutability. Also, to simplify it will be assumed that $y_t > 0$ (interior solution).

In addition, the regulated firm is subject to the indexed aggregate price ceiling that also must hold in each period $t = 1, \ldots, T$:

$$\sum_{i=1}^{N} \omega_i p_{it} \le \kappa_0 (1+\nu)^t.$$

It is possible for the price weighting scheme, ω_i, to vary over time, as under a revenue-weighting scheme, but for simplicity, we assume a fixed-weight formulation.

Note that, by assumption, the assets acquired do not lose their output capacity over time. That is, we are postulating a form of "one-hoss shay" depreciation. As a first approach to the problem, this is a permissible simplifying assumption.

For convenience, the capital accumulation condition is substituted into the operating cost function. The Lagrangian function is then:

$$L(p_{it}, y_t, \sigma_t) = \sum_{i=1}^{N} \sum_{t=1}^{T} p_{it} x_{it}(p_{it}) \delta^t - \sum_{t=1}^{T} C_t(x_t, K_{t-1} + y_t) \delta^t - \sum_{t=1}^{T} r y_t \delta^t + \sum_{t=1}^{T} \sigma_t \left(\kappa_0 (1+\nu)^t - \sum_{i=1}^{N} \omega_i p_{it} \right) \quad (1)$$

2.3 Conditions for Constrained Profit Maximization

We get the following first-order necessary Kuhn-Tucker conditions for a maximum:

$$\frac{\partial L}{\partial p_{it}} = p_{it} \frac{\partial x_{it}}{\partial p_{it}} \delta^t + x_{it} \delta^t - \frac{\partial C_t}{\partial x_{it}} \frac{\partial x_{it}}{\partial p_{it}} \delta^t - \sigma_t \omega_i = 0, \text{ for } p_{it} > 0, \quad (2)$$

$$\frac{\partial L}{\partial y_t} = -\sum_{\tau=t}^{T} \frac{\partial C_\tau}{\partial y_t} \delta^t - r\delta^t = 0, \text{ for } y_t > 0, \quad (3)$$

$$\frac{\partial L}{\partial \sigma_t} = \kappa_0(1+\nu)^t - \sum_{i=1}^{N} \omega_i p_{it} \geq 0, \tag{4}$$

$$\sigma_t \frac{\partial L}{\partial \sigma_t} = \sigma_t\left(\kappa_0(1+\nu)^t - \sum_{i=1}^{N} \omega_i p_{it}\right) = 0. \tag{5}$$

3. Pricing Incentives

The first-order necessary conditions can be used to examine the pricing incentives of the firm subject to price ceiling regulation. (2) yields:[3]

$$p_{it}\,(1 - \frac{1}{\varepsilon_i}) = \frac{\partial C_t}{\partial x_{it}} + \sigma_t \omega_i \left(\frac{\partial x_{it}}{\partial p_{it}} \delta^t\right)^{-1}. \tag{6}$$

The left-hand side of (6) is marginal revenue. The first term of the right-hand side is marginal cost. Because $\partial x_{it}/\partial p_{it} < 0$, the right-hand side shows that the more binding the price ceiling constraint is in t, the lower prices will be in t. (6) also shows that it is possible for price ceiling regulation to lead to an outcome where the firm is forced to operate in a region of inelastic demand. Recall that the unconstrained monopolist maximizes profits by operating where demand is elastic. However, if $\sigma_t > 0$, it is possible for $\varepsilon_i < 1$. When the price ceiling constraint is not binding in period t, that is, $\sigma_t = 0$, (6) reduces to the condition for profit maximization of an unconstrained monopolist.

(2) can also be used to derive another interesting result concerning the price ceiling regulated firm's pricing incentives. With some manipulation, (2) implies:

$$\frac{\left(p_{it} - \frac{\partial C_t}{\partial x_{it}}\right)\frac{\partial x_{it}}{\partial p_{it}} + x_{it}}{\omega_i} = \sigma_t = \frac{\left(p_{jt} - \frac{\partial C_t}{\partial x_{jt}}\right)\frac{\partial x_{jt}}{\partial p_{jt}} + x_{jt}}{\omega_j}.$$

This can also be written as:

$$\frac{1}{\omega_i}\frac{\partial \Pi}{\partial p_{it}} = \frac{1}{\omega_j}\frac{\partial \Pi}{\partial p_{jt}}.$$

If we define the weights as initial quantity shares in the following way:

$$\omega_i \equiv \frac{x_{i0}}{\sum_{l=1}^{N} x_{l0}},$$

we get the following condition:

$$\frac{1}{x_{i0}}\frac{\partial \Pi}{\partial p_{it}} = \frac{1}{x_{j0}}\frac{\partial \Pi}{\partial p_{jt}}. \tag{7}$$

It has been shown previously that the condition for efficient pricing is the following, given some profit level that the firm may not exceed:[4]

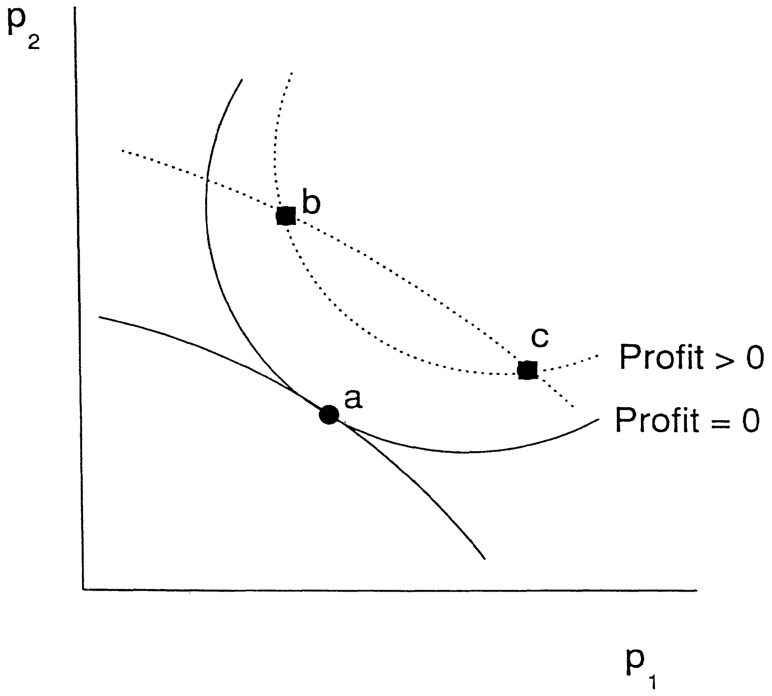
$$\frac{1}{x_{it}}\frac{\partial \Pi}{\partial p_{it}} = \frac{1}{x_{jt}}\frac{\partial \Pi}{\partial p_{jt}}. \tag{8}$$

Only by coincidence will $x_{it} = x_{i0}$. In general, $x_{it} \neq x_{i0}$, so the following is implied by the first-order conditions:

$$\frac{1}{x_{it}}\frac{\partial \Pi}{\partial p_{it}} \neq \frac{1}{x_{jt}}\frac{\partial \Pi}{\partial p_{jt}}. \tag{9}$$

That is, the following statement can be made about price ceiling regulation: given some level of profit that the firm is earning, pricing will not be second-best optimal. Vogelsang and Finsinger (1979) showed that an incentive regulatory mechanism

Figure 1



could result in second-best optimal prices. Our result is that the most commonly discussed implementation of price ceiling regulation, weights fixed at initial quantity shares, will not lead to second-best optimal pricing.

This is illustrated in figure 1. The point of tangency between the isoprofit curve labeled *Profit* = 0 and the isowelfare curve, point *a*, is the second-best optimal set of prices. Price ceiling regulation will, in general, lead to some level of profits different from zero, such as the level of profits implied by the isoprofit curve labeled *Profit* > 0. In general, given that different level of profits, the firm under price ceiling regulation will not choose a point tangent to an isowelfare curve but will instead choose some other point, such as point *b* or point *c*.

4. Investment Incentives

Let us now turn to the first-order conditions to examine investment behavior. (3) rewritten is:

$$r = -\sum_{\tau=t}^{T} \frac{\partial C_\tau}{\partial y_t}. \tag{10}$$

This condition says that the firm will invest in cost reduction until the marginal cost of doing so, *r*, is equal to the marginal benefit of additional reduced costs. This is another way of saying that price ceiling regulation leads to the minimization of total costs, even in the long run.

Since it is rate-of-return regulation that price ceiling regulation has been proposed to replace, a comparison of investment behavior under price ceiling regulation with rate-of-return regulation would be useful to assist in choosing between these alternatives. But both rate-of-return regulation as traditionally practiced, and price ceiling regulation as proposed defy easy (and extensive) comparisons because of their complexity.

Our analysis does allow the following comparison, however. Assume that rate-of-return regulation ensures zero profits and that the regulated price is exogenous to the firm being regulated. This last assumption conforms with the way that traditional regulation has been viewed by some.[5] Assume further that the price ceiling is set at the price from rate-of-return regulation. This becomes a point of comparison between the two regimes.

A statement that is widely held and that is frequently articulated about rate-of-return regulation is that there is room for cost-reducing investment under this form of regulation.[6] Another way of saying this is that the rate-of-return regulated firm is minimizing short-run costs but not long-run costs and that the firm has too little capital. If this is the case, then a change to price ceiling regulation with the ceiling set at the price that was effective under rate-of-return regulation will lead to cost-reducing improvements in investment behavior. This is directly implied by (10). The price ceiling regulated firm will thus see fit to invest more than it did under rate-of-return regulation as we have characterized that form of regulation.

Another interesting result comes from noting that (10) is independent of the firm's ability to pay for additional investment. Since the firm has a common carrier obligation, it must supply all demand that comes forward in response to the prices it sets. (10) says that because it must supply to all comers regardless of its level of profits, the firm's incentive for cost minimization is the same regardless of the profit level. This is in direct contrast to rate-of-return regulation where incentives for cost minimization, as they exist, are strongest when the firm is earning less than its allowed rate.

5. One-Product, One-Period Case

The one-product, one-period case sheds further light as to how price ceiling regulation affects pricing and investment incentives. The first-order conditions for the case where $\sigma > 0$ simplify to:

$$\frac{\partial L}{\partial p} = p\frac{\partial x}{\partial p} + x - \frac{\partial C}{\partial x}\frac{\partial x}{\partial p} - \sigma = 0, \text{ for } p > 0, \tag{11}$$

$$\frac{\partial L}{\partial y} = -\frac{\partial C}{\partial y} - r = 0, \text{ for } y > 0, \tag{12}$$

$$\frac{\partial L}{\partial \sigma} = \kappa_0 - p = 0. \tag{13}$$

The pricing condition becomes:

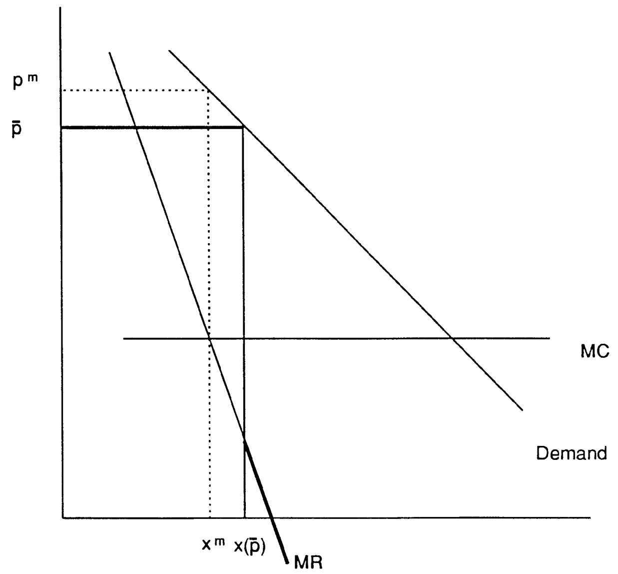
$$p\left(1 - \frac{1}{\varepsilon}\right) = \frac{\partial C}{\partial x} + \sigma\left(\frac{\partial x}{\partial p}\right)^{-1}. \tag{14}$$

This condition is illustrated graphically in figure 2. Under a binding price ceiling constraint, marginal revenue (R') becomes:

$$R' = \begin{cases} \bar{p} & \text{if } p = \bar{p} \\ p\left(1 - \frac{1}{\varepsilon}\right) & \text{if } p < \bar{p} \end{cases}$$

where $\bar{p}$ is the price ceiling. R' is graphed with a heavy line in figure 2. Marginal cost, the first right-hand term in (14), is graphed as C'. The price ceiling has the effect of shifting marginal revenue counter-clockwise as compared to an unconstrained monopolist. Without the price ceiling, the firm would choose p_m and produce x_m. While the price ceiling forces the firm to lower price, it faces a higher marginal revenue for the additional output it must produce to meet the greater demand at the lower price.

Figure 2



Comparative static analysis can also be done with this simple formulation. This analysis yields the following results:

$$\frac{\partial y^*}{\partial \kappa_0} < 0 \tag{15}$$

$$\frac{\partial y^*}{\partial r} < 0 \tag{16}$$

$$\frac{\partial p^*}{\partial \kappa_0} = 1 \tag{17}$$

$$\frac{\partial p^*}{\partial r} = 0 \tag{18}$$

$$\frac{\partial \sigma^*}{\partial \kappa} \gtrless 0 \tag{19}$$

$$\frac{\partial \sigma^*}{\partial r} > 0 \tag{20}$$

The signs of (16) and (20) are as expected. (17) and (18) are trivially true when $\sigma > 0$. (15) fits with the interpretation of (3) offered above, that the cost minimization incentive exists regardless of the profit level. As κ_0 is set lower by the regulator, demand increases and the firm will have an incentive to invest to lower the costs of the greater production. (19)'s indeterminate sign means that the marginal value to the firm of relaxing the constraint could either increase or decrease, depending on specific demand and cost conditions.

6. Incentives for Marketing Activity

Understanding that price ceiling regulation rotates the marginal revenue curve of the firm also sheds light on the incentive of the price ceiling regulated firm to undertake activities that will increase the demand for its services, such as advertising and other marketing.[7]

Suppose that the firm originally faces demand D_0. After some marketing activity it faces demand D_1. The incentive faced by a firm to carry out this particular marketing activity would be its additional profits. In this section we will compare the incentive of the price ceiling regulated firm with that of the unconstrained monopolist.[8] By comparing the incentives in this way, we will be able to see how the imposition of price ceiling regulation could change marketing activity.

The conditions under which the price ceiling regulated firm would have a greater incentive than the unconstrained firm to undertake marketing activity are developed in the following analysis. First, a well-known property of unconstrained monopoly pricing is used. That property is:

$$\frac{p^m - C'}{p^m} = \frac{1}{\varepsilon}. \tag{21}$$

(21) can be used to show a relationship between the prices the unconstrained firm would choose on the two demand curves D_0 and D_1 and the price elasticities at those prices.[9]

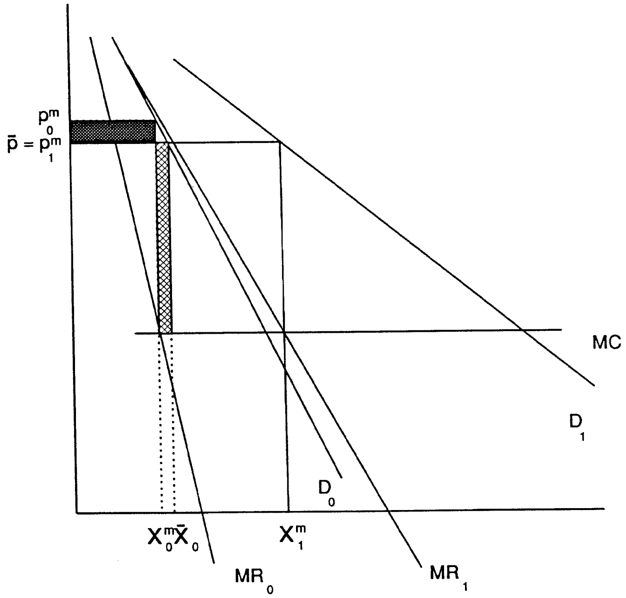
$$p_1^m > p_0^m \text{ iff } \varepsilon_0 > \varepsilon_1 \tag{22}$$

$$p_0^m > p_1^m \text{ iff } \varepsilon_1 > \varepsilon_0 \tag{23}$$

$$p_0^m = p_1^m \text{ iff } \varepsilon_1 = \varepsilon_0.$$

Let us examine first (22), the case where marketing efforts shift the demand curve in a way that causes the unconstrained monopolist to raise price. It is straightforward to see that the unconstrained monopolist has a greater incentive to undertake this particular sort of marketing than the price ceiling regulated firm. Assume that $\bar{p}$ is set at p_0^m. At the new demand, the monopolist is free to keep price at $p_0^m = \bar{p}$ but finds that his profits are greater at $p_1^m > \bar{p}$. Therefore, his incentive to

Figure 3



undertake this marketing is greater than the price ceiling regulated firm that cannot raise price.

Next we will examine (23), the case where marketing efforts shift the demand curve in a way that the unconstrained monopolist chooses to lower price. The price ceiling regulated firm is also free to lower price, which complicates the comparison. If it is assumed that $\bar{p}$ is set at p_0^m as we did in the first case above, they both face the same incentive. However, if it is assumed that $\bar{p} < p_0^m$, then we have an interesting comparison. For the sake of the comparison, assume that $\bar{p}$ happens to be the price the monopolist would choose facing D_1, that is, $p_1^m \equiv \bar{p}$.

This is illustrated in figure 3. By lowering price, the monopolist gives up $p_0^m - \bar{p}$ revenues for each of his x_0^m customers. This is the shaded area in figure 3. However, the monopolist gains $x_1^m - x_0^m$ customers at his new price $p_1^m (= \bar{p})$. Since the price ceiling regulated firm also gains $x_1^m - \bar{x}$ new customers, the unconstrained monopolist only gains $\bar{x}_0 - x_0^m$ new customers beyond what the price ceiling regulated firm will gain. Thus, the new revenues shown by the cross-hatched area in figure 3 should be compared with the lost revenues shown by the shaded area.

Only if the cross-hatched area is greater than the shaded area will the unconstrained monopolist have a greater incentive to undertake this type of marketing activity. Otherwise, the price ceiling regulated firm would have a greater incentive.

This can be represented by the following statement. Only if the following statement is true will the unconstrained monopolist have a greater incentive:

$$(p_0^m - \bar{p})\, x_0^m > (\bar{p} - C')\,(\bar{x}_0 - x_0^m). \tag{24}$$

By using (21) and the assumption that $\bar{p} = p_1^m$, (24) can be restated as:

$$\frac{1}{\varepsilon_0^m} > \frac{1}{\varepsilon_1^m}\frac{\overline{px_0}}{p_0^m x_0^m}. \tag{25}$$

But (23) says that $p_0^m > p_1^m$ implies $1/\varepsilon_1^m < 1/\varepsilon_0^m$. (25) can only be consistent with (23) if total revenue of the price ceiling regulated firm from D_0 is less than the total revenue of the unconstrained monopolist. Since the unconstrained monopolist will only operate in the region of elastic demand, (25) can be contradicted if the price ceiling forces the firm to operate in the region of inelastic demand, which was shown to be possible earlier. Thus, as the price ceiling becomes more binding, the price ceiling regulated firm can have a greater incentive than the unconstrained monopolist to undertake marketing activities.

This result has interesting implications for public policy. Policymakers have expressed interest in protecting the interests of certain classes of customers. That interest can be furthered through price ceiling regulation. Policymakers' interests presumably are not furthered by marketing efforts that increase the regulated firm's desire to raise price. However, marketing efforts that would decrease the firm's desire to raise price should be encouraged, which is what this form of regulation does. This form of regulation would encourage telephone companies to develop and promote their services to those customers whose demand is relatively inelastic, such as those customers who make limited use of the telephone services because of price considerations.

7. Price Ceiling Regulation with Allowed Competition

The preceding sections implicitly assumed that price ceiling regulation was accompanied by entry restrictions. This may not be a realistic assumption, however, and it is instructive to examine the effects of a competitive fringe on the marginal investment conditions derived thus far. This section attempts to do this by assuming that the dominant, price ceiling regulated firm will attract entry if it sets prices too high.[10] Competition has the effect of making the demand curve faced by the regulated firm more elastic, further lowering the price seen by customers.

7.1 Stand-Alone Costs, Entry, and Price Ceilings

The concept of stand-alone cost (SAC) bears importantly on the idea of price ceiling regulation. If price ceilings are based on SAC, then they are no higher than the prices a competitive market would have produced. If prices yield revenues that somehow violate SAC levels, entry is profitable for a firm supplying at least a subset of the incumbent firm's products. This has definite implications for pricing and investment under price ceilings.[11]

If regulatory price ceilings allow revenues significantly above SAC levels, entry will occur and the ceiling constraint will not be binding because prices will instead be constrained by competition. If regulatory price ceilings are well below the levels dictated by SAC, then the ceiling constraint may be binding (if profit maximization can occur at the binding constraint), and entry will not occur. Thus, within the confines of an admittedly static analysis, we can conclude that allowed competition may make price ceilings unnecessary as a regulatory tool, leading to the same level of investment that would have resulted under price ceilings with entry barriers. This, of course, depends on the nature of competition and the level of the ceiling. Because the classic "dominant firm, competitive fringe" model can lead to prices bounded by the competitive and monopoly outcomes, we could expect free entry to police the upper levels on prices under some conditions, but not in the general case.

7.2 Anticompetitive Pricing Behavior

In the recent literature on price ceiling regulation, it has been suggested that the regulated firm has the incentive to practice predatory pricing. For example, Vogelsang's analysis of price ceilings states:

> [A]lthough predation is unlikely to occur under a price cap approach, it cannot be fully ruled out. Using average rates for capped services overall, the regulated carrier might lower its rates in competitive areas below the efficient level and charge fully profit-maximizing rates in monopoly areas with the average complying with the caps. After successfully driving out its competitors, it would reduce the previous monopoly rates and increase the previous predatory rates, again leaving the average within the capped range. (Vogelsang, 1988, 24-25)

Similarly, the Federal Communications Commission (FCC) is concerned with the prospect of predation under price ceiling regulation. When adopting price ceiling regulation for AT&T, the FCC imposed a 5 percent band for services subject to the ceiling, meaning that such services could not be lowered any more than 5 percent annually.[12]

Because a price ceiling in and of itself makes it difficult and risky to recoup short run losses later, the largely anecdotal concern about predation under price ceilings seems groundless. This model of pricing and investment under price ceilings provides a strong qualitative argument against the feasibility of predatory pricing.

Assume that the firm subject to price ceilings chooses to engage in a classical "long purse" predation campaign. If it faces a competitive fringe, then it will choose to set some of its prices below marginal operating costs to drive out this fringe. Once this fringe has exited the market, the firm will raise prices to levels that allow it to recoup its short run losses due to the predation campaign, plus extract monopoly profits from the market.

This strategy involves a risky economic scenario. First, the firm must price at levels below marginal operating costs, which stimulates demand and requires an expansion of capacity (due to an implied common carrier obligation), but provides no contribution to overhead. Second, the firm must somehow raise prices above competitive levels after all other firms have exited the industry. This is difficult for several reasons. The firm still faces the price ceiling constraint, which could be binding in the firm's attempt to enjoy monopoly profits. In addition, the firm has excess capacity in the post-predation period, since it overinvested to meet the demand generated by prices that were less than marginal operating cost. Thus, in the post-predation period, not only does the firm face the price ceiling, it must recover all of its capital investment (including the excess capacity that the predation strategy required). Yet, at the higher post-predation prices, the firm will lose customers that would purchase goods only at the low predatory prices.

In this way, it is clear just how counterproductive a predatory pricing strategy would be under price ceilings. In the predation period, excess capacity must be incurred due to demand stimulation, yet operating costs are not covered and no contribution to overhead is made. Sales are made to customers who will only purchase at the predatory price, but not a higher one. Such customers necessitate an expansion of capacity.

Once the competitive fringe has exited the market, the firm raises prices as high as possible, but finds itself constrained by the price ceilings. This constraint by itself may preclude the successful completion of the predation strategy. In addition, recall that the firm must recover all of its capital expenditures during a period of excess capacity. This combined with the price ceilings themselves makes the collection of monopoly profits quite unlikely. Under price ceiling regulation, predation leads most likely to an underrecovery of invested capital, not monopoly profits.

Similarly, this model indicates that cross-subsidization between products subject to the aggregate indexed price ceiling at a given time period is unreasonable. An examination of (6) shows that, for profit maximization, the regulated firm is not likely to set prices below marginal operating cost, which is necessary for cross-subsidization and is the cost benchmark for predatory pricing used in many of the antitrust courts.[13] A necessary condition for the firm to choose $p_{it} < \partial C_t/\partial x_{it}$ is that $\sigma_t > 0$, that is, that the price ceiling constraint be binding.[14] Thus, the only conditions under which this firm would fail the Areeda-Turner test are those thrust on it by regulation. In this situation, cross-subsidization would be made necessary by exit barriers. Predatory intent would be absent under these circumstances.

8. Policy Implications

The results of this analysis have some immediate implications for issues now being addressed by the FCC and some state public utility commissions.

Marketing Activity. Policymakers' interest in protecting the interests of certain classes of customers can be furthered through price ceiling regulation. Price ceiling regulation does encourage marketing efforts that would decrease the firm's desire to raise price. This form of regulation would encourage telephone companies to develop and promote their "Information Age" services to those customers whose demand is relatively inelastic, such as those customers who make limited use of the telephone services because of price considerations.

Price Ceiling Regulation and Investment. Price ceiling regulation offers a solution to the frequently articulated concern that current rate-of-return regulation induces firms to use too little capital. The imposition of price ceiling regulation gives the firm a clear incentive to cost minimize and to invest up to the point where the marginal benefit from doing so is equal to the marginal cost of doing that.

Cross-Subsidization and Predatory Pricing. This analysis suggests that the firm subject to price ceilings does not have an incentive to set prices below marginal operating costs. In other words, in choosing the mix of prices for the basket of services subject to price ceilings, no service will be priced at less than its marginal cost. There is no rational incentive to cross-subsidize under price ceiling regulation. To set prices of any service, even one with a high price elasticity, at levels below marginal cost would only serve to reduce overall profits allowed under the price ceiling. Thus, prices set below costs are not likely under price ceilings.[15]

However unlikely, prices below marginal cost will only be chosen by the firm if the price ceiling is set at unreasonably low levels (due, for instance, to a low allowed growth index coupled with market exit restrictions). This is of major policy interest because the combination of low price ceilings and barriers to exit are the reasons such pricing would be necessary. A regulated firm laboring under a poorly chosen price ceiling would first choose to delete services from its product line. If it is prohibited from doing this, its only recourse is to price some services below cost. In this case, prices are not predatory, since there is no predatory intent and the prices set below cost are not part of an orchestrated strategy to injure competitors in illegal ways. While prices produced by a poorly administered price ceiling may not pass the simple Areeda-Turner test used by many antitrust courts in detecting predatory behavior, the full set of legal criteria for predation would be passed because the reason for such low prices would be inefficient regulation, not an orchestrated predatory strategy designed to injure other firms.

Notes

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1. *In the Matter of Policy and Rules Concerning Rates for Dominant Carriers*, CC Docket No. 87-313, *Notice of Proposed Rulemaking*, 2 FCC Rcd. 5208 (1987), and *Report and Order and Second Further Notice of Proposed Rulemaking*, 4 FCC Rcd 2873 (1989).

2. One notable exception is the recent paper by Cabral and Riordan (1989).

3. (6) is obtained easily. First, (2) is rewritten as:

$$p_{it} = \frac{\partial C_t}{\partial x_{it}} + \sigma_t \omega_i \left(\frac{\partial x_{it}}{\partial p_{it}} \delta^t \right)^{-1} - x_{it} \left(\frac{\partial x_{it}}{\partial p_{it}} \right)^{-1} .$$

Applying the definition of ε_i to the last term and rewriting yields (6).

4. For example, see Baumol and Bradford (1970).

5. For example, Joskow (1974) found long periods where prices were unchanged by regulators. This was also the assumption employed by Bawa and Sibley (1980) who modeled rate-of-return regulation with the firm taking price as exogenous for considerable periods of time.

6. Sappington (1980) showed that a firm subject to the Vogelsang and Finsinger (1979) regulatory mechanism may have incentives to engage in pure waste. In many ways this is similar to the rate-of-return regulation that we are modeling here, although we do not require the existence of pure waste for our result.

7. We are endebted to Michael Einhorn for helpful discussions regarding the line of analysis in this section.

8. We will accomplish this by comparing additional revenues for the two types of firms, with the assumption that marginal costs are constant over the relevant range of output. Also, in both the unconstrained and price ceiling regulated cases, these additional profits are gained only by incurring additional marketing cost. It is assumed that the marketing cost is the same for both cases.

9. This is seen by subtracting (21) applied to D_1 from (21) applied to D_0 and simplifying.

10. See Brock (1983, 194-195).

11. The theoretical conditions for these ceilings entail the computation of SAC for all possible combinations of services, since only this will ensure that profits do not exceed efficient levels. Thus, if a regulated firm produces, say, three services, x_1, x_2, and x_3, the relevant SAC test requires the following conditions to be met (where R refers to revenues from the services shown in parentheses):

1. $R(x_1) \leq SAC(x_1), R(x_2) \leq SAC(x_2), R(x_3) \leq SAC(x_3)$
2. $R(x_1, x_2) \leq SAC(x_1, x_2), R(x_1, x_3) \leq SAC(x_1, x_3), R(x_2, x_3) \leq SAC(x_2, x_3)$
3. $R(x_1, x_2, x_3) \leq SAC(x_1, x_2, x_3)$.

Since "cost" includes the cost of capital, this last inequality in the list ensures that the firm earns no profits above competitive levels, which means that a SAC-derived ceiling on prices, in theory, will prevent monopoly pricing.

12. *In the Matter of Policy and Rules Concerning Rates for Dominant Carriers*, CC Docket No. 87-313, *Report and Order and Second Further Notice of Proposed Rulemaking*, 4 FCC Rcd. 2873 (1989), at para. 52.

13. This is the Areeda-Turner test, which holds that prices below short-run marginal cost are predatory. Areeda and Turner (1975) suggested using average variable cost in practice to surmount difficulties in measuring marginal cost.

14. This is because for price to be less than marginal cost to be optimal requires also that marginal revenue be less than marginal cost, which can only be the case if $\sigma_t > 0$.

15. Our model has not addressed the case in which price ceilings are applied both to "core" services (for which the regulated firm has market power) and "competitive" services (for which the regulated firm is a price taker) and in the form of an aggregate price cap. This scenario is discussed in Braeutigam and Panzar (1988).

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