Credible Pricing and the Possibility of Harmful Regulation

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Abstract

This paper examines second-best pricing rules that issue "credible" responses to a firm's strategic investment. Provided that capital is a normal input, the firm is able to raise price by reducing investment. As a result, the private cost of capital exceeds the social cost, inducing the firm not only to install insufficient capacity, but to under-capitalize as well. An algebraic example demonstrates that credible pricing may reduce welfare below the monopoly level. Also, "deregulation" of income transfers (in the form of fixed fees) may entail a Pareto improvement. Regrettably, detailed demand and cost information is required to diagnose harmful regulation. The alternative of investment regulation causes over-capitalization but always dominates monopoly. It coincides with optimal rate-of-return regulation, comparing this practice favorably with marginal-cost pricing.

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1. INTRODUCTION

Even when information is perfect, departure from the first-best optimum is inevitable if the set of instruments at the policy maker's disposal is incomplete, as when lump-sum transfers are infeasible, or when there is an irreducible distortion elsewhere in the economy. In this paper, the need for second-best rules derives entirely from the strategic interaction between the regulatory authority and a deviant agent. Specifically, a firm is able to influence cost, and hence, the regulated price through its investment decision.

The reason is quite simple. If the cost of adjusting capital stock is prohibitive, the firm is able to commit to a level of investment in advance of the pricing decision. Consequently, only policies that set price to equate marginal social benefits and costs at each level of investment are "credible." The firm will not believe any other proposal would actually be carried out. If transfers are available (in the form of fixed fees), short-run marginal-cost pricing is the credible rule; otherwise, it exhibits an inverse-elasticity property. Faced with either rule, the firm can raise price by reducing investment provided capital is a "normal" input. As a result, the private cost of capital exceeds the social cost, inducing the firm not only to install insufficient capacity, but to under-capitalize as well.

The welfare consequences of these distortions could be disastrous. Credible pricing may actually reduce final welfare below that attainable by a monopolistic industry. This can occur despite the use of income transfers, a situation we call "workable monopoly." When restricted to uniform pricing, unregulated monopoly may Pareto dominate the second-best regulated outcome with price above the monopoly level. Furthermore, both the firm and its customers may be harmed if unit prices are supplemented with fixed fees. That is, it may be better to have access to fewer instruments since every one is vulnerable to manipulation. These possibilities are demonstrated by an algebraic example. It is especially disturbing from a policy standpoint that simple, verifiable conditions that are symptomatic of harmful regulation have proved to be illusive. Indeed, harmful regulation does not depend in any discernible way on demand elasticities or returns to scale.

This sort pessimism regarding the benefits of intervention is also be found in the theory of the second best. A crucial distinction exists, however, that makes our results even more bothersome. The literature on the second best questioned the wisdom of imposing first-best rules on non-distorted sectors in a general equilibrium setting. Here, in contrast, the issue is whether to enforce a policy that is truly the second-best rule for the deviant industry even when the rest of the economy performs satisfactorily.

In search of a potential remedy, we consider the regulation of investment, delegating price setting to the firm. Investment regulation turns out to be a mixed blessing: it causes allocative distortions that mirror those under price regulation, but it always performs better than monopoly. Notably, the outcome under investment regulation coincides with traditional rate-base regulation when the allowed rate of return is welfare-optimal. Thus, provided that it is properly designed and implemented, rate-base regulation may dominate the uncritical application of such venerable prescriptions as marginal-cost and Ramsey pricing.

To my knowledge, strategic aspects were first introduced into regulatory analysis by Bailey (1974) wherein a regulator fixed the period over which the firm enjoyed the monopoly profits from a cost-reducing innovation, affecting, in turn, the firm's investment in R & D. Spence (1975) considered several configurations of firm-regulator interaction in a situation where the firm chooses product quality (and sometimes investment) and the regulator sets price (or the rate of return).

In a paper closely related to this one, Freixas and Laffont (1985) also establish a dependence of price upon investment, but for a different reason. In their paper, cost becomes known only after managerial effort has been expended. In order for price to reflect cost, it must be set at that time. They then assess the effects on effort and welfare of applying marginal and average cost pricing to a public enterprise. Unlike credible pricing, neither of these rules are optimal, even in a second-best sense. Furthermore, Freixas and Laffont do not compare the two alternatives with the unregulated outcome to weigh the overall effectiveness of government intervention.

The basic model is described in the next section. In Section 3 credible pricing rules are characterized and the regulated outcomes are compared with the optimum. An algebraic example is used in Section 4 to verify the possibility of each type of harmful regulation. Section 5 examines investment regulation and relates it to rate-of-return regulation. The final section contains some concluding remarks.

2. THE MODEL

There is a single homogeneous product. All consumers are identical so that issues of distribution across individuals are ignored. Let the preferences of the representative consumer be represented by the utility function $U(q,y)$ defined over quantity of the good q and money income y. The consumer takes unit price p as given along with the fixed fee t paid for access to the good. The fixed fee is indistinguishable from a transfer of income from consumers to the firm. Indirect utility is given by: $S(p,t) = \max\{U(q,pq + t): pq + t \leq y\}$. The associated demand $Q(p,t)$ is assumed to satisfy:

- Q twice continuously differentiable for $p > 0$, $t < y$.
- $Q_p < 0$, $Q_t < 0$ for $p > 0$, $t < y$.

Thus, there may be income effects but they are always positive.

On the cost side, capital is singled out for special attention. Let $V(q,k)$ denote the short-run, or avoidable, cost of producing q with capital stock k. Formally, $V(q,k) = \{w \cdot x\colon F(k,x) \geq q\}$ where x and w are vectors of inputs and input prices, respectively, and F is a well-behaved production function. This cost may include fixed set-up costs, but there are no sunk costs besides the capital investment. Assume that:

- V twice continuously differentiable for $q > 0$, $k \geq 0$.
- $V_q > 0$, $V_{qq} > 0$, $V_{qk} < 0$ for $q > 0$, $k > 0$.

The last assumption -- marginal cost falls with additional investment -- implies that capital is a normal input in the sense that more is used as output expands. To see this, consider the long-run cost function $C(q) = \min\{V(q,k) + rk\colon k \geq 0\}$ where r is the market cost of capital. At a cost minimum, we have:

$$V_k(q,k) + r = 0 \tag{1}$$

$$V_{kk}(q,k) \geq 0 \tag{2}$$

Total differentiation implies that $dk/dq = -V_{qk}/V_{kk} > 0$ provided $V_{qk} < 0$. Since $C'' = V_{qq} + V_{qk}dk/dq$ the conditions on V are not sufficient to imply that C is convex. Nor do they rule out increasing returns to scale, a typical feature of many regulated industries. The firm's profit can now be expressed as:

$$\pi(p,t,k) = pQ(p,t) + t - V(Q(p,t),k) - rk$$

where a "common carrier obligation" has been imposed requiring the firm to satisfy all demand realized at the regulated price.

Turning to the social problem, a weighted sum of utility and profit is taken as the measure of welfare:

$$W(p,t,k) = \omega S(p,t) + (1-\omega)\pi(p,t,k)$$

where $0 \leq \omega \leq 1$ gives the relative weight assigned to owners and customers. At least in principle, the regulator could choose the price, the transfer and the level of investment so as to maximize welfare. An interior solution to this problem satisfies the standard marginal conditions:

$$p - V_q(Q(p,t),k) = 0 \tag{3}$$

$$\omega S_t(p,t) + (1-\omega) = 0 \tag{4}$$

$$V_k(Q(p,t),k) + r = 0 \tag{5}$$

The first calls for marginal-cost pricing, the second ensures equitable income distribution given the welfare weights; the last is the condition for cost-efficient investment mentioned above. Let the solution to the problem is given by $(p*,t*,k*)$.[1] If the regulator does not have access to income transfers, (5) will continue to hold, but conditions (3) and (4) will be replaced by an inverse-elasticity rule.

This first-best can be supported even if the regulator allows the firm to choose investment. In that case, the best that the firm can do is to minimize cost since its revenue is fixed given that it must meet demand at the regulated price. Of course, decentralization is feasible only as long as the firm passively takes price as given, an assumption that will be dropped in the next section.

1 Variables evaluated at the welfare maximum are modified by a star $*$, at the profit maximum by a hat $\wedge$, and at the regulated outcomes by a bar $-$.

3. CREDIBLE PRICING

Once in place, capital investment can be very costly to alter. Plant and equipment is often immobile and specialized to the product so as to make resale difficult. Also, long lead-times make additions to completed facilities a time-consuming proposition. In comparison, pricing decisions can be revised quickly and at a negligible cost. In practice, of course, rates are by no means perfectly flexible. Complex bureaucratic procedures are notorious for retarding the speed of price adjustment. In addition, regulators may be reluctant to revise rates if customers incur adjustment costs associated with durable investments of their own. These qualifications notwithstanding, the firm usually is in a stronger position than the regulator to commit to a course of action. Consequently, a policy that proposes to set price that is not welfare optimal for some level of investment invites disbelief: should the firm investment that amount, the regulator would subsequently not find it in its interests to carry through. Instead, a pricing rule is constructed that is "credible" in the sense that the firm expects it to be implemented no matter what investment it undertakes.

3.1 UNIFORM PRICING

We begin by considering the simple case in which only the product is sold at a uniform price. (The fixed fee will be suppressed for the time being.) This case is of considerable practical importance and it also provides some insight into the analysis of two-part tariffs. A credible, uniform-pricing rule sets price $p*(k)$ at each level of investment to maximize welfare $W(p,k)$ provided the break even conditions are met: $S(p) \geq U(0,y)$ and $\pi(p,k) \geq 0$. If it exists, an interior solution satisfies:

$$\omega S_p + (1 - \omega)[Q + (p - V_q)Q_p] = 0 \tag{6}$$

$$\omega S_{pp} + (1 - \omega)[2Q_p + (p - V_q)Q_{pp} - V_{qq}Q_p^2] \leq 0 \tag{7}$$

Applying Roy's Identity, $Q = S_p/S_t$, (6) simplifies to a Ramsey pricing rule:

$$[p - V_q(Q(p),k)]/p = \rho/\epsilon(p) \tag{8}$$

where ρ is the Ramsey number[2] $\rho = [\omega S_t(p) + (1-\omega)]/(1-\omega) \geq 1$, and where $\epsilon(p)$ is the (modulus of the) price-elasticity of demand. Average-cost and marginal-cost pricing are special cases of the rule implicit in (8). For instance, if $S_t = -1$ and $\omega = 1/2$, then $p = V_q$, so that price is set at short-run marginal cost. Since the expression in (6) is continuously differentiable under the assumptions, the solution is likewise continuously differentiable by the Implicit Function Theorem. Differentiating with respect to k yields:

$$\{\omega S_{pp} + (1 - \omega)[2Q_p + (p - V_q)Q_{pp} - V_{qq}Q_p^2]\}dp*/dk - (1 - \omega)V_{qk}Q_p = 0 \tag{9}$$

The term in curly brackets is nonpositive by the second-order condition (7) and the remaining term is positive under the assumptions, so that $dp*(k)/dk < 0$. That is, the credible unit price falls with increased investment. Aware of the pricing response that it will evoke, the firm invests so as to maximize profit (provided of course that it breaks even):

$$\text{Maximize } \pi(p,k) \tag{$\bar{P}$}$$

$$\text{Subject to: } p = p*(k)$$

The first-order condition for an interior solution is:

$$[Q + (p - V_q)Q_p]dp*/dk - V_k - r = 0 \tag{10}$$

[2] In contrast to the standard rule, the Ramsey number here is not invariant to monotone transformations of utility because the regulator maximizes a social welfare function.

The term in square brackets is positive by (6), and since $dp*/dk < 0$, we have $V_k + r < 0$. Thus, there is under-capitalization: too little capital is used to minimize cost of producing the given output.

To compare the levels of price and investment, recall that at the optimum investment $k*$, production is cost-efficient, so that $V_k + r = 0$ even though income cannot be transferred. Hence, the left hand side of (10) is negative at $k*$ since the first term is negative, and so $\bar{k} < k*$. Using this fact along with $dp*/dk < 0$, we have that $\bar{p} = p*(\bar{k}) > p*(k*) = p*$, the optimal price. All these results are collected in:

Proposition 1. Under credible uniform pricing, there is:

(i) under-capitalization: $V_k(Q(\bar{p}),\bar{k}) + r < 0$.

(ii) less investment than at the welfare maximum: $\bar{k} < k*$.

(iii) higher price than at the welfare maximum: $\bar{p} > p*$.

The intuition behind these conclusions is straightforward. The regulator treats the firm's investment as sunk, marking up price over short-run marginal cost according to an inverse-elasticity rule. If capital is a normal input, the firm can raise price by scaling back investment since they are related through the marginal cost function. Essentially, the firm's private cost of capital exceeds the social cost by an amount equal to the marginal effect on revenues (the first term in (10)) encouraging it to economize on capital.

A price-capital diagram displays the conclusions of Proposition 1. In Figure 1, $p*(k)$ and $k*(p)$ are, respectively, the short-run welfare-optimal price and investment conditional on the other; $\hat{p}(k)$ and $\hat{k}(p)$ are the corresponding profit-maximizing levels. Since the difference between (market) marginal revenue and marginal cost (i.e., $Q + (p - V_q)Q_p$) is negative at $p*(k)$, but zero at $\hat{p}(k)$, we have $p*(k) < \hat{p}(k)$ as expected. It is also easy to show that $d\hat{p}/dk$ has the same sign as V_{qk} and hence $\hat{p}(k)$ also slopes downward. Notice that $k*(p)$ and $\hat{k}(p)$ coincide since cost minimization is necessary for both profit and welfare maximization. Provided that $V_{kk} > 0$ (which holds by the second-order condition), they are downward sloping as well, but less steeply than the price curves.

The profit curve corresponding to profit maximization constrained by credible pricing is inscribed in the figure. The outcome $(\bar{p},\bar{k})$ lies below the cost-efficient curve, $k*(p)$, indicating there is under-capitalization. Notice that, as pictured in the figure, investment may be even lower under regulation than under monopoly: $\bar{k} < \hat{k}$. Also shown is the possibility that welfare may be lower at the profit maximum than under regulation as, for instance, when regulation increases the price, $\bar{p} > \hat{p}$. Indeed, regulated price could lie in the inelastic region of the demand curve. A closer examination of these possibilities is postponed until the next section.

It is instructive to compare the outcome of credible price regulation with the results from strategic entry deterrence as developed by Dixit (1980) and others. In that scenario, an incumbent drives a wedge between its post-entry cost and that of an entrant by making a pre-entry investment in irreversible capital. Potential entry induces the incumbent to lower price and expand capacity relative to the monopoly outcome. Furthermore, it engages in over-capitalization under exactly the cost conditions assumed above (Dixit (1980, p. 104)). The physical and economic characteristics of capital investment are crucial features of both models. In both, capital is assumed to be a normal input. However, in order for the firm to manipulate regulated prices, capacity expansion must be impossible. On the other hand, an incumbent was able to make entry unattractive because it could not easily liquidate its investment. Thus, for instance, depreciation would tend to enhance the firm's ability to raise the regulated price but it would make entry deterrence more difficult.

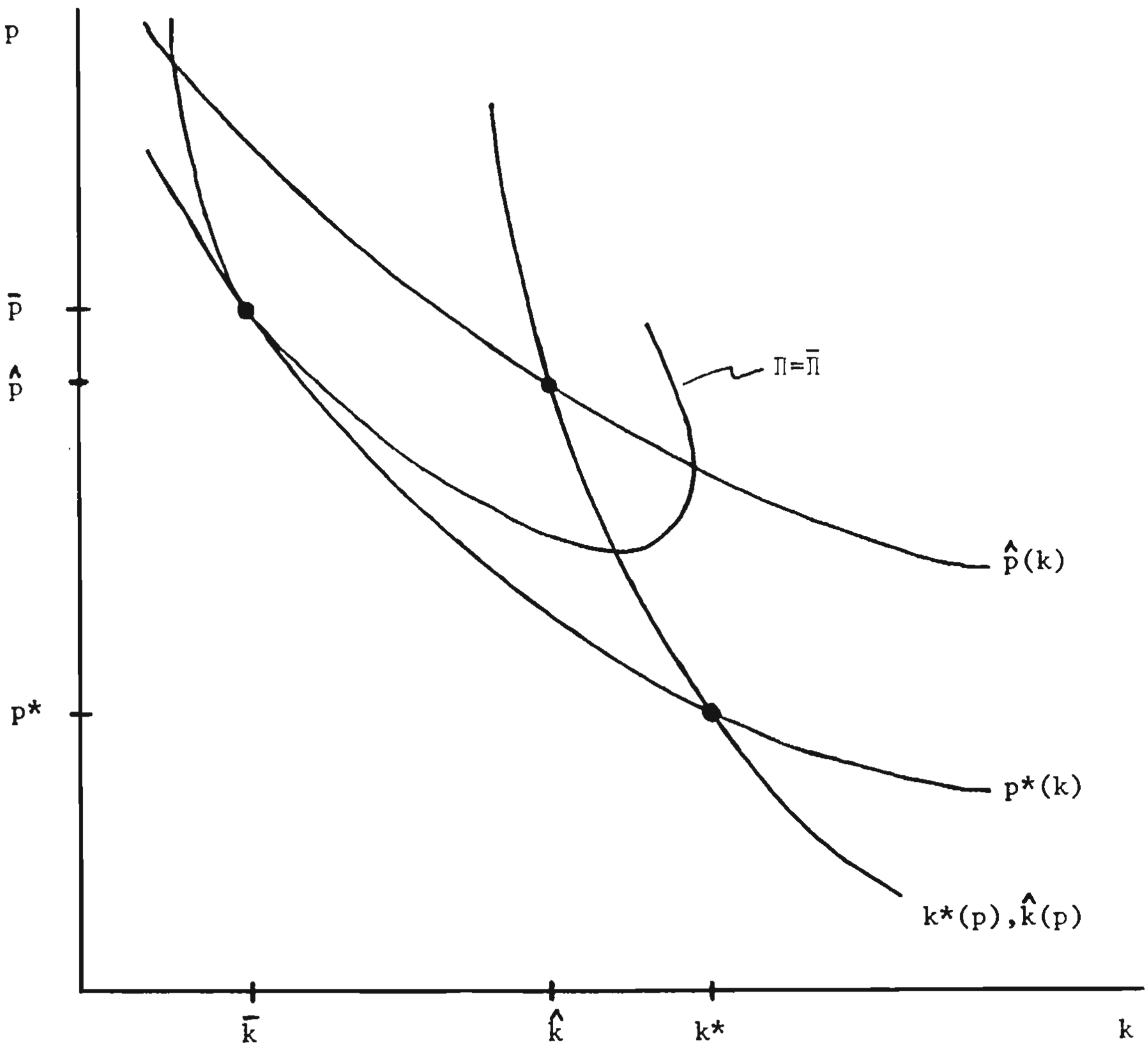

Figure 1: Credible Pricing and Investment

Nor is ordinary investment in plant and equipment the only activity that could provide the firm with the benefits of commitment. If, for example, the firm could enter into a binding contract for a factor prior to rate setting, then it may be able to affect regulated prices even though all inputs are perfectly variable. To take a specific case, suppose that the wage rate w can be negotiated in advance. If there are equal welfare weights and no income effects, then price is set at long-run marginal cost for each wage rate: $p*(w) = \partial C(Q(p*(w)),w)/\partial q$. At a profit maximum, $[Q + (p - \partial C/\partial q)]dp*/dw - \partial C/\partial w = 0$ which, using Shepherd's Lemma, reduces to: $Qdp*/dw = \partial C/\partial w = L$, labor demand. Therefore, the firm would negotiate a wage so that $dp*/dw = L/Q > 0$. A simple application of the Envelope Theorem establishes that welfare (disregarding rents to labor) is strictly decreasing in the wage so that the regulator would choose to reduce the wage as far as possible. But only in rare instances will the regulated outcome occur at this level.

3.2 TWO-PART TARIFFS

The distortions caused by capital commitment may not be so worrisome given that the set of instruments was incomplete. As it turns out, however, virtually all the distortions persist if a fixed fee is available to transfer income. In that case, a credible pricing rule consists of a unit price $p*(k)$ and a fixed fee $t*(k)$ that maximizes welfare $W(p,t,k)$ subject to $S(p,t) \geq U(0,y)$. Necessary conditions include:

$$W_p = \omega S_p + (1-\omega)[Q + (p - V_q)Q_p] = 0 \tag{11}$$

$$W_t = \omega S_t + (1-\omega)[1 + (p - V_q)Q_t] = 0 \tag{12}$$

which together reduce to (3) and (4). Again, by the Implicit Function Theorem, provided the Jacobian does not vanish, the solutions exist and are continuously differentiable. Anticipating the regulator's response, the firm invests so as to:

$$\text{Maximize } \pi(p,t,k) \tag{$\bar{\bar{P}}$}$$
$$\text{Subject to: } p = p*(k),\ t = t*(k)$$

In contrast to the case of uniform pricing, little can be said about the unit price relative to the optimum since it is impossible to determine how it varies with capital, nor how investment affects the fixed fee. Reductions in investment will raise short-run marginal cost, and price will follow suit unless there is a simultaneous increase in the fixed fee large enough to reduce demand to overwhelm the effect of higher cost. In the special case of no income effects, regulated price will exceed the optimal price. What is certain is that total revenue falls with increased investment, once again raising the opportunity cost of capital.

Proposition 2. Under credible two-part pricing, there is:

(i) under-capitalization: $V_k(Q(\bar{\bar{p}},\bar{\bar{t}}),\bar{\bar{k}}) + r < 0$.

(ii) less investment than at the welfare maximum: $\bar{\bar{k}} < k*$.

Proof: (i) At a profit maximum:

$$\pi_p\ dp*/dk + \pi_t\ dt*/dk + \pi_k = 0 \tag{13}$$

which, using the fact that $p = V_q$, $\pi_p = Q$, $\pi_t = 1$, and $\pi_k = -V_k - r$, reduces to:

$$Q\ dp*/dk + dt*/dk - (V_k + r) = 0 \tag{14}$$

A simple comparative statics exercise yields:

$$dp*/dk = (1-\omega)V_{qk}[\omega(Q_pS_{tt} - Q_tS_{pt}) - (1-\omega)Q_t^2]/D \tag{15}$$

$$dt*/dk = (1-\omega)V_{qk}[\omega(Q_tS_{pp} - Q_pS_{pt}) + (1-\omega)Q_pQ_t]/D \tag{16}$$

where $D = W_{pp}W_{tt} - W_{pt}^2$ is the determinant of the Hessian of W with respect to p and t which is positive by the second-order conditions. Substituting (15) and (16) into (14) gives:

$$V_k + r = Q\ dp*/dk + dt*/dk \tag{17}$$
$$= (1-\omega)V_{qk}\{\omega[Q_p(QS_{tt} + Q_tS_t - S_{pt}) -$$
$$Q_t(QS_{pt} + Q_pS_t - S_{pp})] + (1-\omega)(Q_p - Q_tQ)Q_t\}/D$$

Differentiating Roy's Identity, $QS_t - S_p = 0$, with respect to p and t yields:

$$QS_{pt} + Q_pS_t - S_{pp} = 0 \tag{18}$$

$$QS_{tt} + Q_tS_t - S_{pt} = 0 \tag{19}$$

so that the term in square brackets in (17) vanishes leaving:

$$V_k + r = (1-\omega)^2V_{qk}(Q_p - Q_tQ)/D \tag{20}$$

The term in square brackets is just the Slutsky substitution effect which is negative. Finally, since $V_{qk} < 0$ and $Q_t < 0$ by assumption, The right-hand side is negative, establishing under-capitalization.

(ii) Finally, $d\pi/dk = Qdp*/dk + dt*/dk < 0$ at $k*$ since $V_k + r = 0$ and hence $\bar{\bar{k}} < k*$. ■

4. THE POSSIBILITY OF HARMFUL REGULATION

Since the regulated outcome is not an optimum, it is natural to wonder whether it registers any improvement at all. Could unregulated monopoly provide a higher level of welfare than the second-best optimum? The discussion of Proposition 1 suggests this possibility, and it is confirmed in this section.

It is particularly alarming that, relative to the monopoly solution, price regulation may afford a lower level of welfare (measured by the weighted sum of utility and profits) when two-part tariffs are employed. Should this occur when the regulator is confined to to uniform pricing, it would not be so disturbing. In that case, however, regulation may be Pareto inferior to unregulated monopoly. This leads us to question whether partial deregulation of price is warranted. It is shown that relinquishing control over fixed fees could also lead to a Pareto improvement.

Ideally, demand and cost conditions that imply price regulation would be detrimental to welfare could be specified. Even better, these conditions could be expressed in terms that are familiar to economists and that could easily be understood by policy makers. Unfortunately, sufficient conditions of this sort are not available because a comparison of the two outcomes depends upon a complete description of demand and cost conditions.[3] Instead, we examine an algebraic example that admits a rich variety of specifications in order to verify harmful regulation and to identify the symptoms.

4.1 AN ALGEBRAIC EXAMPLE

For simplicity, assume that there are only two commodities, one of which is regulated while the other serves as the numeraire. Then,

$$V(p,t) = (y-t)^{(1-\eta)}/(1-\eta) + p^{(1-\epsilon)}/(\epsilon-1)$$

satisfies all the requirements of an indirect utility function provided that $p^{(\epsilon-1)} > y^{(\eta-1)}$ which guarantees an interior solution to the utility maximization problem. Reservation utility is given by $U(0,y) = y^{(1-\eta)}/(1-\eta)$. The demand function,

$$Q(p,t) = p^{-\epsilon}(y - t)^{\eta}$$

has a constant price elasticity $\epsilon > 1$ and a constant income elasticity $\eta \geq 0$, $\eta \neq 1$.

3 Freixas and Laffont (1985) are partially successful at making a welfare comparison of average and marginal cost pricing because they are able to establish an unambiguous ordering of both output and effort (equivalently, price and investment).

Take the short-run cost function to be:

$$V(q,k) = q^{\alpha}k^{-\beta}$$

where $\alpha > 1$ and $\beta > 0$ so that the (long-run) cost function is:

$$C(q) = (1+\beta)\beta^{-\beta/(1+\beta)}q^{(\alpha/1+\beta)}$$

assuming unit cost of capital and no fixed cost. Returns to scale is given by $\mu = (1+\beta)/\alpha$. These cost functions could be derived from a two-input Cobb-Douglas production function:

$$F(k,x) = k^{(1/\alpha)}x^{(\beta/\alpha)}$$

taking the price of both inputs is unity. In that case, the capital-labor ratio k/x is equal to β .

The solutions to various forms of regulation are calculated for a range of values for the parameters ω, y, α, β, ϵ and η . Feasibility conditions for the firm and the consumer are always respected along with other restrictions on demand and cost conditions mentioned above.

4.2 HARMFUL FIXED FEES

It is widely believed that the use of two-part tariffs is always superior to uniform pricing. This assertion rests on the observation that the option of no fixed fee is always open (see Leland and Meyer (1976)).[4] We show that this dominance may fail to hold when the two-part tariff must be credible. By limiting itself to uniform pricing, the regulator may surrender an additional means to restrain market power, but it also

[4] Ordover and Panzar (1982) show that uniform pricing may dominate two-part tariffs when customers are imperfect competitors.

eliminates another channel through which the firm can influence prices. In fact, both the firm and its customers may prefer to preclude the use of fixed fees.

This is demonstrated by comparing the outcomes under two-part tariff and uniform-price regulation. Unfortunately, the constraints on the problem ($\bar{\bar{P}}$) do not properly contain those for ($\bar{P}$). Instead, each problem is solved using the algebraic example and evaluated at different numerical values of the parameters. For two-part tariff regulation, the solution to ($\bar{\bar{P}}$) is obtained by first solving (11) and (12) for $p*(k)$ and $t*(k)$. These solutions are plugged into the expression for profit; the first-order conditions for a profit-maximum in k are then solved, arriving at:

$$\bar{\bar{p}} = \bar{\bar{q}}^{-1/\epsilon}[\omega/(1-\omega)]^{1/\epsilon}$$

$$\bar{\bar{t}} = y - [\omega/(1-\omega)]^{1/\eta}$$

$$\bar{\bar{k}} = \{\beta(\epsilon-1)(a-1)/a[1+\epsilon(a-1)]\}[\omega/(1-\omega)]^{1/\epsilon}\bar{\bar{q}}^{(\epsilon-1)/\epsilon}$$

where

$$\bar{\bar{q}} = \{\{[\beta(\epsilon-1)(a-1)]/[1+\epsilon(a-1)]\}^{(\beta\epsilon)}[a^{-\epsilon}\omega/(1-\omega)]^{(1+\beta)}\}^{\gamma}$$

using the abbreviation $\gamma = 1/[a\epsilon-(1+\beta)(\epsilon-1)]$.

When the regulator sets only the uniform price, the fixed fee constrained to be zero, the same procedure is followed to solve ($\bar{P}$):

$$\bar{p} = \bar{q}^{-1/\epsilon}y^{(\eta/\epsilon)}$$

$$\bar{k} = [\beta(\epsilon-1)(1-\delta)]/[1+\epsilon(a-1)]\ y^{(\eta/\epsilon)}\ \bar{q}^{(\epsilon-1)/\epsilon}$$

where

$$\bar{q} = \{\{[\beta(\epsilon-1)(1-\delta)]/[1+\epsilon(a-1)]\}^{(\beta\epsilon)}\ \delta^{\epsilon}\ y^{(1+\beta)\eta}\}^{\gamma}$$

and where $\delta = [(\epsilon-1)(1-\omega) + \omega y^{-1/\eta}]/a\epsilon(1-\omega)$ must lie between 0 and 1.

Differences in price, quantity, investment, utility and profit were calculated for the various values of the parameters. Some of the cases that demonstrate harmful fixed fees are displayed in Table 1. A positive (negative) entry in the table indicates that extending regulation to cover fixed fees increases (decreases) the variable in question.

TABLE 1

Two-Part v. Uniform Price Regulation

y	ω	μ	ϵ	η	$\bar{\bar{p}}-\bar{p}$	$\bar{\bar{q}}-\bar{q}$	$\bar{\bar{k}}-\bar{k}$	$\bar{\bar{V}}-\bar{V}$	$\bar{\bar{\pi}}-\bar{\pi}$
1	0.25	1.00	1.1	2.2	−1.98	−0.07	−0.001	−0.08	−0.13
1	0.25	1.27	1.1	2.2	1.95	−0.05	−0.02	−0.82	−0.07
1	0.25	1.00	1.1	2.2	−2.51	−0.05	0.08	−0.35	−0.10
1	0.25	.85	1.1	1.8	−2.85	−0.05	0.71	−0.41	−0.04
1	0.25	1.00	1.1	1.8	−2.36	−0.04	0.40	−0.61	−0.01
2	0.25	1.21	1.1	1.4	−2.21	−0.10	−0.03	−1.42	−0.003
2	0.25	1.00	1.1	1.4	−4.41	−0.10	−0.70	−1.28	−0.04
2	0.50	.70	1.4	1.8	−1.96	−0.15	2.63	−0.17	−0.03
2	0.50	1.30	1.1	1.4	4.53	−0.08	0.23	−0.78	−0.10
2	0.75	1.00	1.4	1.8	−0.02	−0.05	−0.59	−0.05	−0.02

Few systematic patterns can be gleaned from these simulations. There does not appear to be a relationship between price and income elasticities and harmful fixed fees. Nor are scale economies crucial since they can be harmful under decreasing, constant or increasing returns to scale. Note that it is possible to have the unit price higher under two-part tariffs and yet utility be higher as well. Of course, this is possible because of a discrepancy in the fixed fees under the two regimes.[5] Also, increased

[5] The example has an idiosyncrasy that should be pointed out. Since $S_t = (y-t)^\eta$ the regulator's choice of the fixed fee is independent of the unit price. In this way, the firm can influence the outcome only through its effect on unit price.

regulation can actually cause a contraction in the firm's capital stock.

4.3 WORKABLE MONOPOLY

Next, we want to verify that the regulator can do worse than the profit maximum even with the aid of income transfers. This possibility especially surprising when it is recalled that two-part tariffs were capable of sustaining the first-best optimum as long as they need not be credible. It makes sense to refer to such an industry as a "workable monopoly" because there is no admissible regulatory policy that yields a welfare improvement over the unregulated outcome, taking the monopoly structure as given.[6]

It is first necessary to establish the unregulated benchmark in which the firm sets two-part tariffs unobstructed. At the profit maximum, investment is cost-efficient, so that the firm's problem is simply to choose a two-part tariff $(\hat{p},\hat{t})$ so as to:

$$\text{Maximize } pQ(p,t) + t - C(Q(p,t)) \qquad (\hat{P})$$

$$\text{Subject to: } S(p,t) \geq U(0,y)$$

At the solution, price equals long-run marginal cost $(p = C'(Q(p,t))$. In addition, the fixed fee is set to drive the consumer to his reservation utility $(S(p,t) = U(0,y))$, so that the two outcomes cannot be Pareto ordered. Nevertheless, it is possible that the weighted sum of utility and profit will rise when the regulator releases all control over the two-part tariff.

Differentiating long-run cost to get marginal cost, then substituting the demand function for quantity, and solving for price yields:

[6] The term workable was first used by J. M. Clark (1940) to describe an industry that exhibited acceptable performance. Use of it here parallels Markham's (1950) interpretation in terms of the limits of policy intervention.

$$\hat{\hat{p}} = [\alpha^{(1+\beta)}\beta^{-\beta}(y-\hat{\hat{t}})^{(\alpha-\beta-1)\eta}]^{\gamma}$$

The constraint in $(\hat{\hat{P}})$ is:

$$(y-\hat{\hat{t}})^{(1-\eta)}/(1-\eta) + \hat{\hat{p}}^{(1-\epsilon)}/(\epsilon-1) = y^{(1-\eta)}/(1-\eta)$$

Since closed-form solutions of these simultaneous equations do not exist, $\hat{\hat{p}}$ and $\hat{\hat{t}}$ were approximated using numerical methods. Differences in values of the variables are reported in Table 2. Once again, a wide variety of conditions can cause harmful regulation. Take note of the fact that regulation can reduce capacity and raise the unit price. Also, it can lead to a negative fixed fee which implies that customers face quantity premia.

TABLE 2

Regulation v. Profit Maximization Under Two-Part Tariffs

y	ω	μ	ϵ	η	$\bar{\bar{p}}-\hat{\hat{p}}$	$\bar{\bar{q}}-\hat{\hat{q}}$	$\bar{\bar{k}}-\hat{\hat{k}}$	$\bar{\bar{V}}-\hat{\hat{V}}$	$\bar{\bar{\pi}}-\hat{\hat{\pi}}$	$\bar{\bar{t}}$	$\hat{\hat{t}}$
1	.25	1.00	1.7	2.2	0.40	0.007	0.009	0.28	−0.10	0.39	0.52
1	.25	1.27	1.4	2.2	6.11	−0.01	−0.03	0.35	−0.16	0.39	0.59
1	.50	1.00	2.3	0.6	0.31	−0.04	−0.004	0.40	−0.40	0.00	0.44
1	.50	.78	2.6	0.2	0.11	−0.04	9.90	0.34	−0.35	0.00	0.37
2	.25	1.00	1.4	1.4	0.49	0.03	0.001	0.43	−0.14	1.54	1.71
2	.50	1.00	2.0	2.2	0.34	0.02	−0.008	0.12	−0.16	1.00	1.21
2	.50	.78	2.0	1.8	0.22	0.02	6.56	0.11	−0.12	1.00	1.18
2	.75	1.00	2.3	1.8	1.19	−0.11	0.74	0.12	−0.13	0.16	0.73
10	.80	1.00	1.7	0.6	1.93	−0.59	−0.06	0.57	−2.65	−0.08	3.14
10	.80	1.00	1.7	1.8	1.93	−0.04	0.48	0.07	−0.39	7.84	8.80

4.4 HARMFUL UNIFORM PRICING

Once the use of fixed fees is ruled out, there remains a simple tradeoff between lower prices and higher costs. Price may be lower under regulation making for greater consumer utility, but the level of capital is inefficient for the quantity produced leading to higher costs. Not only can the loss in terms of welfare overwhelm the gain, but the unit price may be even higher under regulation resulting in both lower utility and lower profits.

Remarkably, this sort of harmful regulation could occur under the common assumptions of no income effects ($\eta = 0$), and equal welfare weights ($\omega = 1/2$). Plugging these values into the expressions for $\bar{p}$, $\bar{q}$, and $\bar{k}$ provides the regulated benchmark. As for the monopoly solution under uniform pricing, profit maximization yields the usual marginal conditions:

$$[p - V_q(Q(p),k)]/p = 1/\epsilon(p) \tag{21}$$

$$V_k(Q(p),k) + r = 0 \tag{22}$$

which can be solved explicitly for the example:

$$\hat{p} = q^{(-1/\epsilon)}y^{(\eta/\epsilon)}$$

$$\hat{k} = \beta^{1/(1+\beta)}\hat{q}^{(a/1+\beta)}$$

where

$$\hat{q} = \{[(\epsilon-1)/a\epsilon]^{(1+\beta)\epsilon}\beta^{(\epsilon\beta)}y^{(1+\beta)\eta}\}^{\gamma}$$

Clearly, regulated profit is lower than monopoly profit because credible pricing places an additional constraint on the firm. Consumer surplus will also be lower if price (quantity) is higher (lower) under regulation. The ratio of the quantities is simply:

$$\hat{q}/\bar{q} = [(\epsilon-1)/\epsilon][1 + 1/\epsilon(a-1)]^{(\beta\gamma/\epsilon)}$$

Now γ is positive provided that $\mu = (1+\beta)/a < \epsilon/(\epsilon-1)$. For fixed β and ϵ, as a approaches 1, the right-hand side grows without bound. Thus, even in the canonical case in which the sum of consumer surplus and profit is an exact measure of welfare, the second-best policy may be worse than no intervention whatsoever. This instance of harmful regulation along with the others from this section are summarized in:

Proposition 3. Credible pricing (i) may reduce welfare below the level attainable by profit maximization, (ii) may be Pareto inferior when restricted to uniform pricing. Also, "deregulation" of income transfers in the form of fixed fees may entail a Pareto improvement. Moreover, conditions that indicate harmful regulation depend on detailed demand and cost information.

5. INVESTMENT REGULATION

In order to avoid the damage caused by price regulation, it is necessary for the regulatory authority to regain the power of commitment. A simple way for it to accomplish this is to switch roles, taking control of investment and delegating price setting to the firm. It is common practice for regulatory commissions to expend considerable time and effort overseeing investment projects from conception to construction, all the way through to abandonment.[7] This arrangement differs from private management of a franchise of public facilities so prevalent in Western economies. Instead, we assume the regulator has discretion over the size of the investment projects and the firm is com-

[7] Usually, proposals for investment projects originate with the firm, while regulators pass judgement on their merits; less commonly, regulators order the firm to undertake specific projects. Resistance to abandonment -- especially when it clashes with the goal of universal service -- is well documented. Kahn (1970, pp. 76-77, 83, 154-155)) reports on the experience in rail transportation and pipelines.

pelled to finance the expenditure.

To assess the implications of investment regulation, we examine the simple case of uniform pricing. (Fixed fees complicate the derivations without contributing anything new.) Constrained to invest the amount ordered by the regulator, the firm sets price at the short-run profit-maximizing level $\hat{p}(k)$. At an interior solution, it satisfies $\pi_p(\hat{p}(k),k) = 0$. Rearrangement produces the usual monopoly mark-up:

$$[p - V_q(Q(p),k)]/p = 1/\epsilon(p) \tag{23}$$

Differentiating with respect to k gives $\pi_{pp}d\hat{p}/dk + \pi_{pk} = 0$. Since $\pi_{pp} \leq 0$ by second-order condition, and since $\pi_{pk} = -V_{qk}Q_p < 0$ by assumption, we have $d\hat{p}/dk < 0$. Once again, unit price falls with investment. Now, however, the regulator dictates the level of investment $\tilde{k}$ so as to:

$$\text{Maximize } W(\hat{p}(k),k) = \omega S(\hat{p}(k)) + (1 - \omega)\pi(\hat{p}(k),k) \tag{$\tilde{P}$}$$

$$\text{Subject to: } S(\hat{p}(k)) \geq U(0,y)$$

In order to induce the firm to lower price, the minimum investment must exceed the monopoly level. An increase in welfare is registered in the process, but not without sacrificing efficiency since the firm will engage in over-capitalization. These assertions are established in the following proposition. They are pictured in the price-capital diagram of Figure 2, which also shows that investment regulation could lead to a price that is too low, and a level of investment that is too high, relative to the optimum. In addition, the figure indicates that investment regulation could yield a higher level of welfare than price regulation, even when the latter is superior to monopoly.

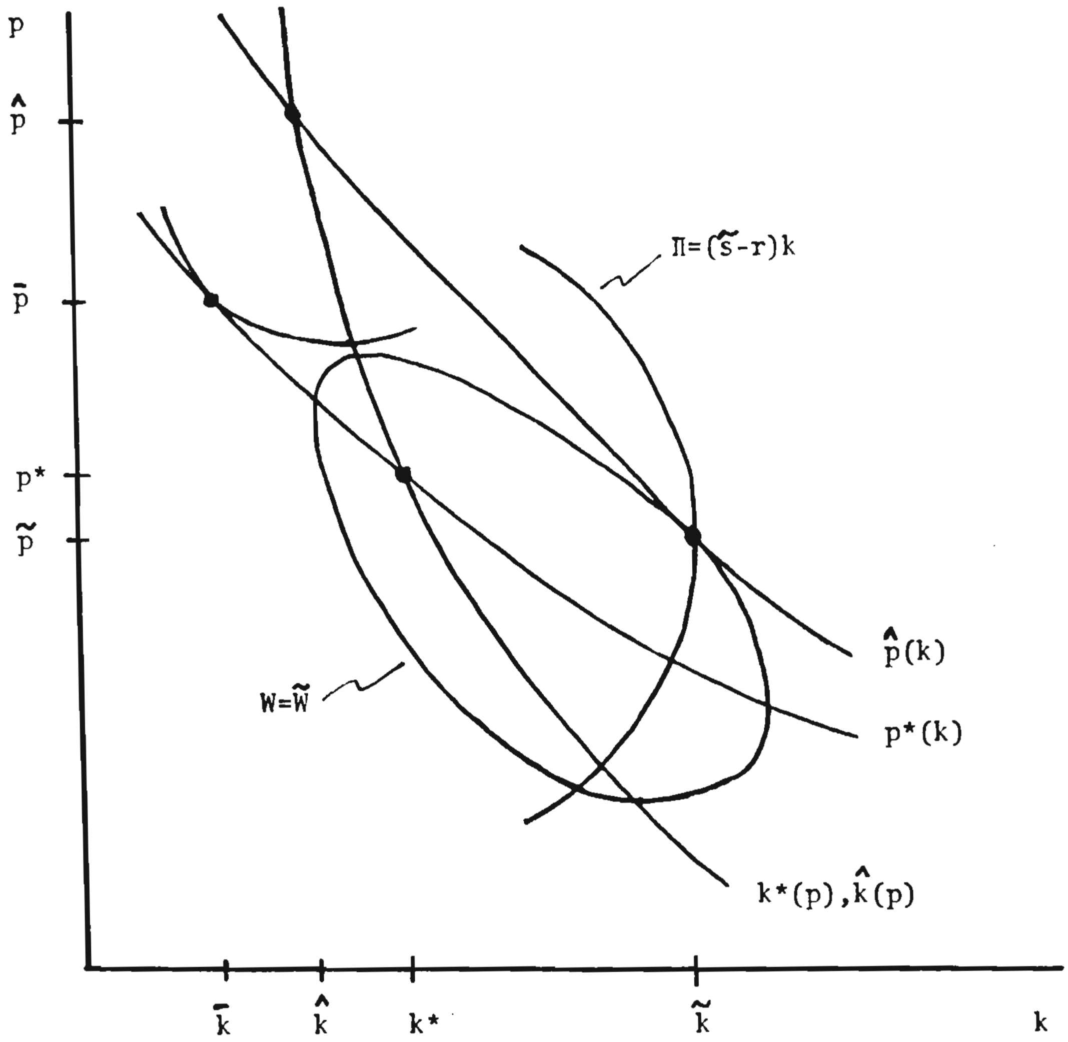

Figure 2: Investment Regulation and Rate-of-return Pricing

Proposition 4. Under optimal investment regulation, there is:

(i) over-capitalization: $V_k(Q(\tilde{p}),\tilde{k}) + r > 0$.

(ii) larger investment than at the profit maximum: $\tilde{k} > \hat{k}$.

(iii) lower price than at the profit maximum: $\tilde{p} < \hat{p}$.

(iv) higher (lower) welfare than at the profit (welfare) maximum:

$$W(\hat{p},\hat{k}) < W(\tilde{p},\tilde{k}) < W(p*,k*).$$

Proof: (i) The first-order condition for an interior solution is $W_p = \omega S_p + (1 - \omega)\pi_p = 0$. Differentiating the identity $W_p = 0$ with respect to k yields:

$$[\omega S_p + (1 - \omega)\pi_p]d\hat{p}/dk + (1 - w)\pi_k = 0 \tag{24}$$

where use was made of the fact that $\hat{p}(k)$ is continuously differentiable by the Implicit Function Theorem. By the first-order conditions $\pi_p = 0$, so that (21) reduces to $S_p d\hat{p}/dk - (1 - \omega)(V_k + r) = 0$. Hence, $V_k + r > 0$ so there is over-capitalization.

(ii) At $\hat{k}$, $dW/dk = \omega S_p d\hat{p}/dk > 0$ since the second term in (24) vanishes, and hence, $\tilde{k} > \hat{k}$. and since $d\hat{p}/dk < 0$ from above, the result follows.

(iii) Using (ii), $\tilde{p} = \hat{p}(\tilde{k}) < \hat{p}(\hat{k}) = \hat{p}$, again using $d\hat{p}/dk < 0$.

(iv) $(\hat{p},\hat{k})$ was feasible but was not a constrained welfare maximum and $(p*,k*)$ is infeasible. ■

Notice that — as in the case of credible pricing — the source of inefficiency is the dependence of price on investment. The allocative consequences of investment regulation are the mirror image of those for credible pricing, and furthermore, at least in terms of over-capitalization, they are reminiscent of the effects derived by Averch-Johnson (1962) for rate-base regulation. In their model, the regulator imposes an upper bound on the firm's rate of return:

$$[\pi(p,k) - rk]/k \le s \tag{25}$$

where s is the allowed rate of return, $r < s < \hat{r}$, $\hat{r}$ being the monopoly rate of return. Imagine that the regulator could not only relinquish control of price and investment, but it could also commit to an allowed rate of return. Assume also that it can mete out a punishment severe enough to ensure that the firm adheres to the constraint; the firm is otherwise free to choose price and investment so as to maximize profit. At an interior profit maximum, $\tilde{p}(s)$ and $\tilde{k}(s)$, there is a nonnegative multiplier λ such that:

$$\pi_p = \lambda \pi_p \tag{26}$$

$$\pi_k = \lambda[\pi_k - (s - r)k] \tag{27}$$

Takayama (1969) has shown that λ increases continuously between 0 and 1 as s varies between r and $\hat{r}$. Therefore, $\pi_p = 0$, or equivalently, $\tilde{p}(s) = \hat{p}(\tilde{k}(s))$. That is, for each allowed rate of return s, a price-capital pair is implemented. Since $\tilde{k}(s)$ is continuous in s, and since $\tilde{k}(r) < \tilde{k} < \tilde{k}(\hat{r})$, by the Intermediate Value Theorem there is an $\tilde{s} \in (r,\hat{r}]$ satisfying $\tilde{k}(\tilde{s}) = \tilde{k}$, the capital stock under investment regulation. A simple comparative statics exercises verifies that $d\tilde{k}/ds < 0$ (Takayama (1969, p. 259)), so that $\tilde{s}$ is unique.

Proposition 5. Investment regulation coincides with optimal rate-of-return regulation.

A corollary to Propositions 4 and 5 is that optimal rate-of-return regulation improves upon the unregulated profit maximum, a result first established by Sheshinski (1971). The rate-of-return curve associated with this outcome is inscribed in Figure 3. The curve representing regulated profit is entirely contained in the rate-of-return curve, and tangent to it at the outcome.

It deserves to be repeated that when the optimal rate-of-return is imposed (or any rate-of-return for that matter), price maximizes profit for the given level of investment. Invariably, discussions of the Averch-Johnson model concentrate on the implications for investment and input mix, neglecting the effects on price. It is usually overlooked that the regulated firm prices at the short-run profit maximum, albeit at a capital stock that exceeds the monopoly level.

6. CONCLUDING REMARKS

This paper was motivated by the belief that the ability of regulators to improve upon the market solution may be severely constrained by the strategic behavior of firms. It was shown that, not only was the first-best outcome out of reach, but the distortions attributable to the second-best policy may call for limited intervention, and occasionally, for abandonment of any attempt whatsoever to outperform monopoly.

As a result, the widespread attempts to institute some form of marginal-cost pricing in the controlled sectors of many Western economies should be of some concern. Such initiatives are ill-advised if these policies are sufficiently vulnerable to manipulation by regulated firms. It is an open empirical question whether the current programs have in fact produced the distortions predicted in this paper (e.g., under-capitalization). In any event, for each new target of marginal rules, our results prescribe a careful assessment of the strategic aspects of the firm-regulator relationship that will develop. They also serve to at least partially rehabilitate the much-maligned institution of rate-base regulation popular in the U.S. Whenever capital commitment is feasible, constraints on rate of return could generate a higher level of welfare than the application of the marginal rules so dear to economists. In specific cases, of course, the ranking of price and investment regulation could be reversed, so that more information is clearly needed to make a rational choice among these institutions.

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