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REGULATION, COMPETITION, AND THE OPTIMAL RECOVERY OF STRANDED COSTS

I. Introduction

The emergence of competition in traditional public utility industries has given rise to a number of important challenges to both positive and normative theories of regulation. Among these challenges, perhaps none is creating more controversy than the debate regarding embedded cost recovery once a traditionally regulated monopoly market is opened to competition.[1] Of particular concern in this instance is the prospect that embedded costs which have been incurred in a monopoly environment will be unrecoverable (i.e., stranded) in a competitive environment.

[1] Embedded costs are those (sunk) costs that have historically been incurred but have not yet been fully depreciated. Within this set of embedded costs, some portion may be unrecoverable were the regulated firm to supply its service in a competitive environment. It is this portion of the firm's embedded costs that is said to be stranded. See Joskow (2000) for a congruent definition. For example, a regulated firm might build distribution plant to serve a specific customer who subsequently obtains service from a previously unforeseen competitor. Alternatively, the regulated firm might invest in capital equipment that becomes partially or totally obsolete because of a technological advance that creates competition and, thereby, destroys the natural monopoly rationale for regulation. Embedded costs may be above, equal to, or below economic (forward looking) costs. See Kahn (1988) for a more detailed discussion of costs in regulated industries.

For instance, natural gas markets in both the U.S. and Britain have seen the issue of stranded costs arise as retail customers seek out low-cost suppliers and in so doing bypass local distribution companies (LDCs) and/or pipeline companies.[2] LDCs and pipeline companies, however, traditionally operated with take-or-pay contracts and as a consequence of competition have faced the very real prospect that assets (for which significant costs were incurred) become stranded. Similarly, the emergence of new technologies (e.g. combined cycle gas turbines) and market liberalization have created the prospect of potentially huge stranded costs in the electric utility industry.[3]

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[2]For detailed discussions of the evolution of natural gas markets, see Broadman and Kalt (1989) and MacAvoy, Spulber and Strangle (1989).

[3]For a more detailed discussion of stranded cost issues in the context of the electric utility industry, see Joskow (2000).

The existence of such stranded costs gives rise to a fundamental dilemma for public policy officials regarding the embedded costs of the firms they regulate. On the one hand, these costs represent past investments that stockholders have made, arguably with the understanding that they ultimately would be allowed to recover them (including, of course, a normal profit). On the other hand, however, the emergence of competition is generally expected to bring lower prices; but, if stranded costs are recovered through traditional regulatory mechanisms (e.g., accelerated depreciation, explicit surcharges, or supracompetitive prices for inputs supplied to new entrants), higher prices likely will be the immediate outcome.[4] Moreover, to the extent that stranded costs are recovered through revenues earned on the sale of essential inputs to emerging competitors, the entire transition to more competitive markets may be jeopardized or delayed. Thus, the regulatory authority is torn between honoring what has been portrayed as the implicit bargain struck between it and the firm's investors and the desire to bring the full benefits of competition to the consumers it also represents.

Two fundamental questions surround the embedded cost/stranded investment issue.[5] First, should the regulated firm be compensated for these costs at all and, if so, to what extent? And second, if stranded costs are to be (fully or partially) compensated, what is the efficient mechanism through which the necessary funds should be raised?[6] These questions currently are

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[4] For a discussion of the economic impact of alternative cost recovery methods, see Crew and Kleindorfer (1999).

[5] These same questions are relevant to the takings issue surrounding much of the debate in the area of environmental (as opposed to utility) regulation. See the collection of papers contained in Contemporary Economic Policy, Vol. 15 (October 1997).

[6] Obviously, the second question arises only if the first question is answered affirmatively. Moreover, the policy significance of the second question hinges upon the level of

the focus of considerable debate in regulatory and policy-making arenas. Our paper focuses on the first.

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cost recovery required to achieve optimality. Most economists would agree that, regardless of the level of cost recovery chosen, the funding mechanism should be made competitively neutral so that the goal of increased competition is not sacrificed on the altar of stranded cost recovery. Indeed, the issues of cost recovery and efficient pricing are (or can be addressed as) largely if not completely separate questions.

To our knowledge, the question of whether and to what extent a regulated firm should be compensated for its embedded costs when the emergence of competition strands the underlying assets has not been considered analytically to date. While there exists a vast literature on optimal regulation (see, e.g., Train (1991), Brown and Sibley (1986), Sherman (1989), and Laffont and Tirole (1993)), little or no formal treatment of the problem of stranded cost recovery is currently available. Rather, most discussion of this issue has centered on legal aspects (the so-called "takings" issue) or has pointed to the consequences of regulatory failure to reimburse stranded costs on the future capital costs of regulated utilities.[7] We believe, however, that an examination of the economic incentives affecting the design of the "regulatory contract" is necessary for any valid assessment of optimal cost recovery.[8]

Accordingly, in this paper we present a simple model of the socially optimal level of stranded cost recovery for a regulated firm facing emerging competition for its services. Despite the simplicity of our model, some very useful generalizations emerge from the analysis. Among these, perhaps the most important is that, under reasonable assumptions, full recovery of the regulated firm's stranded costs is not generally socially optimal. Rather, partial recovery appears

[7]See, for example, Baumol and Sidak (1995), Sidak and Spulber (1997), and Baumol and Merrill (1997). An interesting exception to the primarily legal approach is Brennan and Boyd (1997), who consider, from an economic contracting perspective, the issue of why franchise agreements did not include specific contingency clauses for the onset of competition. They then go on to examine what the nature of such contingencies would be if they were to be included in the regulatory contract. Similarly, see Lyon and Huang (forthcoming) who present an incomplete contracting model (with renegotiation) of the regulatory process and cost recovery.

[8]In so doing, we explicitly circumvent the present debate regarding whether the present regulatory mechanisms in place constitute, either explicitly or implicitly, a "regulatory contract" surrounding the issue of stranded cost recovery. That is, we abstract from the present situation to examine what characteristics such an (optimal) regulatory contract would include were one designing such a contact ex ante.

to dominate. While a more detailed model might yield more specific conclusions, the findings we shall present should help to elevate the general level of debate on this subject and offer some broad guideposts to regulators who are now wrestling with this issue.

II. Model Framework

Our analysis considers the optimal recovery of stranded investments as an aspect of an optimal contract between a welfare-maximizing regulator and a profit-maximizing, regulated firm. Because the regulator ordinarily regulates prices/returns (subject, of course, to various legal restrictions), the issue of inducing a reluctant firm to undertake a socially optimal investment would appear to be simple: the regulator need only condition the regulated price on the firm's investment choice to force compliance by, for example, setting a sufficiently low price if the firm does not act as the regulator wishes. In most western countries, however, publicly-regulated but privately-owned firms may not be treated in such a manner: in the U.S., for example, the Courts have long held that (reasonable) profits are property, and may not be arbitrarily seized by the government.[9] Thus, the regulator cannot ordinarily force a certain course of action on the regulated firm through such means.

The discussion above highlights the issue: why might a given investment be socially desirable but privately undesirable? An investment is socially desirable if it creates benefits (to

[9]The Takings Clause of the Fifth Amendment of the U.S. Constitution states that "No person shall ... be deprived of life, liberty, or property without due process of law; nor shall private property be taken for public use without compensation." Also, in Smyth v. Ames, 169 U.S. 466 (1898), 546-547, the Supreme Court ruled that "The basis for all calculations as to the reasonableness of rates ... must be the fair value of the property being used ... The company is entitled to ask for a fair return upon the value of that which it employs for the public convenience...".

anyone) that exceed costs. For the regulated firm, however, only those benefits it can capture are relevant to the profit calculus. The regulator, however, is constrained by its inability to capture and efficiently convert "social" benefits into firm compensation. For example, regulators can usually "reward" firms only by allowing price increases or taking other actions that reduce consumer welfare by amounts greater than the profits produced.

Thus, we propose the following conceptualization of the problem of optimal recovery of stranded assets. Suppose that a given capital investment is socially desirable, at least under some regulatory policies. Since the investment is costly, the firm must be compensated to undertake it. Compensation takes two forms, price (profit) regulation contingent on whether the investment is undertaken or not, and a credible promise by the regulator to reimburse some part, or all, of the investment costs should the investment become stranded.

This "stranding" occurs because of the possibility of some technical (or other) innovation that is assumed to simultaneously: (i) undermine the natural monopoly conditions that either prohibit entry or make it uneconomic, and (ii) lead to an inability of the regulator to control prices, output, and so on, in the relevant market. Thus, to compensate the firm facing stranded assets, the regulator must raise other prices it still can control, obtain public funding, or utilize some other distortionary means of funding its obligation.

Our analysis that follows demonstrates that, under a relatively weak set of assumptions applicable to a very wide array of more specific regulatory situations, the regulated firm will not receive complete recovery of stranded costs. Rather, under very general conditions, at least some portion of stranded costs will be borne by the firm in all optimal "regulatory contracts." Complete recovery of stranded costs is shown, in general, to be neither optimal nor necessary.

To the maximum extent possible, we seek to provide results that are independent of any particular assumptions about either the precise form of regulation (price caps, rate-of-return, etc.), or the precise nature of competition should an unforeseen technical innovation "strand" a portion of the regulated firm's assets. As will be seen below, our findings will depend only on relatively weak assumptions about the specific form of regulation and the nature of emergent competition. In contrast, we do assume that information is complete, so that the regulator can observe both the firm's costs and the firm's investments that might be stranded. Some discussion of the consequences of this assumption is given below.

The time line for the game is as follows. First, the regulator announces a policy that amounts to firm compensation levels (revenues less variable costs) of π_0 and π_1, where π_0 is profit allowed to the firm if it selects <u>not</u> to make a potentially sunk investment $K_1 > 0$, and π_1 is allowed revenue less variable costs if the investment is made. Thus, if the firm undertakes the potentially stranded investment, its profit if the investment is <u>not</u> stranded is $\pi_1 - K_1$. We assume throughout that legal precedents imply the restriction that $\pi_0 \geqq$ and $\pi_1 - K_1 \geqq$, for some exogenously-determined minimum profit . This assumption reflects the fact that the ability of the regulator to "punish" the regulated firm is legally limited.

The regulator has one further instrument -- its credible commitment to compensate the firm for some part of the investment K_1 should that investment become stranded.[10] Let θ

[10]We abstract here from the prospect that the magnitude of costs that are stranded may be subject to considerable controversy between the incumbent firm and the regulator (or consumer groups). Indeed, this controversy itself may be seen as a game where the regulated firm has private information on the proportion of the undepreciated value of its assets and the regulator would like to induce it reveal that value via the construction of incentive-compatible regulatory mechanisms.

represent the portion of K_1 liable to the firm should events strand the investment. Then $\theta = 0$ implies a regulatory guarantee of full cost recovery, while $\theta = 1$ implies no assistance whatsoever.

Given the regulatory policy (π_0, π_1, θ), the regulated firm decides whether to undertake the potentially stranded investment K_1. This decision is observable by the regulator. Once this decision has been made, the "state of the world" $S \varepsilon \{\underline{S}, \quad\}$ is then revealed to both parties. If $S = \underline{S}$, no "technological revolution" occurs. In this case, the investment, if made, is not stranded; and either π_0 or π_1 is realized, depending upon the firm's investment choice. The probability that $S = \underline{S}$ is equal to λ, $0 < \lambda < 1$, and is (initially) assumed to be exogenous.

Conversely, if $S = \quad$, competition emerges, the investment is stranded, and the regulator is no longer able to compensate the firm by setting prices (at least in this market). In this state, then, the formerly regulated firm earns a profit of $\pi_e - \theta K_1$, where π_e is a profit level reflecting competitive entry and is not affected, per se, by K_1, which is stranded and sunk. The actual level of π_e is largely irrelevant to our analysis. All that is required here is that these profits be too small to compensate fully the regulated firm's embedded costs. And, of course, if they are large enough to cover these costs, then the stranded cost issue does not arise.

The regulator is assumed to select its policy to maximize social welfare.[11] Given this objective, it is important to examine the constraints faced by the regulator. As mentioned above, we assume throughout that any policy (π_0, π_1, θ) must satisfy $\pi_0 \geqq \quad$, $\pi_1 - K_1 \geqq \quad$, and $\theta \leqq 1$.

[11] In essence, we are assuming away the principal-agent problem analyzed by the economic theory of regulation. Because we are searching for the socially optimal policy toward stranded cost recovery, however, this abstraction is useful.

Yet, in what ways, and at what costs, can the regulator provide profits to the regulated firm? While we abstract from the actual form of regulation by focusing on profits, presumably the regulator uses some form of price regulation, such as price caps, to alter the firm's returns. Such actions necessarily affect the surplus obtained by consumers, and this surplus is also of interest to the welfare-maximizing regulator.

In order to make our results as general as possible, we make only the following assumptions about the relationship between consumer and firm welfare. Let CS_i indicate consumer's surplus, and π_i the firm's profits, when the state of the world is i, $i \; \varepsilon \{\underline{S}, \quad \}$. Then, for <u>any</u> regulatory mechanism that is used efficiently, we have the following:

(1) one may write $CS_i = CS_i\,(\pi_i)$, where $CS_i{}' < 0$;

(2) CS_i is a concave function of π_i ; and

(3) $CS_i' + 1 \leq 0$ when π lies between 0 and the monopoly level.

The first property is an immediate consequence of the efficient use of regulation: if $CS_i{}' > 0$, both the firm and consumers can be simultaneously made better off, then the initial policy is Pareto inferior. Property (2) is somewhat more substantive and implies that the "cost" of producing an additional dollar of profits (in terms of lost surplus) is increasing as profits increase. This must be true, of course, when profits approach the monopoly level from below, since profit obtains a maximum. It is generally true, however, whenever profits are below monopoly levels and the price elasticity of demand is increasing in price. We note that simple models, such as those with linear demand, or constant elasticity, elastic demand and constant incremental costs, satisfy this property when price lies between incremental cost and the monopoly level. Intuitively, assumption (2) merely requires that rewarding the firm with an additional dollar of profits becomes more costly (to society) as profits increase. We note finally that, if the regulator could affect costless, lump-sum type transfers, the function CS (π) would be a straight line with slope

-1. Finally, property (3) formalizes the observation that a dollar of profits provided to the firm through feasible price regulation cannot increase total surplus since the "welfare cost" of the dollar is at least one dollar, when the regulatory policy is sensible to begin with.

While viewing profit -- as opposed to price -- as a control variable of the regulator is somewhat unconventional, this conceptualization has two important advantages. First, this framework is applicable regardless of the form price regulation takes: two-part or nonlinear tariffs, price caps, and rate-of-return mechanisms may all be represented by this format. (Given our complete information framework, we abstract from the inefficiencies inherent in some crude regulatory schemes in the presence of incomplete information). Second, this approach is simple, tractable, and allows the basic strategic issue that is of direct interest here -- optimal recovery of stranded costs -- to be highlighted.

We allow the relationship CS(π) to vary, depending on whether the potentially stranded investment K_1 is made or not, and denote the resulting values (CS_0, π_0) and (CS_1, π_1). There are several reasons for this. First, and most simply, the investment K_1 might lower production costs (when $S = \underline{S}$) without affecting demand. Alternately, K_1 might increase demand (when $S = \underline{S}$) if it is interpreted as some sort of promotional activity, such as "universal service" investment or the like. More generally, the investment might do both. We do assume, however, that K_1 is, in fact, potentially stranded so that it is worthless if S = , i.e., if technological innovation occurs.

III. Formal Analysis

We begin the formal analysis with an evaluation of the incentives of the firm and regulator. For simplicity, we assume both parties are risk-neutral.[12]

The firm will select K_1 over K_0 (= 0) when expected profits are greater with the former investment; i.e., when:

$$\lambda(\pi_1 - \pi_0) + (1-\lambda)(\pi_\varepsilon - \theta K_1) \geqq \lambda\pi_0 + (1-\lambda)\pi_\varepsilon, \tag{1}$$

which we rewrite as:

$$\theta \leqq (\lambda/(1-\lambda))((\pi_1 - K_1 - \pi_0)/K_1) . \tag{2}$$

[12] This assumption appears appropriate given that the regulator is a public body, and the regulated firm is ordinarily a widely-held, public stock company. In general, publicly-traded firms' owners need to be compensated only for risks that they cannot diversify away; and, in the case at hand, diversification would appear to be possible by buying shares in potential competitive entrants, their suppliers, and so on. The attitude towards risk of the regulatory authority is somewhat more complex. As noted by Laffont and Tirole (1993, p. 666), "the 'regulator'... (is) really (a) black box ... Organizations are not per se risk averse. Their members may be." There is, therefore, some ambiguity about how risk aversion of the regulators should be represented. Risk aversion itself, however, is not a significant factor; because when it is sufficiently "mild", the regulators' utility is nearly linear in surpluses, and the results can be made arbitrarily close to those reported here.

For example, if $\lambda = .9$ and $(\pi_1 - K_1 - \pi_0)/K_1 = .1$, the firm is willing to select K_1 if $\theta < .9$. Note that the term $(\pi_1 - K_1 - \pi_0)/K_1$ measures the additional (net) profit the firm would earn (in state $S = \underline{S}$) if it selected K_1, expressed as a percentage of the cost of the investment.

Inducing the choice K_1 is socially optimal, however, if and only if the expected sum of consumer and producer surplus is greater under K_1 than under the (costless) choice K_o. Given any $(1-\theta) > 0$, however, the regulator commits to reimbursing the firm for a portion of K_1 should it become stranded, and these funds must come from somewhere. In most circumstances, such funds would presumably be raised in some other market in which the regulatory authority retains control of prices. For purposes of our initial analysis, however, the source of these funds is less important than their social cost. To this end, let δ (where $\delta > 1$) represent the social cost of raising one dollar through the least-cost available mechanism.[13]

Given this notation, the investment plan K_1 is socially optimal if and only if:

$$\lambda(CS_1 + \pi_1) - K_1 \quad - \quad (1-\lambda)\delta(1-\theta)K_1 > \lambda\,(CS_0 + \pi_0). \qquad (3)$$

We note that the social consequences of the potential technological innovation are not relevant to whether an investment that does not affect these values is optimal or not.

We rewrite (3) as

$$\theta \geqq (1-\lambda)\delta^{-1} + 1 \quad + \quad (\lambda/(1-\lambda))((CS_0 - CS_1)/\delta K_1)$$
$$+ \quad (\lambda/(1-\lambda))(\pi_0 - \pi_1)/\delta K_1)\,. \qquad (4)$$

Inequality (4) states that K_1 is optimal from the social point-of-view only if the firm's share of liability for the investment (θ), should it be stranded, is above some minimal level. Yet (4) also

[13]The requirement that $\delta > 1$ reflects the welfare costs of collecting the funds used for reimbursement.

reveals that this value depends on the regulatory policy (π_0, π_1), the cost K_1, and so on. If there exist values of π_0 and π_1 that: (i) induce the firm to select K_1, and (ii) make K_1 the socially optimal investment policy, then our interest focuses on what this value of θ is. Clearly, if K_1 is "small", but simultaneously allows $\pi_1 > \pi_0$ and $CS_1 > CS_0$ over a wide range of instrument values, then K_1 is socially desirable and can be implemented. Thus, we assume in what follows that there exist circumstances in which K_1 is, in fact, socially desirable, although we will check the validity of this assumption below. Combining inequalities (2) and (4) produces the requirement:

$$\lambda(\pi_1 - \pi_0)(1 + \delta) > K_1(1+\delta) - \lambda(CS_1 - CS_0). \tag{5}$$

If the investment K_1 allows values (CS_1, π_1) to be selected to satisfy (5) given the welfare-maximizing values of (CS_0, π_0), then K_1 is both socially desirable and implementable.

Formally, the regulator's problem is:

$$\max_{\pi_0,\, \pi_1,\, \theta} \quad \lambda((CS_1 + \pi_1) + (1-\lambda)(\overline{CS} + n\pi_e) - K_1 - \delta(1-\lambda)(1-\theta)K_1 \tag{6}$$

s.t. (i) $\pi_1 - K_1 \geqq$,

(ii) $\pi_0 \geqq$, and

(iii) $\theta - (\lambda/(1-\lambda))((\pi_1 - K_1 - \pi_0)/K_1) \leqq 0$,

where $\overline{CS}$ is consumer surplus if technological change leads to competition, π_e is profit to a representative firm in that case, and n is the number of such firms (assumed to be independent of θ, K, π_0, and π_1). Constraints (i) and (ii) assure minimum profits to the regulated firm, while (iii) induces the firm to select K_1. Recall that $CS_i = CS_i(\pi_i)$, i = 0, 1, corresponding to $K = K_0$ and K_1.

Writing all constraints in the "$\leqq$" form (so the corresponding multipliers must be non-negative), noting that (iii) will always be satisfied as an equality, and denoting the corresponding multipliers as γ_1, γ_2 (where $\gamma_1 > 0$, $\gamma_2 > 0$ at any optimum), we obtain the following optimality conditions:

(7.1) $\lambda(CS_1' + 1) + \gamma_1 + \mu \quad (\lambda/(1-\lambda)) = 0$ (7)

(7.2) $\gamma_2 - \mu(\lambda/(1-\lambda))\ \mu \quad = 0,$

(7.3) $\delta(1 - \lambda)K_1 \quad - \ \mu = \ 0,$

(7.4) $- (\quad - \pi_1 + K_1) \geqq 0$,

$\gamma_1 \ \geqq \ 0$,

$\gamma_1(\quad - \ \pi_1 + K_1) = 0$,

(7.5) $-(\quad - \pi_0) \geqq 0$,

$\gamma_2 > 0$,

$\gamma_2 (\quad - \pi_0) = 0$, and

(7.6) $\theta \ - (\lambda/(1-\lambda))((\pi_1 - K_1 - \pi_0)/K_1) = 0$.

We are now in a position to establish our primary result: if the investment K_1 is optimal, then, in general, $\theta^* > 0$; i.e., the regulated firm will bear some portion of its stranded costs -- complete reimbursement is not optimal.[14] To establish this result we must first prove a Lemma:

Lemma 1: At the optimum, $\mu^* = \delta(1-\lambda)K_1$, $\gamma_2^* = \delta\lambda > 0$, and $\quad = \quad$.

[14]This result is akin to the heuristic argument made by Crew and Kleindorfer (1999, p. 66) that "[I]t should be clear that full indemnification of the firm against downside risk, if anticipated ex ante, will lead the firm to make exceedingly risky choices, since it will in effect be playing with 'house money."'

Proof. (7.3) establishes $\mu^* = \delta(1-\lambda)K_1$. This result and (7.2) establish that $\gamma_2^* = \delta\lambda > 0$.

This result, in turn, implies that $\pi_0^* =$.

The Lemma shows, unsurprisingly, that, if K_1 is optimal, then the firm is not "rewarded" for selecting K_0 by a profit level π_0 exceeding the legally required minimum.

The Lemma allows us to now establish our primary result. Evaluation of (7.6) shows that θ^* equals zero (i.e., the firm is completely reimbursed for stranded investment) if and only if $\pi_1^* - K_1 = \pi_0^*$, i.e., optimal net profits if K_1 is selected equal the minimum value $\pi(= \pi_0^*)$. Thus, the question of optimal reimbursement for stranded investments is seen as equivalent to the question of whether any profits are given to the firm if it undertakes K_1 and the investment is not stranded. This latter question, in turn, depends upon the social cost of such reimbursement, the cost of alternative reimbursement (i.e., δ), and the probability that the investment K_1 is stranded. Given this result, we obtain the following theorem:

Theorem 1: $\theta^* > 0$ if (a) λ is close to 1, or (b) δ is sufficiently large, or (c) the regulator is sufficiently socially efficient in providing profits to the regulated firm.

Proof. Suppose that $- \pi_1 + K_1 = 0$. In this case, $\gamma_1 > 0$, so that $CS_1' + 1 + \delta/(1-\lambda) \leqq 0$ must be true at $\pi_1 = + K_1$.

(a) If δ is sufficiently large, this condition is violated, so $\pi_1 > + K_1$ at the optimum and $\theta^* > 0$;

(b) if λ is close to 1, then the condition is violated for any $\delta > 1$ since CS_1 is strictly concave with bounded derivatives, so $\pi_1 \geqq + K_1$ at the optimum and $\theta^* > 0$; and

(c) if the regulator is efficient in providing profits, then $CS_1' + 1$ 0, and the condition is violated for any values of δ and λ, so that $\pi_1 > + K_1$ and $\theta^* > 0$.

Q.E.D.

Theorem 1 establishes a set of conditions under which incomplete reimbursement for stranded assets is socially optimal. First, regardless of the value of λ, if δ is large, then it is always optimal to use profits to help induce selection of K_1. Yet, this result is more subtle than is first apparent. Consider the term $(CS_1' + 1)$: this value is the social cost of providing a dollar to the regulated firm by regulating prices in this market. On the other hand, δ is ordinarily the social cost of providing funds to the firm by regulating prices in some other market. Although this circumstance is not formally modeled here, optimal regulation across many markets presumably implies an equilibrium relationship between social marginal costs of the form $(CS_1' + 1)$ across markets.[15] In any event, it seems reasonable to suppose that the value of δ, as defined, is similar to $-(CS_1' + 1) + 1$, in which case the condition $(CS_1' + 1) + \delta/(1-\lambda) < 0$ is "always" violated, implying $\theta^* > 0$ in all, or virtually all, conceivable cases.

Second, Theorem 1 shows that, as λ is close to 1, $\theta^* > 0$. This finding is relevant to the current debate on recovery of stranded costs. Recall that λ is the probability of no (technological) development providing a stranded investment. If λ is close to 1, stranded assets are quite unlikely, and $\theta^* > 0$. Contrast this result with the common conceptualization inherent in the question: if competition was unforeseen, should not the regulator compensate the firm for the stranded costs? Of course, "unforeseen" can be represented in our analysis only by the condition that λ is "very close" to 1. In that case, however, $\theta^* > 0$ and complete compensation is never optimal. This result does not arise from risk-aversion or insurance arguments but simply from the concavity and boundedness of CS_1 in profits.

[15] This is the case, as is shown in the next section.

Finally, the efficiency of price regulation affects the degree to which the firm will be liable for stranded costs. The term ($CS_1' + 1$) represents the effect on social welfare (when S = <u>S</u>) of raising π_1 by \$1 using pricing to produce the result. As a consequence, $CS_1' + 1 \leq 0$. If $CS_1' + 1$ is "close to" 0, then $\pi_1^* >$ $+ K_1$ and $\theta^* > 0$. This reflects the fact that, if price policy can be used (cheaply) to assure the investment K_1 occurs, then $\pi_1^* >$ $+ K_1$ and only incomplete "insurance" is offered.

IV. Multimarket Regulation

The model considered thus far has assumed an exogenous social cost of profits provided to the firm, denoted $\delta > 0$. In order to provide profits, the regulator must allow the firm to obtain funds in some manner. A probable source of such funds is presumably price regulation itself, although direct public appropriations are certainly conceivable. Given the assumptions of the previous section, however, the regulator controls only a single product market which may become competitive, depriving the regulator of the ability to effectively control prices. We therefore consider the multimarket case as an extension of our prior model.

In contrast to our previous assumptions, a regulator now controls profits in two markets, one subject to potential competitive development, the other a "safe" market in which there is no prospect of entry. Again, a socially desirable but privately risky investment of K_1 is possible in the "at risk" market. The regulator now controls profits in the <u>alternative</u> ("A") market (π_A), and may condition these profits on the firm's choice of potentially stranded investment. While we assume the regulator may not condition firm profit in market A on the state of the world, this assumption is actually noninformative and irrelevant, because the regulator may compensate the firm for a stranded investment, conditional on both the firm undertaking the investment and the state of the world S. Thus, for every combination of state of the world and firm investment choice, profits may arbitrarily differ. As a consequence, the results are quite general.

Let π_0, π_1 indicate "profit" (revenue less variable production costs) in the at-risk market, conditional on the firm's investment choice. As before, the "no competition" state is denoted $S = \underline{S}$ (where prob $(S = \underline{S}) = 1-\lambda$). Let $\pi_A(i)$, i = 0, 1, be "profits" awarded the firm in the safe, regulated market A, where i = 1, indicates the investment K_1 is made, and i = 0 indicates it is not. Let $CS_A(\pi_A(i))$ be consumer surplus in market A given $\pi_A(i)$, and let θ, λ, $\overline{CS}$, n, and π_e have their previous meanings.

The multimarket problem is, in one sense, much more complex than that considered previously. In all cases, in order to avoid uninteresting "forcing contracts", we assume limits on the ability of the regulator to punish the firm. This implies that the regulator may not take actions that reduce profits in either market below some exogenously determined level(s). In the previous analyses, the regulator merely had to fulfill its contractual obligations, i.e., compensate the firm for $(1-\theta)$ of stranded investment K_1, and could do nothing to influence prices in the newly-competitive market.

These considerations require that, with multimarket regulation, the minimum profit levels be carefully specified. For example, if competition does strand investment in one market, would regulated operations then be subject to the same minimum profits that would apply if competition did not occur in any market? Further, how should profits earned by a regulated firm in an unregulated market be treated in these minimum profit constraints?

Fortunately, for purposes of showing that complete compensation for stranded costs is not optimal, the particular assumptions made on minimum profit constraints are not critical. The following assumptions, however, seem reasonable and are adopted here. First, if the firm makes the desired, potentially-stranded investment K_1, then legal (and perhaps political) constraints require that net, final profits from regulated operations not be less than   if competition does not occur, nor less than $\hat{\pi}$ if competition does occur, where $\geqq \hat{\pi}$. This last inequality reflects the fact that, should a portion of the regulated industry become competitive and unregulated, the regulated firm would presumably earn a "normal" return on nonstranded assets in that unregulated market, while those assets remaining in the regulated market would earn some regulated rate-of-return, leading to lower total profits from regulated businesses.

Thus, the welfare-maximizing regulator solves the problem:

$$\max_{\pi_0,\ \pi_1,\ \pi_A(0),\ \pi_A(1),\ \theta} \quad \lambda[\pi_1 - K_1 + \pi_A(1) + CS_1 + CS_A(\pi(A))] + (1-\lambda)[CS + n\pi_e - K_1 + (1-\theta)K_1 + CS_A(\pi_A(1) + (1-\theta)K_1) + \pi_A(1)] \tag{8}$$

s.t. (C.1) $- \pi_1 - \pi_A(1) + K_1 \leqq 0$,

(C.2) $- \pi_A(1) + \theta K_1 \leqq 0$,

(C.3) $- \pi_0 - \pi_A(0) \leqq 0$,

(C.4) $- \pi_A(0) \leqq 0$, and

(C.5) $\lambda(\pi_0 + \pi_A(0)) - \lambda(\pi_1 - K_1 + \pi_A(1))$

$+ (1-\lambda)(\pi_e + \pi_A(0))$

$$- (1-\lambda)(\pi_e - \theta K_1 + \pi_A(1)) \leqq 0.$$

Constraints (C.1) through (C.4) reflect the minimal profits required from regulated businesses, discussed above. Note that such constraints are ex post: it is insufficient that expected profits meet a minimum level; actual profits along every path must be (legally) adequate. Constraint (C.5) is the incentive compatibility condition that induces the firm to select the potentially stranded investment K_1.

The functions CS_1, $\overline{CS}$, and CS_A are consumer surpluses for: (i) the "at risk" market if competition does not occur; (ii) the "at risk" market if competition does occur; and (iii) the other regulated market, respectively. As before, $CS_1 = CS_1(\pi_1)$ while $\overline{CS}$, whatever it may be, is beyond the regulator's control. The function $CS_A(\pi_A)$ represents consumer surplus in the "safe" market over which the regulator will maintain control in all cases. Recall that we assume that $CS'(\pi) < -1$, and that $CS'' \leqq 0$ (so CS is a concave function of profits). Note also that, in this formulation, compensation for stranded investment $(1-\theta)K_1$ can be funded through increased profit extractions in the "safe" market. This circumstance makes endogenous the welfare cost of firm compensation previously described by the "exogenous" parameter "δ".

The problem given by (8) may be simplified prior to its analysis by noting that, in any optimum, $\pi_A{}^*(0) =$ and $\pi_0{}^* =$ - ; i.e., if the firm fails to make the desired investment, it receives only minimal profits. This condition holds because any level of profits above minimums lowers welfare, and such awards are given to the firm only to induce it to undertake the socially desirable but potentially stranded investment K_1 in the "at risk" market. As usual in all optimal contracts, noncooperative behavior is not rewarded.

Substituting the constraints $\pi_A*(0) =$ and $\pi_0* =$ -   , and denoting the multipliers for constraints C.1, C.2, and C.5 as γ_1, γ_2, and μ, first order conditions for $\pi_A*(1)$, π_1*, and $\theta*$ are, after simplification:

$$\lambda(CS_1' + 1) + \gamma_1 + \mu\lambda = 0, \tag{9.1}$$

$$\lambda(CS_1'(\pi_A(1) + 1) + (1-\lambda)(CS_A'(\pi_A(1) + (1-\theta)K_1) + 1) + \gamma_1 + \gamma_2 + \mu = 0, \text{ and} \tag{9.2}$$

$$(1 - \lambda)(CS_A'(\pi_A(1) + (1-\theta)K_1)) + \gamma_2 + \mu(1 - \lambda) = 0, \tag{9.3}$$

where $\gamma_1 \geqq 0$, $\gamma_2 \geqq 0$, $\mu \geqq 0$.

We may now establish the main result of this extension, which is an analog to Theorem 1 in which the "social cost" δ is endogenous. Solving (9.2) for μ, adding (9.1) and (9.3) and manipulating leads to the conclusion that $CS_1' = CS_A'(\pi_A(1))$; i.e., the welfare cost of raising a dollar of profit in the at risk market when the potentially stranded investment is made must equal the social cost of raising a dollar in the "safe" market when competition does not occur (so that no compensation is due to the firm). This conclusion is independent of whether the constraints are strictly binding or not.

Using this result, we get the following theorem:

<u>Theorem 2</u>: $\theta*$ 0.

<u>Proof</u>: The demonstration is by contradiction. Suppose $\theta* = 0$ (i.e., there is complete "insurance" for stranded investment). Then

$$CS_A' (\pi_A(1) + (1-\theta)K_1) = CS_A'(\pi_A(1) + K_1)$$

Since CS_A is assumed to be strictly concave, $CS_A'(\pi_A(1) + K_1) < CS_A'(\pi_A(1))$. This inequality implies

$$(1-\lambda)(CS_A'(\pi_A(1)) + 1) + \gamma_2 + \mu\,(1-\lambda) < 0.$$

But optimality implies that

$$\lambda(CS_A'(\pi_A(1)) + 1)) + \gamma_1 + \mu\lambda = 0\ .$$

Adding these two expressions yields

$$CS_A'(\pi_A(1)) + 1 + \gamma_1 + \gamma_2 + \mu < 0\ .$$

Yet optimality implies that

$$\lambda(CS_A'(\pi_A(1)) + 1) + (1-\lambda)CS_A'(\pi_A(1) + K_1) + \gamma_1 + \gamma_2 + \mu = 0\ .$$

Thus, we must have

$$CS_A'(\pi A(1)) + 1 < \lambda\, CS_A'(\pi_A(1)) + 1 + (1-\lambda)(CS_A'(\pi_A(1) + K_1) + 1),$$

or

$$CS_A'(\pi_A(1) < CS_A'(\pi_A(1) + K_1).$$

But if CS_A is concave and decreasing in π, this is clearly false. Thus, $\theta^* \quad 0$.

QED.

Importantly, Theorem 2 shows that complete "insurance" for stranded assets is never optimal in a multimarket setting. Previously, Theorem 1 merely gave conditions under which $\theta^* > 0$, with one condition establishing that $\theta^* > 0$ (the firm has some liability for stranded assets) when δ, the social cost of a dollar's profit, was "sufficiently large." The extension given by Theorem 2, however, shows that, in fact, δ is sufficiently large, given the assumptions of the model. Because the regulator can compensate the firm in several ways, some of which create liabilities only under certain states of the world, the amount of profits provided through different channels should be selected to minimize the social cost of inducing the firm to behave correctly.[16] This requirement, in turn, implies that complete insurance ($\theta = 0$) is socially so costly as not to be undertaken in an optimal contract.

V. Endogenous Probabilities.

The regulatory policy adopted in an industry presumably affects the probabilities of entry, innovation, or other developments that can, in time, destroy the initial justification for regulation. For example, high regulated prices for switched access services in U.S. telecommunications markets led to the emergence of so-called "CAPs" (competitive access providers), who offered access services to large office buildings and firms in a position to benefit from evading use of local networks. Although, as economists often note, entry depends on expected post-entry prices rather than current prices, few would argue that current policy is totally unrelated to entry decisions. Similarly, investment decisions that may create stranded costs may also affect the extent or probability of entry.

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[16] At the same time, the compensation package selected is likely to have distributional consequences as revenue burdens are shifted away from consumers in those markets in which competition has emerged. As a result, distributional considerations may influence the regulator's choice among the remaining profit sources.

How would such considerations affect our conclusions regarding optimal reimbursement policy? To answer this question, suppose that we have $\lambda = \lambda(\pi_1)$ in the relatively simple model presented in Section III.[17] The "probability of no competition", λ, is taken to depend on π_1 alone, rather than π_1 and π_0, since $\pi_0 =$ in the optimal contract. Presumably $\lambda' > 0$, since higher profits π_1 are taken to increase the chance of entry. Although somewhat crude, this formulation allows at least an initial assessment of this issue.

Performing the necessary analysis, optimal π_1 must solve:

$$\lambda(CS_A' + 1) \;\; + \;\; \gamma_1 + \mu$$
$$+ \lambda'[(CS_1 + \pi_1) - (\overline{CS} + n\pi_e) + \qquad (\pi_1 - K_1 - \pi_0)] = 0 \,. \tag{10}$$

We note first that other derivatives are the same as before and that the expression above includes the previous derivative, plus a term multiplied by λ'. Since $\lambda' < 0$, this latter term determines if π_1 is greater or smaller than previously.

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[17] Another possible extension to the model would be to treat λ as a subjective probability, with regulators having one *ex ante* view of λ, while the incumbent firm has a potentially different estimate of the probability of a technological change that would undermine its investments. We defer this generalization to subsequent research.

If competition improves social welfare, then presumably we will have $(CS_1 + \pi_1) - (\overline{CS} + n\pi E) < 0$ in general -- a result that indicates π_1^* will be higher than previously. On the other hand, $\delta(1-\lambda)^{-1}(\pi_1 - K_1 - \pi_0) > 0$, "reducing" π_1. In other words, if an increase in allowed "profit", π_1, increases the likelihood of beneficial competitive development, then the regulator will take this benefit into account by increasing allowed profits. In contrast, though, if an increase in π_1 raises the probability of such development, then it becomes more socially costly to induce the firm to undertake the potentially stranded investment. Thus, the consequences of letting λ be endogenous in this way are ambiguous on a priori grounds.

VI. Conclusion

Delineation of a sound public policy toward stranded cost recovery for regulated firms in the presence of emerging competition stands as one of the more crucial issues currently facing regulators. To date, much of the literature in this area has failed to cast this issue in the light of modern economic analysis. In the absence of such guidance, policy advocates have tended to gravitate toward extreme positions, and regulators possess few, if any, solid criteria for adjudicating competing claims.

In this paper, we have presented a simple model of the socially optimal level of compensation of stranded investments that, we hope, will begin to shed some light on this important policy issue. While the analysis certainly does not resolve all of the economic questions surrounding this issue, it may provide a starting point for further investigations. And, in the interim, the conclusions we have been able to draw here can provide some foundation for regulatory decision making.

In closing, we make three observations. First, while we believe that our model provides the basis for an improved level of understanding regarding the economic issues surrounding the issue of stranded costs, it is fashioned within the context of a limited number of regulatory instruments. If additional policy instruments are available to regulators, the use of these additional instruments (e.g., both a partial recovery mechanism plus a price cap together with the ability of the firm to self-select) may lead to welfare results that dominate those considered in the present paper. Second, it is important to note the relationship between the model we present herein and the present debate regarding the existence and nature of a so-called "regulatory contract." Specifically, the optimal regulatory policy being designed in the paper is predicated on the assumption that a clear policy - a regulatory contract - between the firm and the regulatory agency can be constructed and credibly enforced. This is not to say, however, that such an optimal policy or regulatory contract exists under present conditions. Finally, the models developed here abstract from a number of potentially interesting strategic issues, such as an incumbent firm's incentives to accurately reveal the magnitude of its stranded costs, the use of stranded cost recovery mechanisms as an entry deterrence device, alternative more specific regulatory regimes, and so on. We view this level of abstraction as both an advantage and a limitation. It is an advantage in that it minimizes the number and specificity of assumptions required to support our findings. It is a limitation in that other potentially interesting questions must be left unanswered. Given the (virtually nonexistent) state of the literature on this subject at this time, we believe that the relatively high level of abstraction reflected here is preferable. Other, more specific issues may be addressed in subsequent studies.

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