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The Capital Structure and Investment of Regulated Firms Under Alternative Regulatory Regimes

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Abstract
This paper explains how regulated firms choose their capital structure and examines the effects of this choice on investment and on regulated prices. It is shown that in equilibrium, firms have an optimal debt level and that given this debt level, the regulated price is set high enough to ensure that firms never become financially distressed. The analysis of the equilibrium yields testable hypotheses concerning the effects of changes in cost parameters and in the regulatory climate on the equilibrium investment level, capital structure, and regulated price. The analysis also shows that a regulatory restriction on the ability of the firm to issue securities may have an adverse effect on investment and consequently may harm consumers.

1. Introduction

Regulatory commissions set the rates of regulated firms to assure the firm a "fair" rate of return on its capital. The determination of this "fair" rate of return depends to a large extent on the firm's capital structure. This suggests that by properly choosing its capital structure, a regulated firm can affect its rates and hence its profitability. Despite its importance, very little work has been devoted to an examination of how regulated firms choose their capital structure, and to the effects of these choices on regulated rates and on the incentives of regulated firms to invest.

Recently, Spiegel and Spulber (1991; 1993) and Spiegel (1992) have developed models that examine the strategic interaction between capital structure, regulated price, and investment. These papers show that by issuing debt, a regulated firm can induce the regulator to increase the regulated price in an attempt to reduce the probability that the firm becomes financially distressed. Moreover, these papers show that this price increase has a positive effect on the firm's incentive to invest and on its choice of technology. The current paper builds on this work and makes two contributions. First, it offers a model that is amenable to a comparative statics analysis. This analysis yields a number of testable hypotheses regarding the effects of changes in cost parameters and in the regulatory climate on the equilibrium investment level, capital structure, and regulated price. Second, the paper shows that the equilibrium may change substantially when regulators impose a restriction on the firm's ability to raise external funds and that this restriction may eventually harm consumers.

To concentrate on rate regulation as the force driving the firm's capital structure, the paper abstracts from taxes, asymmetric information, agency problems, and corporate control considerations.[1] The regulatory process is modelled as a three-stage game in which the players are the firm, outside investors, and consumers. At the beginning of the game, the firm is all-equity and has no liquid assets. In stage 1, the firm chooses how much to invest in enhancing the quality of its output, and it issues a mix of debt and equity to outsiders to finance this investment. The market value of these securities is determined in a competitive capital market in stage 2. Finally, in stage 3, the regulated price is determined in a rate-setting process.

The sequential structure of the model reflects two important features of rate regulation. First, it reflects the inability of regulators to commit to particular rates before the firm makes irreversible investment decisions.[2] This inability to commit stems from the fact that historically, Courts gave regulators a great deal of leeway in choosing rates. According to the Supreme Court in the landmark Hope Natural Gas decision of 1944, regulators are "not bound to the use of any single formula or combination of formulae in determining rates...it is the result reached not the method employed which is controlling."[3] Second, the sequential structure of the model reflects the fact that "The selection of the class and the amount of securities to be issued for utility purposes ordinarily is a management function in the first instance."[4]

The equilibrium of the three-stage game is obtained by solving the game backwards. Thus, in each stage, players are assumed to choose their actions by taking into account the reactions of their opponents in all following stages. It is shown that in equilibrium, the firm chooses an optimal debt level that induces a regulated price which is high enough to ensure that it never becomes financially distressed. The latter result is consistent with the fact that since the early 30's only two regulated utilities, the Public Service Company of New Hampshire and El Paso Electric Co., have filed for bankruptcy. Since the only reason for issuing debt in this model is to induce a higher regulated price, the model provides an explanation for the findings of Bradley, Jarrell, and Kim (1984) that regulated firms are among the most highly leveraged and Taggart (1985) that firms increased their debt/equity ratios as a response to rate regulation.

A comparative statics analysis shows that counterintuitively, an increase in the cost of financial distress has a positive effect on the equilibrium levels of debt and investment. The reason for this positive effect is that an increase in the cost of financial distress makes both consumers and the firm more eager to avoid financial distress and hence the regulated price is raised. As a result, the firm can increase its debt level even further, thereby capturing a larger share of the expected social surplus, which in turn, strengthens its incentive to invest. The analysis also shows that an increase in expected operating costs leads to a decrease in the equilibrium levels of debt and investment. The effect on the regulated price, however, is ambiguous. On the one hand, an increase in expected operating costs has a positive direct effect on the regulated price, because the firm is compensated for its higher costs. But, on the other hand, the firm issues less debt, and this has a negative indirect effect on the regulated price, which may be larger or smaller than the direct effect.

1 See Myers (1984) for a general discussion on tax-based theories and Harris and Raviv (1991) for an extensive survey of theories based on agency costs, asymmetric information, and corporate control. The implications of asymmetric information for the capital structure of regulated firms are examined in Spiegel and Spulber (1993) and Lewis and Sappington (1992).

2 The absence of regulatory commitment to rates is also explored by Banks (1992) in the context of regulatory auditing and by Besanko and Spulber (1992) in the context of the choice of investment.

3 *Federal Power Comm. v. Hope Natural Gas Co.*, 320 U.S. 591, 603 (1944).

4 Turner (1969, 575).

Finally, the analysis shows that as the regulatory climate becomes more hostile to the firm, the equilibrium levels of investment, debt, and the regulated price fall. The overall effect on consumers, however, is ambiguous, reflecting the fact that while consumers pay less for the firm's output, the quality of this output falls as well as a consequence of the reduction in investment.

Regulatory commissions sometimes do not approve the issuance of securities if the proceeds are not directly related to new investments.[5] When the issuance of securities is restricted in this way, the firm's investment and financing decisions become interrelated. In particular, the firm can reach its optimal debt level only when its investment level is sufficiently large. As the analysis shows, such an investment level may not be profitable, so the firm may invest less than it would have absent the restriction. Consequently, consumers may be worse-off.

The rest of the paper is organized as follows. The basic three-stage game is presented in Section 2. The equilibrium of this game is characterized in Section 3. In Section 4, the properties of the equilibrium are studied and comparative statics results are derived. Section 5 examines how the firm's investment level, capital structure, and the regulated price are affected by a regulatory restriction on the issuance of securities. Concluding remarks are offered in Section 6.

2. The Basic Model

Consider a regulated monopoly producing a single product or service. The willingness of consumers to pay for the firm's output is given by $V(k)$, where k represents the firm's investment in improving the quality of its product/service. For example, k may represent an investment in service reliability (e.g., investment in redundancy to reduce the probability of service interruptions) or investment in a superior technology that enhances current services (e.g., fiber optic technology in telecommunication). Assume that $V(k)$ is twice differentiable, upward sloping, and concave, i.e., $V'(k) > 0 > V''(k)$, and that $V'(0) = \infty$, so some quality-enhancing investment is always profitable. To simplify the analysis, assume that the firm's output is fixed either because the demand for the firm's output is inelastic in the relevant range or because the firm operates under a binding capacity constraint. While this assumption is restrictive, it allows to solve the model in a closed-form, thereby facilitating the comparative statics analysis.[6] Normalizing the firm's output to one unit and using p to denote the regulated price, consumers' surplus is given by $CS(k,p) = V(k) - p$.[7]

The firm's operating costs are $C = c\,(1-z)$, where z is a random variable distributed uniformly over the unit interval. This implies that C is distributed uniformly over the interval $[0, c]$. Since C is decreasing in z, higher values of z represent better states of nature. In addition to C, the firm incurs an investment cost, k. This cost is assumed to be sunk, say because investment is irreversible and firm-specific. Thus, investment affects only the sunk costs of the firm, but not its (avoidable) operating costs. Throughout the analysis, it is assumed that

5 See for example Phillips (1988, 220) and Turner (1969, 573-577).

6 Spiegel and Spulber (1991) consider a more general model in which demand is downward sloping, but are unable to derive comparative statics results because the resulting equilibrium is too complex.

7 An alternative interpretation of the model is that the firm produces multiple products/services. Under this interpretation, $V(k)$ is the total willingness of consumers to pay for the firm's output and p is the firm's total revenues.

for all k, $V(k) > c$, i.e., production generates a positive social surplus in all states of nature.

The strategic interaction between the firm, outside investors, and consumers is modeled as a three-stage game. The sequence of events is shown in figure 1. In stage 1, the firm chooses how much to invest in enhancing the quality of its output and issues a mix of equity and debt to outsiders in order to finance this investment. In stage 2, the market value of the new securities is determined in a competitive capital market and the firm collects the proceeds and invests. In stage 3, given the firm's investment level and capital structure, the regulated price is established in a rate-setting process. Finally, the random variable z is realized, output is produced and payments are made.

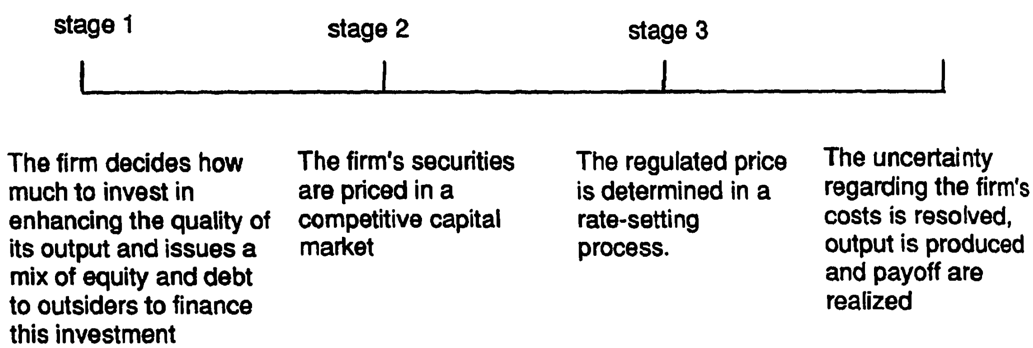

Figure 1. The Sequence of Events

Underlying the sequential structure of the model is the assumption that the regulated price is set after the firm's investment and capital structure have been already determined. This assumption captures the lack of regulatory commitment to rates that stems from the fact that the "social contract" between the firm and its regulators is necessarily incomplete.[8]

Initially, the firm is all-equity and has no liquid assets. To finance its investment the firm goes to the capital market. Let E be the market value of new shares representing a fraction $\alpha \in [0, 1]$ of the firm's equity, and let B be the market value of debt with face value D. Assume that debt is riskless in the sense that debtholders are eventually paid in full and equityholders remain the residual claimants even if the firm becomes financially distressed.[9] Since the new securities should cover the cost of the project, the firm's budget constraint is

$$k + m = E + B, \tag{1}$$

where $m \geq 0$, is the amount of external funds raised by the firm in excess of k. Assume that m is fully distributed to the original equityholders as a dividend. This assumption entails no loss of generality because so long as m is kept as part of the firm's cash flow, it effectively reduces the portion of debt that has to be paid out of firm earnings.[10] Thus, D can be thought

8 Even if this "social contract" would have been complete, it would still be nonbinding since the state is sovereign to amend it at its own discretion.

9 Without this assumption, debtholders become the residual claimants whenever they are not paid in full, in which case they bear the costs associated with financial distress. But, since debtholders are also protected by limited liability, they will refuse to take over the firm if the costs of financial distress exceed the operating income of the firm. This raises some technical issues that complicate the analysis considerably without adding any new insights.

10 This argument is no longer true if taxes are incorporated into the model, due to the preferential treatment

of as representing the "effective" debt obligation of the firm.

The operating income of the firm is $p - C = p - c\,(1-z)$. For a given debt obligation D, and a regulated price p, let $z^*(p,D)$ be the critical state of nature at which the firm is just able to pay its debt. When $D \le p - c$, the firm can always pay its debt, so $z^*(p,D) = 0$. When $D \ge p$, the operating income of the firm falls short of its debt obligations in all states of nature, so $z^*(p,D) = 1$. For debt levels strictly between p and $p - c$, $z^*(p,D)$ is defined implicitly by $p - c\,(1-z^*(p,D)) = D$. Thus,

$$z^*(p, D) = \begin{cases} 0, & D \le p - c, \\ \dfrac{D + c - p}{c}, & p - c < D \le p, \\ 1, & D > p. \end{cases} \tag{2}$$

For states of nature such that $z \ge z^*(p,D)$, the firm's operating income is sufficient to cover its debt obligation. Otherwise, the operating income falls short of the debt obligation, so the firm becomes financially distressed. Since z is uniformly distributed over the unit interval, $z^*(p,D)$ is the probability of financial distress. When $z < z^*(p,D)$, the firm pays its debt either by borrowing money from external sources against future earnings or by selling assets. Both options are assumed to be costly: Outsiders may require a very high interest rates on any loans that the firm takes given its current financial situation, while a sale of assets may fetch less than their true value to the firm, especially if assets are firm-specific. Moreover, financial distress may impose additional costs on the firm due to legal fees and court costs and due to a possible interruption of normal operations. Let T denote the cost of financial distress and assume that T is fixed, i.e., it is independent of the size of the shortfall of earnings from the debt obligation.[11] In addition, assume that in the relevant range, $V(k) - c \le T < V(k) - c/2$.[12] That is, the cost of financial distress is larger than the social surplus generated by the firm in the worst state of nature, but smaller than the expected social surplus. As shown in the Appendix, this assumption allows to characterize the equilibrium unambiguously, but is not too restrictive since Propositions 1-4 continue to hold even when this assumption is relaxed.

The combined expected ex post return to equityholders (both old and new) and debtholders is represented by the firm's (stage 3) expected profits and is divided between them according to their respective claims. Given the regulated price, p, and the firm's debt obligation, D, expected profits are

$$\pi(p, D) = p - \int_0^1 c\,(1 - z)\,dz - T z^*(p, D) = p - \frac{c}{2} - T z^*(p, D). \tag{3}$$

Thus, expected profits are equal to the expected operating income net of the expected costs

of capital gains. However, the current model includes no taxes to concentrate on the interaction between rate regulation and capital structure.

11 See Spiegel and Spulber (1993) for a similar model with proportional costs of financial distress.

12 This assumption can be made more formal by assuming that $V(k)$ is bounded from above, such that $V(\infty) - c \le T < V(0) - c/2$ Alternatively, it can be assumed that the firm chooses its investment level from the set $[0, K]$, such that $V(K) - c \le T < V(0) - c/2$.

of financial distress. The cost of investment, k, is not included in $\pi(p,D)$ since in stage 3 it is already sunk.

3. Equilibrium Characterization

The issuance of securities by regulated firms may be subject to certain regulatory restrictions. In this section, however, the model is solved under the assumption that no such restrictions apply, so that in stage 1 of the game the firm selects the type and quantity of its new securities at its own discretion. This assumption seems to be a natural starting point for the analysis for at least two reasons: First, in several states, e.g., Alaska, Iowa, Mississippi, North Dakota, and Texas, regulated firms do not need to obtain the commission's approval prior to security issues.[13] Second, even when commissions have the authority to regulate the issuance of securities they rarely use it because as the Colorado Supreme Court argues: "...a guiding principle of utility regulation is that management is to be left free to exercise its judgment regarding the most appropriate ratio between debt and equity."[14] Moreover, even when a deviation from this guiding principle is possible, "...few commissions are willing to substitute their judgments for those of the management except in reorganization cases" (Phillips 1988, 226). In Section 5 below, the model is analyzed under the alternative assumption that the regulatory authority imposes a restriction on the amount of external funds that the firm can raise.

The model is solved backwards: First, given the firm's capital structure and its level of investment, the rate setting process is solved for the optimal regulated price, $p^*(D,k)$. Second, given the (correct) expectations of outside investors concerning the optimal regulated price, $p^*(D,k)$, the capital market clears, and the market values of the firm's equity and debt, $E^*(\alpha,D,k)$ and $B^*(\alpha,D,k)$ are determined as functions of the firm's capital structure (α, D) and its investment level, k. Third, anticipating the optimal regulated price, $p^*(D,k)$, and the market values of the firm's securities, $E^*(\alpha,D,k)$ and $B^*(\alpha,D,k)$, the management of the firm chooses the level of quality-enhancing investment, k^*, and the mix of equity and debt, (α^*, D^*), to maximize the payoff of the original equityholders, subject to the firm's budget constraint given in equation (1). An equilibrium in the three-stage game is the six-tuple $< p^*(D,k), E^*(\alpha,D,k), B^*(\alpha,D,k), \alpha^*, D^*, k^* >$.

3.1. The Rate-Setting Process

Consider first the rate-setting process that takes place in stage 3 of the game. Following Spulber (1989, ch. 20), this process is modeled as a bargaining game between the firm and consumers over the division of the net expected ex post social surplus, $V(k) - c/2 - T z^*(p,D)$.[15] The regulator's role in this bargaining is simply to implement the bargaining outcome. In the current model, the firm represents its claimholders, i.e., debthold-

13 In addition, such an approval is required only from electric and gas companies in Colorado and Florida, electric companies in Utah, and the Black Hills Power Light Company in South Dakota (NARUC Annual Report on Utility and Carrier Regulation 12/31/90).

14 In *Re Mountain StatesTeleph. & Teleg. Co.* 39 PUR 4th 222, 247-248.

15 The term ex post refers to the fact that the cost of investment, k, is not included in the expected social surplus because in stage 3 it is already sunk.

ers and both original and new equityholders, whose combined payoff is equal to the (stage 3) expected profits of the firm, $\pi(p,D)$. The payoff of consumers is represented by consumers' surplus, $CS(k,p) = V(k) - p$.

Specifically, the bargaining process between consumers and claimholders is modelled as an asymmetric Nash bargaining problem. In the event that the bargaining fails, consumers receive a payoff of zero. This entails no loss of generality as $V(k)$ can be viewed as consumers' willingness to pay for the firm's output, over and above their next best alternative. Similarly, the firm's disagreement payoff can be set equal to zero without a loss of generality since investment, k, is completely sunk and since claimholders are protected by limited liability.[16] Thus, $p^*(D,k)$ is the solution to

$$\underset{p}{Max}\; CS(k, p)^{\gamma}\, \pi(p, D)^{1-\gamma}, \tag{4}$$

where γ represents the bargaining power of consumers and $1-\gamma$ represents the bargaining power of the firm. Assume that $0 \le \gamma \le \tilde{\gamma} \equiv (V(0)-c)/(V(0)-c/2)$. The right inequality implies that the firm's share in the net expected ex post social surplus is sufficiently large to ensure that at least for low debt levels, the firm is completely immune from financial distress. Note that the maximand in (4) can also be interpreted as the regulator's own (Cobb-Douglas) utility function. This interpretation is consistent with Peltzman's (1976) political economy model of regulation.

By solving (4), $p^*(D,k)$ divides the net expected ex post social surplus between consumers and the firm according to their respective bargaining powers. The size of the surplus, however, is increasing in p, because such an increase leads to a reduction in the expected cost of financial distress, $Tz^*(p,D)$. At the same time, however, an increase in p also shifts a larger share of the expected ex post surplus from consumers to the firm. Thus, $p^*(D,k)$ is determined by trading off consumer surplus against the expected cost of financial distress.

The solution to (4) is provided in the Appendix. The resulting optimal regulated price as a function of D and k is given by

$$p^*(D,k) = \begin{cases} D_1(k) + c, & D \le D_1(k), \\ D + c & D_1(k) < D \le D_2(k), \\ D_1(k) + c + \dfrac{\gamma T}{c+T}\left(D + \dfrac{c}{2}\right), & D_2(k) < D \le D_3(k), \\ D_1(k) + c + \gamma T, & D > D_3(k), \end{cases} \tag{5}$$

where

16 To see why this assumption is without loss of generality, note that since claimholders are protected by limited liability, their disagreement payoff cannot be negative. Now, if the firm has additional (possibly unregulated) businesses whose total value is $B > 0$ (rather than 0), the disagreement payoff of claimholders is B. Consequently, the difference between agreement and disagreement becomes $x = B + \pi(p,D) - B = \pi(p,D)$. But, since x is independent of B, B has no effect on analysis.

$$D_1(k) = (1-\gamma)\,(V(k) - \frac{c}{2}) - \frac{c}{2}, \tag{6}$$

$$D_2(k) = \frac{(1-\gamma)\,(c+T)\,(V(k) - c/2)}{c + T\,(1-\gamma)} - \frac{c}{2}, \tag{7}$$

and

$$(1-\gamma)\,V(k) + \gamma\frac{c}{2} + \gamma T < D_3(k) < \frac{(1-\gamma)\,(\,c+T\,)\,V(k) + \gamma\, c\,(c/2+T)}{c + T\,(1-\gamma)}. \tag{8}$$

Note that k affects the optimal regulated price only through $V(k)$, but not directly. This is because the regulated price is set after k has already been sunk, at which point the firm is being held-up by consumers in the rate-setting process.

The optimal regulated price, $p^*(D,k)$, is shown in figure 2 as a function of D. When $D \le D_1(k)$, financial distress is a zero probability event, so $p^*(D,k)$ is independent of D. When $D > D_1(k)$, the slope of $p^*(D,k)$ is one, so $p^*(D,k)$ increases in D just enough to ensure that the probability of financial distress remains zero. However, as $D > D_2(k)$, the marginal loss in consumer's surplus from increasing $p^*(D,k)$ at this rate becomes larger than the gain from keeping the probability of financial distress at zero. Nevertheless, since the cost of financial distress is relatively large (recall that in the relevant range $T \ge V(k) - c$), $p^*(D,k)$ still increases with D to reduce the probability of financial distress, but now the slope of $p^*(D,k)$ is less than one, so the firm becomes financially distressed with positive probability. Finally, when $D > D_3(k)$, the loss to consumer's surplus from reducing the probability of financial distress becomes too large. Consequently, $p^*(D,k)$ jumps downward to below D, leaving the firm susceptible to financial distress with probability one. Since, financial distress occurs in this range for sure, $p^*(D,k)$ need no longer increase with D and it therefore becomes

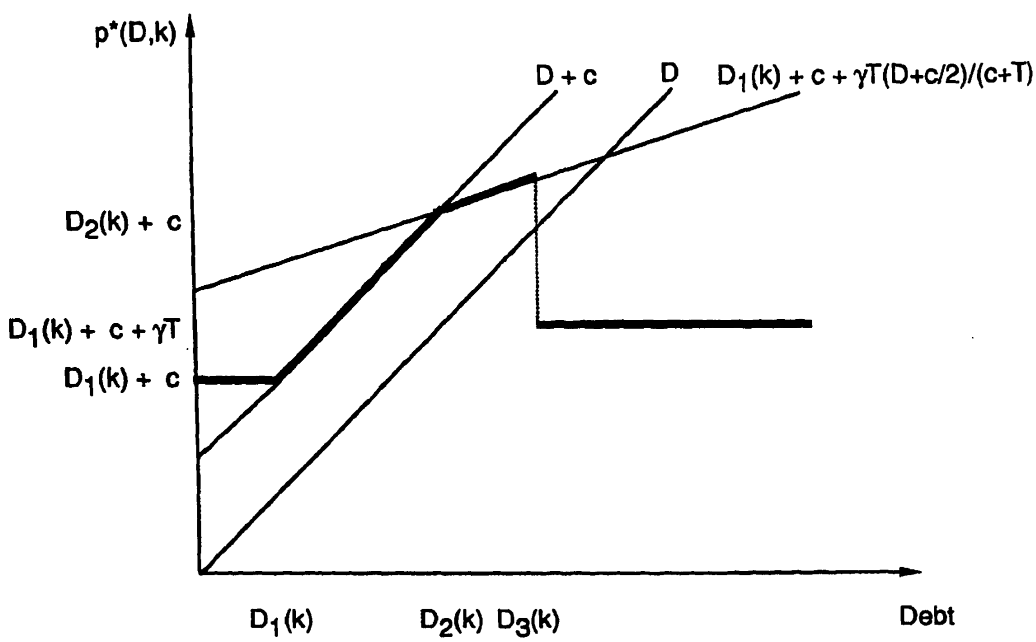

Figure 2. The Optimal Regulated Price as a Function of Debt, *D*, Given the Level of Investment, *k*

a constant.

3.2. Capital Market Equilibrium

Next, consider the equilibrium in the capital market, obtained in stage 2 of the game. Assuming that the capital market is competitive and that investors correctly anticipate the regulated price that results from the bargaining with consumers in stage 3, securities are priced fairly. Normalizing the risk-free interest rate to zero, this means that when the capital market is in equilibrium, the market value of new equity and debt is exactly equal to their expected return,

$$E^*(\alpha, D, k) = \alpha\,[\pi(D, k) - D\,], \quad B^*(\alpha, D, k) = D, \tag{9}$$

where $\pi(D,k) \equiv \pi(p^*(D,k),D)$. Thus, new equityholders receive a share of α in the firm's profits net of debt payments, while debtholders receive the face value of debt (paid in all states of nature). Substituting from (9) into equation (1), the budget constraint of the firm becomes,

$$k + m = \alpha\,\pi(D, k) + (1 - \alpha)\,D. \tag{10}$$

The capital structure of the firm is fully characterized by a pair (α, D) that satisfies equation (10).

3.3. Optimal Level of Investment and Capital Structure

Throughout, the firm's management is assumed to act as a perfect agent for the original equityholders. Hence, the firm's investment level, k, and its capital structure, (α, D), are chosen to maximize the expected payoff of the original equityholders of the firm, given by

$$Y(\alpha, D, k) = (1 - \alpha)\,[\pi(D, k) - D\,] + m. \tag{11}$$

The first term in (11) represents the original equityholders' share in the firm's profits net of debt payments, while the second term represents the value of the dividends distributed to the original equityholders in stage 1. Substituting for m from equation (10) into (11), yields

$$Y(D, k) = \pi(D, k) - k. \tag{12}$$

Hence, when the capital market is in equilibrium, the original equityholders' expected payoff is equal to the firm's expected profits net of the sunk cost of investment. Note that m has no effect on $Y(D,k)$ because outside investors pay a fair price for the firm's securities.

The equilibrium levels of investment and debt, k^* and D^*, maximize $Y(D,k)$ while the equilibrium level of new equity, α^*, can be found by substituting k^* and D^* into equation (10) and solving for α. Using (3) and (5)-(7), the original equityholders' expected payoff becomes

$$Y(D, k) = \begin{cases} D_1(k) + \frac{c}{2} - k, & D \le D_1\,(k), \\ D + \frac{c}{2} - k, & D_1(k) < D \le D_2(k), \\ D_2(k) + \frac{c}{2} - k + \frac{(1-\gamma)\,T}{c}\,(D_2(k) - D), & D_2(k) < D \le D_3(k), \\ D_1(k) + \frac{c}{2} - (1-\gamma)\,T - k, & D > D_3(k). \end{cases} \tag{13}$$

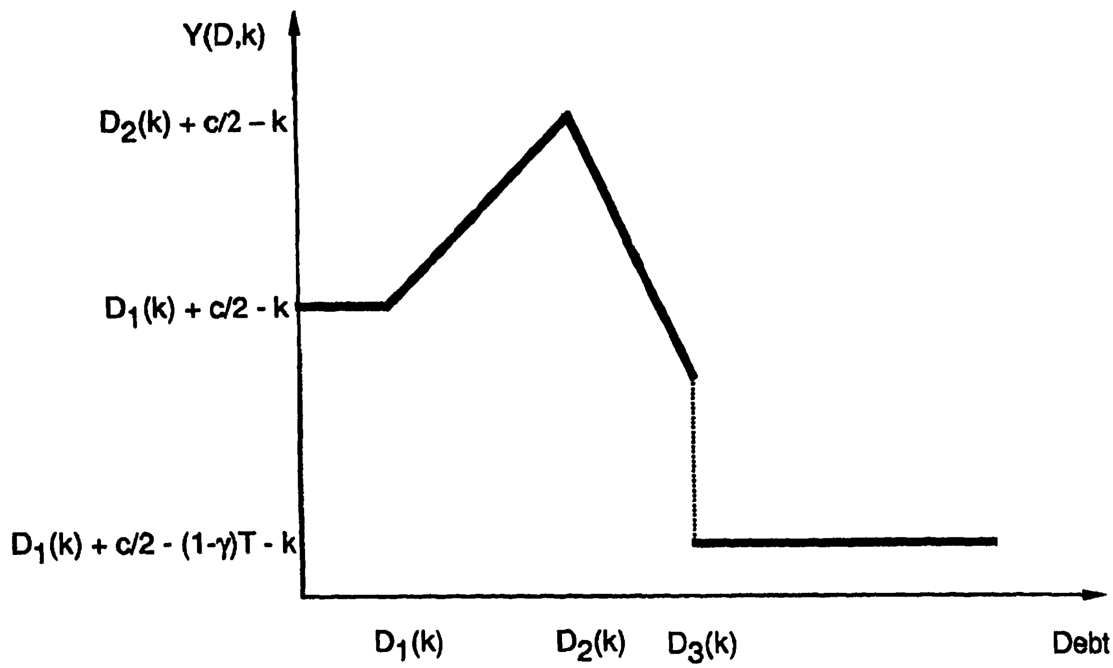

Figure 3. The Original Equityholders' Expected Payoff as a Function of Debt, *D*, Given the Level of Investment, *k*

Figure 3 shows $Y(D,k)$ as a function of D. It is easy to see that given k, $Y(D,k)$ attains a unique maximum at $D = D_2(k)$. Whenever D is below this level, additional debt leads to a price increase due to a concern about financial distress. When D exceeds this level, the regulated price is no longer sufficiently high to ensure that the firm is immune from financial distress. On the margin, each additional dollar of debt beyond $D_2(k)$, increases the expected costs of financial distress by $T\,\partial z^*/\partial D = T/c$. The resulting reduction in the return to the firm's original equityholders is $(1-\gamma)\,T/c$, representing the firm's share in the expected marginal costs of financial distress (the remaining costs are passed on to consumers). When $D > D_3(k)$, the firm becomes financially distressed for sure, so the expected payoff of the original equityholders is lower than in the case where the firm is all-equity by $(1-\gamma)\,T$, which is the firm's share in the total cost of financial distress.

Thus, the equilibrium debt level of the firm as a function of the level of investment, k, is $D^*(k) = D_2(k)$. Substituting $D^*(k)$ into (13), it follows that, evaluated at the optimal debt level, the expected payoff of the original equityholders is

$$Y^*(k) \equiv Y(D^*(k), k) = D_2(k) + \frac{c}{2} - k. \tag{14}$$

The equilibrium investment level, k^*, maximizes this expression. The first-order condition for k^* is

$$\frac{(1-\gamma)(c+T)}{c+T(1-\gamma)}\, V'(k^*) = 1, \tag{15}$$

where $V'(0) = \infty$, ensures that $k^* > 0$. Evaluating equation (7) at k^*, the equilibrium debt level is

$$D^* = D_2(k^*) = \frac{(1-\gamma)(c+T)(V(k^*) - c/2)}{c + T(1-\gamma)} - \frac{c}{2}. \tag{16}$$

Since α does not affect the payoff of the original equityholders directly, the firm issues equity only when $k^* > B(D_2(k^*)) = D_2(k^*)$, in order to finance the amount $k^* - D_2(k^*)$. Thus, $\alpha^* > 0$, only if $k^* > D_2(k^*)$, in which case $m = 0$ because the firm has no use for financial slack. Otherwise, $\alpha^* = 0$ and $m = D_2(k^*) - k^* > 0$, i.e., the firm creates a financial slack by issuing debt whose face value exceeds the cost of investment. Thus, using equation (10),

$$\alpha^* = Max\left\{\frac{k^* - D^*}{c/2}, 0\right\}. \tag{17}$$

3.4. Equilibrium in the Overall Game

Having solved the three-stage game, the equilibrium is now characterized. The equilibrium level of investment, k^*, is given implicitly by equation (15). To finance this investment, the firm issues debt with face value $D^* = D_2(k^*)$. When $k^* < D^*$, the firm distributes the amount $D^* - k^*$ as a dividend, while when $k^* > D^*$, the firm issues equity with $\alpha^* = (k^* - D^*)/(c/2)$ to finance the amount $k^* - D^*$. Substituting k^*, α^*, and D^* into (9) reveals that the equilibrium market values of the firm's new securities are $E^*(\alpha^*,D^*,k^*) = \alpha^* c/2$ and $B^*(\alpha^*,D^*,k^*) = D^*$. The equilibrium regulated price is $p^* \equiv p^*(D^*,k^*) = D^* + c$.

Finally, it is interesting to examine how the equilibrium is affected by assumption that in the relevant range, $V(k) - c \leq T < V(k) - c/2$. To this end, suppose first that $T < V(k) - c$. Then, the cost of financial distress is relatively low, so $p^*(D,k)$ may jump downward to below D at a lower debt level than before. Clearly, if this jump occurs above $D_2(k)$, the equilibrium remains unaffected, so the assumption is effectively innocuous. Otherwise, as shown in the Appendix, $p^*(D,k) = D_1(k) + c$ for all $D \leq D_1(k)$, $p^*(D,k) = D + c$ for all D such that $D_1(k) < D \leq D_3(k)$, and $p^*(D,k) = D_1(k) + c + \gamma T$ otherwise. The equilibrium debt level of the firm is now $D_3(k)$, instead of $D_2(k)$, and as a result, $p^* = D_3(k) + c$, and $Y^*(k) = D_3(k) + c/2 - k$. Finally, the firm chooses k^* to maximize $D_3(k) + c/2 - k$, instead of $D_2(k) + c/2 - k$. While this equilibrium differs from the one characterized above, it has very similar qualitative properties.[17] Second, suppose that $T \geq V(k) - c/2$. Then, as argued in the Appendix, $p^*(D,k)$ may differ from the one characterized in (A-5) for debt levels exceeding $D_2(k)$. Such debt levels, however, are never issued in equilibrium, so the analysis remains as before.

4. Empirical Implications

In this section, the properties of the equilibrium are examined and empirical implication are

17 It is straightforward to show that Propositions 1-4 remain unchanged when $T < V(k) - c$.

derived. First, note that as in Spiegel and Spulber (1991; 1993) and Spiegel (1992), the equilibrium regulated price increases with debt, but is unaffected by equity. This implies that debt issues should lead to price increase, while equity issues should have no effect on regulated prices. Moreover, since the only benefit to the firm from issuing debt comes in the form of a higher regulated price, an unregulated firm would have no reason to issue debt in this model. This suggests that firms should increase their debt levels once they become regulated.

Proposition 1: The equilibrium regulated price increases with the firm's debt but is unaffected by equity. Moreover, in this model a firm would increase its debt level in response to rate regulation.

Proposition 1 is consistent with empirical evidence. In a survey of 27 regulatory agencies and 65 utilities reported Besley and Bolten (1990) report that about 60% of the regulators and the utilities surveyed believe that an increase in debt relative to equity results in a price increase. Bradley, Jarrell and Kim (1984) study 25 industries over the period 1962-1980 and find that firms in regulated industries are among the most highly leveraged firms. Taggart (1985) studies the capital structure of electric utilities and natural gas firms in the early days of rate regulation by state commissions (1912-1922), and finds support for the hypothesis that the establishment of rate regulation is associated with an increase in utility debt levels.

Second, note that the equilibrium operating income of the firm is $D_2(k^*) + c - c\,(1-z) \geq D_2(k^*)$. This implies that in equilibrium the firm's earnings are sufficient to cover its debt obligation even in the worst state of nature. Thus,

Proposition 2: In equilibrium, the firm never becomes financially distressed.

Proposition 2 is consistent with the observation that since the mid 30's only two public utilities, the Public Service Company of New Hampshire and El Paso Electric Co., have filed for bankruptcy. Intuitively, the firm never issues debt to the point where it becomes susceptible to financial distress, because in this model, the regulated price is determined by bargaining, so whenever the firm is susceptible to financial distress, it bears a share of the associated cost. This result, however, stands in contrast with the corresponding result in Spiegel and Spulber (1991), where the equilibrium probability of financial distress is strictly positive. The reason for this difference is that Spiegel and Spulber assume marginal cost pricing, which has the feature that an increase in the regulated price due to the issuance of debt benefits the firm not only on the margin, but also on all the inframarginal units it sells. This more than compensates the firm for the increase in its expected costs of financial distress and induces it to issue debt to point where financial distress becomes a positive probability event. Here in contrast, the bargaining over the regulated price leads to an average cost pricing. Consequently, the firm cannot gain from a price increase on inframarginal units, so debt levels that render the firm susceptible to financial distress are not profitable.

The effects of changes in the exogenous parameters of the model on the equilibrium investment level, capital structure, and regulated price are studied next. The key parameter in this model is the fixed cost of financial distress, T. It is the presence of this cost that enables the firm to affect the regulated price by issuing debt. To examine the effects of an increase in T, differentiate equation (15) with respect to T and k^*,

$$\frac{d\,k^*}{d\,T} = \frac{-\gamma\, c\, V'(k^*)}{(c+T)\,(c+T\,(1-\gamma))\,V''(k^*)} > 0. \tag{18}$$

Differentiating (16) and (17) with respect to T and using (18) yields,

$$\frac{dD^*}{dT}=\frac{(1-\gamma)}{c+T(1-\gamma)}\left[\frac{\gamma c(V-c/2)}{c+T(1-\gamma)}+(c+T)\,V'(k^*)\frac{dk^*}{dT}\right]>0, \tag{19}$$

and

$$\frac{d\alpha^*}{dT}=\frac{dk^*/dT-dD^*/dT}{c/2}. \tag{20}$$

Finally, since $p^* = D^* + c$, it follows that $dp^*/dT = dD^*/dt > 0$. Thus,

Proposition 3: The equilibrium levels of investment and debt and the regulated price increase with the cost of financial distress, T. The effect on the equilibrium equity participation of outsiders, however, is ambiguous.

The result of Proposition 3 seems counterintuitive because typically, e.g., Myers (1984), the cost of financial distress represent the cost of debt from the firm's perspective. Thus, as these costs increase, the firm issues less debt. But, in this model, the firm never becomes financially distressed in equilibrium, so an increase in T does not affect the firm directly. At the same time, such an increase has a positive indirect effect on the firm's earnings, because the equilibrium regulated price is set by trading off consumer surplus against the cost of financial distress and is therefore increasing with T. The effect of an increase in T on the equilibrium equity participation of outsiders is ambiguous, however, because the numerator in (20) can be either positive or negative, depending on whether, in equilibrium, the increase in investment is larger than the increase in debt or vice versa.

Since k^* increases with T, it is interesting to examine what happens to k^* in the limit, as T approaches either 0 or to ∞. In the first case, financial distress is costless so debt does not affect the regulated price and consequently the original equityholders' payoff. Indeed, setting $T = 0$ in (14), reveals that $Y(k) = D_1(k) + c/2 - k$, which is exactly the expected payoff of the equityholders of an all-equity regulated firm. Thus, k^* is equal to k^E, the investment level of an all-equity firm. On the other hand, when $T \rightarrow \infty$, the prevention of financial distress becomes the overriding concern in the rate-setting process, so the firm is able to capture the entire net expected social surplus. To confirm this intuition, let $T \rightarrow \infty$ in (14). Then, $Y(k) = V(k) - c/2 - k$, implying that

$$\lim_{T\rightarrow\infty} k^* \rightarrow k^{fb},$$

where k^{fb} is the first-best level of investment.[18] The investment levels k^{fb} and k^E, respectively, are given implicitly by the first-order conditions $V'(k^{fb}) = 1$ and $dD_1(k)/dk = (1-\gamma)\,V'(k^E) = 1$ ($k^E = 0$ if $D_1(k) = 0$). Clearly, $k^E < k^{fb}$ since the firm captures only a fraction of the benefits from its investment but bears the entire cost. This is the well-known underinvestment problem, e.g., Spulber (1989, ch. 20). Thus,

Proposition 4: The equilibrium level of investment, k^*, is such that, (i) $k^* = k^E < k^{fb}$, if $T = 0$; (ii) $k^E < k^* < k^{fb}$, if $0 < T < \infty$; and (iii) $k^E < k^* = k^{fb}$, if $T \rightarrow \infty$.

[18] At the first-best, $D = 0$ because debt has only a strategic advantage in this model. Thus, at the first-best, $z^*(p,D) = 0$, so the expected social surplus which k is chosen to maximize is $V(k) - c/2 - k$.

Intuitively, debt financing alleviates the underinvestment problem since it leads to a higher regulated price, thereby enabling the firm to capture a larger share in the benefits from its investment. But, unless $T \to \infty$, the underinvestment problem is not solved completely.

Next, consider the effects of an increase in the firm's cost parameter, c, on the equilibrium. Differentiating equation (15) with respect to c and k^*,

$$\frac{dk^*}{dc} = \frac{\gamma T V'(k^*)}{(c+T)(c+T(1-\gamma))V''(k^*)} < 0. \tag{21}$$

Intuitively, as c increases, the expected return on each dollar of investment decreases, so investment becomes less attractive. Differentiating (16) and (17) with respect to c and using (21) yields,

$$\frac{dD^*}{dc} = -\frac{(1-\gamma)(2\gamma T V(k^*) + (1-\gamma)T(2c-T) + c^2)}{2(c+T(1-\gamma))^2} - \frac{1}{2} + \frac{(1-\gamma)(c+T)V'(k^*)}{c+T(1-\gamma)}\frac{dk^*}{dc} < 0, \tag{22}$$

and

$$\frac{d\alpha^*}{dc} = \frac{dk^*/dc - dD^*/dc - \alpha^*/2}{c/2}. \tag{23}$$

From (22) it is clear that as c increases, the firm issues less debt in equilibrium both because otherwise it would become susceptible to financial distress and because it needs less external funds. The effect on equity, however, is ambiguous, because in general, the numerator in (23) can be either positive or negative. Finally, differentiating the equilibrium regulated price with respect to c,

$$\frac{dp^*}{dc} = \frac{dD^*}{dc} + 1. \tag{24}$$

Thus, an increase in c has two opposing effects on the regulated price: A negative indirect effect due to the reduction in debt and a positive direct effect. In general, it is impossible to determine the sign of the net effect. To further explore the effect of an increase in c on the equilibrium regulated price, let $V(k) = a + v\sqrt{k}$, where $a > c/2$ and $v > 0$. Then, using equation (15),

$$k^* = \left[\frac{v(1-\gamma)(c+T)}{2(c+T(1-\gamma))}\right]^2. \tag{25}$$

Substituting this expression in $p^* = D^* + c$ and differentiating with respect to c yields,

$$\frac{dp^*}{dc} = \frac{\gamma[(c+T(1-\gamma))(c^2 - 2T(1-\gamma)(a-c)) - 2Tv^2(1-\gamma)^2(c+T)]}{2(c+T(1-\gamma))^3}. \tag{26}$$

Define

$$\tilde{v} = Max\left\{\sqrt{\frac{(c+T(1-\gamma))(c^2 - 2T(1-\gamma)(a-c))}{2T(1-\gamma)^2(c+T)}}, 0\right\}, \tag{27}$$

as the critical value of v above which $d\,p^*/d\,c < 0$. Then whenever, $v > \tilde{v}$, the counterintuitive result is that an increase in the expected operating costs leads to an overall decrease in the regulated price. This result is rather surprising because it implies that cases may exist (e.g., consumer's willingness to pay is high) where consumers are better-off when the firm is relatively cost-inefficient than when the firm is relatively cost-efficient.

Proposition 5: The equilibrium levels of investment and debt decrease with the firm's cost parameter, c, while the effect on the equilibrium level of new equity and the regulated price is in general ambiguous. When $V(k) = a + v\sqrt{k}$, $a > c$, $v > 0$, the equilibrium regulated price decreases with c for all $v > \tilde{v}$.

Finally, consider the effect of a change in regulatory climate. Such a change is captured in this model through a change in γ. As γ increases, consumers get a larger share in the net ex post social surplus, a situation that corresponds to the regulatory climate becoming more hostile to firms. Differentiating equation (15) with respect to γ and k^*,

$$\frac{d\,k^*}{d\,\gamma} = \frac{c\,V'(k^*)}{(1-\gamma)\,(c + T(1-\gamma))\,V''(k^*)} < 0. \tag{28}$$

Using this result, differentiate (16) and (17) with respect to γ to obtain

$$\frac{d\,D^*}{d\,\gamma} = \frac{(c+T)}{c + T(1-\gamma)}\left[\frac{-c(V - c/2)}{c + T\,(1-\gamma)} + (1-\gamma)\,V'(k^*)\,\frac{d\,k^*}{d\,\gamma}\right] < 0, \tag{29}$$

and

$$\frac{d\,\alpha^*}{d\,\gamma} = \frac{d\,k^*/d\,\gamma - d\,D^*/d\,\gamma}{c/2}. \tag{30}$$

Equation (30) shows that the effect of an increase in γ on the equilibrium equity participation of outsiders is ambiguous because the numerator in (30) can be either positive or negative, depending on whether, in equilibrium, the decrease in investment outweighs the decrease in debt or vice versa. Finally, since $p^* = D^* + c$, it follows that $d\,p^*/d\,\gamma = d\,D^*/d\,\gamma < 0$. Thus,

Proposition 6: The equilibrium levels of investment and debt and the regulated price decrease with the bargaining power of consumers, γ. The effect on the equilibrium equity participation of outsiders, however, is ambiguous.

Dasgupta and Nanda (1993) find in a cross-section of United States electric utilities for the years 1980-1983, that regulatory environments that are harsher to firms are associated with increased debt to total capitalization ratios. Their finding is not necessarily inconsistent with Proposition 6, because here, both investment and debt decrease with γ, so the ratio of debt to total capitalization can still increase if the reduction in investment is larger than the reduction in debt.

Observe that consumers do not necessarily gain from an increase in their bargaining power: Although the regulated price falls as a result of such an increase, investment and hence the quality of the firm's output fall as well. Consequently, the overall effect on the equilibrium level of consumers' surplus, $CS^* = V(k^*) - p^*$, is ambiguous. To explore the effect of an exogenous change in γ on consumers' surplus further, assume again that $V(k) = a + v\sqrt{k}$, so that k^* is given by (25). Substituting for k^* in CS^*,

$$CS^* = \frac{(1-\gamma)\,(c+T)\,[\gamma c v^2 - (c+T(1-\gamma))\,(2a-c))]}{2(c+T\,(1-\gamma))^2} + a - \frac{c}{2}. \tag{31}$$

Differentiating CS^* with respect to γ,

$$\frac{d\,CS^*}{d\gamma} = \frac{c\,(c+T)\,[(2a-c)\,(c+T(1-\gamma)) + (c - 2\gamma c + T(1-\gamma)\,)\,v^2\,]}{2(c+T(1-\gamma))^3}. \tag{32}$$

Hence, in this example, consumers gain from an increase in their bargaining power only when

$$\gamma < \frac{(c+T)\,(2a-c+v^2)}{T(2a-c+v^2)+2cv^2}. \tag{33}$$

Otherwise, consumers will prefer to be less aggressive in the bargaining because the resulting increase in the quality of the firm's output will more than compensate them for having to pay a higher price. A similar result is derived in Spulber and Besanko (1992) in the context of environmental regulation. There, when the regulatory agency lacks the ability to commit in advance to environmental standards, a policy-maker appoints a regulator whose preferences are not aligned with his own, so as to commit not to hold-up the firm, thereby strengthening the firm's incentives to invest in productive capacity.

5. An Alternative Regulatory Regime

Thus far, the model was solved under the assumption that the firm's management is free to choose the type and quantity of the new securities that the firm issues, without any regulatory restrictions. However, as Phillips (1988, 220) points out, regulatory commissions sometimes do not approve the issuance of securities if the proceeds are not directly related to new investments.[19] In what follows, the impact of such a restriction on the equilibrium is examined. To this end, note that in the current model, restricting the firm to issue new securities only to the extent that the proceeds are needed to finance investment, amounts to mandating that $m = 0$. In the presence of this restriction, the firm's budget constraint becomes

$$k = \alpha\,\pi(D, k) + (1-\alpha)\,D, \tag{34}$$

so the capital structure of the firm is tied to the cost of investment. Since $\alpha \geq 0$, it follows that $D \leq k$, i.e., the firm's debt is bounded above by the cost of investment.

Let k^{**} and D^{**}, respectively, be the equilibrium levels of investment and debt in a regulatory regime in which m is restricted to be zero. To characterize k^{**} and D^{**}, note that the restriction that $m = 0$ does not affect the optimal regulated price which continues to be given by (5). Moreover, since $Y(D,k)$ is independent of m, the restriction also has no effect on the original equityholders' payoff. Thus, the objective of the firm's management remains

19 A case in point is *Re Budd Lake Water Co.* (63 PUR3d p. 169), where the New Jersey Board stated that "The amount of securities to be capitalized should, under normal circumstances, bear a reasonable and direct relationship to the company's net investment for property and related items used or available for use in the utilities operations."

to maximize $Y(D,k)$, but now it is subject to the constraint that $D \leq k$. But, when $k > D_2(k)$, the constraint is not binding, so $D^{**} = D_2(k)$. On the other hand, when D is such that $D_1(k) < D \leq D_2(k)$, the constraint is binding, so in this range, $D^{**} = k$. Finally, for all $D \leq D_1(k)$, $Y(D,k)$ is a constant, so the firm is indifferent to its debt level. Thus, the equilibrium debt level of the firm as a function of k is

$$D^{**}(k) = \begin{cases} [0, D_1(k)], & k \leq D_1(k), \\ k, & D_1(k) < k \leq D_2(k), \\ D_2(k), & D_2(k) < k. \end{cases} \tag{35}$$

Substituting $D^{**}(k)$ into (13) yields,

$$Y^{**}(k) \equiv Y(D^{**}(k), k) = \begin{cases} D_1(k) + \frac{c}{2} - k, & k \leq D_1(k), \\ \frac{c}{2}, & D_1(k) < k \leq D_2(k), \\ D_2(k) + \frac{c}{2} - k, & k > D_2(k). \end{cases} \tag{36}$$

The equilibrium level of investment, k^{**}, maximizes $Y^{**}(k)$. The first line in (36) describes the expected payoff of the equityholders of an all-equity regulated firm and will be denoted by $Y^E(k)$. The third line in (36) is equal to $Y^*(k)$, i.e., the expected payoff of the original equityholders of a regulated firm which is not subject to a regulatory restriction on the issuance of new securities. Since $D_2(k) > D_1(k)$, it follows that for all k, $Y^*(k) > Y^E(k)$.

To facilitate the analysis, add and subtract $c/2$ from each one of the bounds in (36), rearrange terms, and use the definitions of $Y^E(k)$ and $Y^*(k)$ to obtain

$$Y^{**}(k) = \begin{cases} Y^E(k), & \frac{c}{2} < Y^E(k), \\ \frac{c}{2}, & Y^E(k) \leq \frac{c}{2} \leq Y^*(k), \\ Y^*(k), & Y^*(k) < \frac{c}{2}. \end{cases} \tag{37}$$

The expected payoff function $Y^{**}(k)$ is shown in figure 4. Since $V'(k) > 0 > V''(k)$, both $Y^E(k)$ and $Y^*(k)$ are strictly concave and their respective maxima are k^E and k^*. From Proposition 4 it follows that $k^E < k^*$. As figure 4 illustrates, there are three cases to consider depending on the magnitude of $c/2$. First, when $c/2 < Y^E(k^E)$, the equilibrium is identical to the one that would be obtained under all-equity financing, so $k^{**} = k^E$, $D^{**} \leq k^E$, and $p^E \equiv p^*(D^{**},k^E) = D_1(k^E) + c$. Second, when $Y^E(k^E) \leq \frac{c}{2} < Y^*(k^*)$, then $k^{**} \in [k_1, k_2]$, where k_1 and k_2 are defined implicitly by $Y^*(k_1) = Y^*(k_2) = c/2$. From (36) it then follows that the firm uses debt financing exclusively, i.e., $D^{**} = k^{**}$. Hence, (5) implies that, $p^*(D^{**},k^{**}) = k^{**} + c$. Since $Y^*(k)$ is strictly concave, it is clear that $k_1 < k^* < k_2$, so the regulatory restriction has an ambiguous effect on the equilibrium levels of investment, debt,

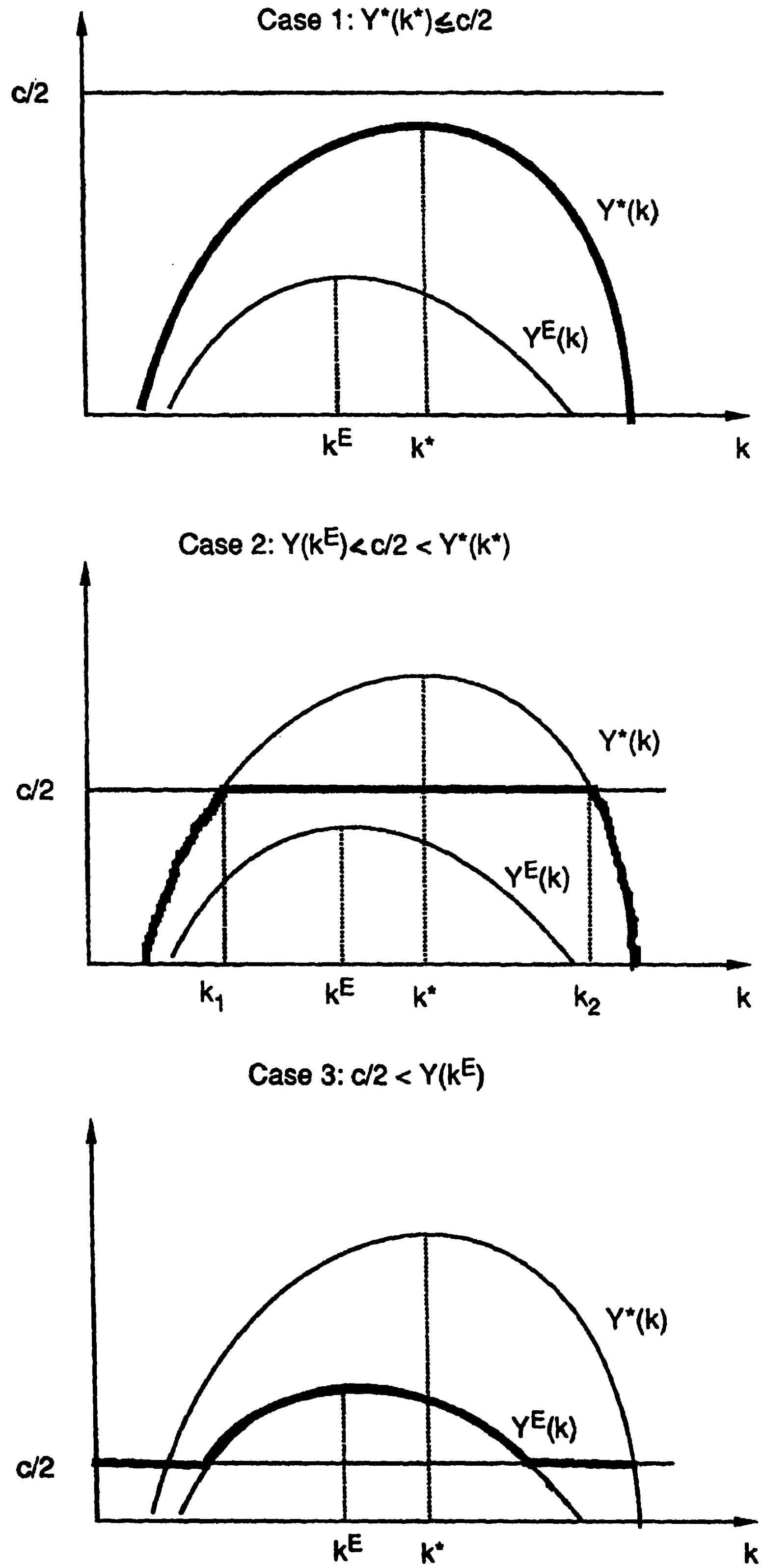

Figure 4. The Payoff Function $Y^{**}(k)$

and regulated price. Finally, when $\frac{c}{2} \geq Y^*(k^*)$, the regulatory restriction is not effective. This discussion is now summarized in the following Proposition:

Proposition 7: Assume that the regulatory regime is such that the firm is restricted to raise external funds only to the extent that it needs the proceeds to finance investment (i.e., $m = 0$). Then,

(i) if $c/2 < Y^E(k^E)$, then the equilibrium investment level and regulated price are equal to those that would be obtained under all-equity financing, while the firm's debt level does not exceed k;

(ii) if $Y^E(k^E) \leq c/2 < Y^*(k^*)$, then $k^{**} = D^{**} = [k_1, k_2]$, where $k_1 < k^* < k_2$, i.e., the firm is indifferent to all investment levels in the interval $[k_1, k_2]$, and uses debt financing exclusively, while $p^*(D^{**}, k^{**}) = k^{**} + c$.

(iii) if $c/2 \geq Y(k^*)$, the equilibrium is the same as it would be absent the restriction.

Since much of the stated goal of rate regulation is the protection of consumers, it is interesting to evaluate the impact of the regulatory restriction on the issuance of securities on consumers' surplus. To this end, let $V(k) = a + v\sqrt{k}$ and assume that $a > c/2$, $v > 0$, and $c + T > 1$. Then, absent the restriction, consumers' surplus is given by (31). When the restriction applies and is effective, i.e., $Y^*(k^*) > c/2$, consumers' surplus depends on the magnitude of $c/2$. There are two cases to consider. First, when $c/2 < Y^E(k^E)$, Proposition 8 implies that $k^{**} = k^E$, where k^E is defined implicitly by the first-order condition $(1-\gamma)\,V'(k^E) = 1$. In the example, $k^E = (1-\gamma)^2 v^2/4$, so $V(k^E) = a + (1-\gamma)\,v^2/2$. Using these expressions, it follows from (5) that $p^{**} = a\,(1-\gamma) + (1-\gamma)\,v^2/2 + \gamma\, c/2$. Hence, when the restriction applies consumers' surplus is $CS^{**} = V(k^E) - p^{**} = \gamma\,(2a - c + v^2(1-\gamma)/2$. A comparison of this expression with CS^*, given by (31), reveals that $CS^* > CS^{**}$ if and only if

$$T > \frac{c\,(2a - c + (1-2\gamma)\,v^2)}{(1-\gamma)\,(-2a + c - (1-\gamma)\,v^2)}. \tag{38}$$

When this condition holds, i.e., when T is sufficiently large, the restriction harms consumers.

Second, when $Y^E(k^E) \leq c/2 < Y(k^*)$, then $CS^{**} = a + \sqrt{v(k^{**})} - (k^{**} + c)$, where $k^{**} \gtreqless k^*$. A comparison of this expression with CS^*, given by (31), shows that the restriction has an ambiguous effect on the welfare of consumers. For example, if $\gamma = 1/2$, $v = c = 1$, and $k^{**} = k^*$, then $CS^* > CS^{**}$ if and only if $a < (11 + 12T + 3T^2)/(8 + 12T + 4T^2)$. When this condition holds, i.e., when a is not too large, the restriction harms consumers.

6. Conclusion

The choice of investment and capital structure by a regulated firm has been examined using a sequential game between the firm, outside investors and consumers. The analysis shows that regulated price is set as an increasing function of the firm debt so as to reduce the probability that the firm becomes financially distressed and incurs a deadweight loss. Anticipating this, the firm issues an optimal debt level that takes advantage of this high price. At this debt level, the regulated price is sufficiently high to ensure that financial distress never occurs.

The contribution of the paper is twofold. First the paper provides a comparative statics analysis which yields testable hypotheses regarding the effects of changes in the cost of financial distress, operating costs, and regulatory climate on the equilibrium levels of debt, investment, and the regulated price. Some of these hypotheses are rather surprising. For example, the analysis shows that consumers may benefit from not being too aggressive in the regulatory process, otherwise the firm will cut its investment in quality to the point where the loss to consumers from the reduction in the quality of services will outweigh their gain from the corresponding reduction in the regulated price. In addition, the analysis shows that consumers may be better off when the firm becomes less cost-efficient. Although such a decline in efficiency will have a negative direct effect on consumers, as the regulated price is increasing with firm cost, it will also induce the firm to reduce its debt level, thereby leading to reduction in the regulated price which is increasing with firm debt. An example shows that the latter indirect effect may be the dominate the former direct effect, therefore leaving consumer better-off.

Second, the paper shows that when regulatory commissions limit the ability of firms to raise external funds, the firm may reduce its investment level, and the result could be detrimental to consumers. Thus, although the rationale for such restrictions is the protection of the public from overcapitalization by the firm, they may in fact achieve just the opposite.

Appendix

This appendix characterizes the solution to the bargaining problem between consumers and the firm over the regulated price. Using equation (2), the maximand in (4) can be rewritten as

$$W(p) = \begin{cases} W_1(p) \equiv (V(k) - p)^{\gamma} (p - \frac{c}{2})^{1-\gamma}, & p \geq D + c, \\ W_2(p) \equiv (V(k) - p)^{\gamma} (p - \frac{c}{2} - T\left(\frac{D+c-p}{c}\right))^{1-\gamma}, & D < p \leq D + c, \\ W_3(p) \equiv (V(k) - p)^{\gamma} (p - \frac{c}{2} - T)^{1-\gamma}, & p < D. \end{cases} \tag{A-1}$$

Note that $W(p)$ is continuous in p, i.e., $W_1(D + c) = W_2(D + c)$, and $W_2(D) = W_3(D)$. Also note that $W_1(p) > W_3(p)$ for all p, $W_1(p) >(<) W_2(p)$ for all $p <(>) D + c$, and $W_2(p) >(<) W_3(p)$ for all $p >(<) D$. Let $p_i \equiv \underset{p}{Argmax}\ W_i(p)$. Since each $W_i(p)$ is strictly concave, p_i, $i = 1,2,3$ are unique. A straightforward computation establishes that

$$p_1 = (1 - \gamma)\, V(k) + \gamma \frac{c}{2}, \tag{A-2}$$

$$p_2 = (1 - \gamma)\, V(k) + \gamma \frac{c}{2} + \frac{\gamma T}{c + T}(D + \frac{c}{2}), \tag{A-3}$$

and

$$p_3 = (1-\gamma)\, V(k) + \gamma\frac{c}{2} + \gamma\, T. \tag{A-4}$$

Note that $p_1 < p_2$ and $p_1 < p_3$ for all D, and p_2 <(>) p_3 for all D <(>) $c/2 + T$. There are now possibly six cases to consider:

(1) $p_1 \geq D + c$. Then, since $W_1(p) > W_2(p)$ for all $p < D + c$, and $W_1(p) > W_3(p)$ for all p, $p^*(D,k) = p_1$.

(2) $p_1 < D + c \leq p_2$ and $p_3 > D$. Then, since $W_2(p) > W_3(p)$ for all $p > D$, $p^*(D,k) = D + c$.

(3) $p_1 < D + c \leq p_2$ and $p_3 < D$. Then, $p^*(D,k) = D + c$ if $W_1(D + c) \geq W_3(p_3)$ and $p^*(D,k) = p_3$ if $W_1(D + c) < W_3(p_3)$.

(4) $D \leq p_2 < D + c$ and $p_3 > D$. Then, since $p_1 < p_2$ for all D, $p^*(D,k) = p_2$.

(5) $p_3 \leq D \leq p_2 < D + c$. Then, since $p_1 < p_2$, $p^*(D,k) = p_2$ if $W_2(p_2) \geq W_3(p_3)$ and $p^*(D,k) = p_3$ if $W_2(p_2) < W_3(p_3)$.

(6) $p_2 < D$ and $p_3 < D$. Then, since $p_1 < p_2$, $p^*(D,k) = p_3$.

Next, define $D_1(k)$ as the debt obligation above which the constraint $p_1 \leq D + c$ is binding. Substituting from (A-2) into the constraint and solving for D,

$$D_1(k) = (1-\gamma)\,(V(k) - \frac{c}{2}) - \frac{c}{2}. \tag{A-5}$$

The assumption that $\gamma \leq \tilde{\gamma}$ ensures that $D_1(k)$ is nonnegative. Similarly, using (A-3) and (A-4), define $D_2(k)$ as the debt obligation below which the constraint $p_2 < D + c$ is binding,

$$D_2(k) = \frac{(1-\gamma)\,(c+T)(V(k) - c/2)}{c + T(1-\gamma)} - \frac{c}{2}; \tag{A-6}$$

$D_4(k)$ as the debt obligation above which the constraint $p_2 < D$ is binding,

$$D_4(k) = \frac{(1-\gamma)\,(c+T)\; V(k) + \gamma c(c/2 + T)}{c + T(1-\gamma)}; \tag{A-7}$$

and $D_5(k)$ as the debt obligation below which the constraint $p_3 < D$ is binding,

$$D_5(k) = p_3. \tag{A-8}$$

Note that for all k, $D_1(k) < D_2(k) < D_4(k)$ (the left inequality follows since $0 < \gamma < 1$).

Having defined $D_i(k)$, $i = 1,2,4,5$, it is now possible to characterize $p^*(D,k)$:

When $D \leq D_1(k)$, case (1) applies, so $p^*(D,k) = p_1$.

When $D_1(k) < D \leq D_2(k)$, cases (2) and (3) apply. But, from the assumption that in the relevant range, $T \geq V(k) - c$, it follows that $D_2(k) \leq \frac{c}{2} + T$. Together with the fact that $p_2 < p_3$ for all $D < c/2 + T$, this implies that $p_2 < p_3$ for all $D \leq D_2(k)$. Hence, case (3) is ruled out, implying that in this range, $p^*(D,k) = D + c$.

When $D_2(k) < D \leq D_4(k)$, cases (4) and (5) apply. To determine the value of $p^*(D,k)$ in this range, note that since $p_2 < p_3$ for all $D < D_2(k)$, then for D close to $D_2(k)$, $p^*(D,k) = p_2$. On the other hand, since $T < V(k) - c/2$ in the relevant range, then $p_2 > p_3$ for all $D \geq D_4(k)$, implying that for D close to $D_4(k)$, $p^*(D,k) = p_3$. Thus, by continuity, there exists a debt level, $D_3(k)$, (where $D_2(k) < D_3(k) < D_4(k)$), such that $p^*(D,k) = p_2$ for all D such that $D_2(k) < D < D_3(k)$ and $p^*(D,k) = p_3$ for all D such that $D_3(k) \leq D < D_4(k)$.

Finally, when $D \geq D_3(k)$, case (6) applies so $p^*(D,k) = p_3$.

Thus, $p^*(D,k)$ is given by

$$p^*(D,k) = \begin{cases} p_1, & D \leq D_1(k), \\ D + c, & D_1(k) < D \leq D_2(k), \\ p_2, & D_2(k) < D \leq D_3(k), \\ p_3, & D > D_3(k). \end{cases} \quad \text{(A-9)}$$

Substituting for $D_1(k)$ and $D_2(k)$ from (A-5) and (A-6) into (A-9) yields equation (5) in the text.

The Appendix is concluded by showing the significance of the assumption that in the relevant range, $V(k) - c \leq T < V(k) - c/2$. To this end, suppose first that $T < V(k) - c$. Then, case 3 cannot be ruled out, so whenever $D_1(k) < D \leq D_2(k)$, $p^*(D,k)$ is either equal to $D + c$, or to p_3 depending on whether $W_2(D + c) \geq W_3(p_3)$ or vice versa. Hence, $p^*(D,k)$ cannot be characterized unambiguously. Note, however, that since $W_1(p) > W_3(p)$ for all p, and since $p^*(D_1(k),k) = p_1$, then by continuity, there still exists a range of debt levels for which $p^*(D,k) = D + c$, even when $W_2(D + c) < W_3(p_3)$. In that case, $p^*(D,k) = p_1$ for all $D \leq D_1(k)$, $p^*(D,k) = D + c$ for all D such that $D_1(k) < D \leq D_3(k)$, and $p^*(D,k) = p_3$ otherwise.

Now, suppose that $T \geq V(k) - c/2$. Then, whenever $D_2(k) < D \leq D_4(k)$, $p^*(D,k)$ is either equal to p_2, or to p_3 depending on whether $W_2(p_2) \geq W_3(p_3)$ or vice versa. Again, $p^*(D,k)$ cannot be characterized unambiguously. In equilibrium, however, the firm never issues debt beyond $D_2(k)$, so this ambiguity has no real effect on the outcome of the game.

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