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REGULATION OF NATURAL MONOPOLIES AND THE FAIR RATE OF RETURN

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by

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Regulation is a common phenomenon in "natural monopolies," those industries with decreasing average costs. Optimal resource use in such industries dictates that output be provided by a single firm, but this leads to inefficient monopolistic practices by firms in the absence of regulation. Regulation, however, requires meaningful regulatory objectives and behavior. While economic theory provides appropriate objectives and behavioral rules when there is no uncertainty, the presence of uncertainty is central to the knottiest problems of regulation. And until recently, economic theory had little to say about optimal production in the presence of uncertainty.

A particularly crucial problem facing regulatory agencies is an appropriate definition of a "fair" rate of return. The legal guideline for regulation, based on the Hope decision, requires that regulatory policies provide a return to the equity holder "commensurate with returns on investments with corresponding risks."[1] Under certainty, this guideline

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is well defined: equity holders should receive the riskless rate of return which prevails throughout the economy. Under uncertainty, the guideline is much less clear. Often corresponding risks are not present. And if they are present, they usually are associated with other regulated firms, leaving a simultaneity problem. In short, economic theory has not provided a definitive concept of "fair" return under conditions of risk, and this lack of clarity has led to costly hearings and litigation with final results which are often inconsistent with the goal of optimal resource allocation in the economy."[2]

In this paper, we build on the production/stock market equilibrium model developed in [5] to construct a concept of fair return, and to suggest regulatory behavior consistent with the achievement of optimal resource use. Unique to our theory of fair return is the fact that, while profits are random variables, we do not need to measure subjective probabilities in order to set policies which generate fair returns. But stock market values, which reflect investors' expectations and attitude towards risk, are essential to our theory.

The spirit of our approach is similar to that of Myers [6] and Gelhaus and Wilson [3], who suggested that stock market values were important in assessing fair returns. But the theoretical underpinnings of those papers were not grounded on an equilibrium model of both production and the stock market, and Myers' theory of fair return required a) estimates of expected returns to investment; and b) estimation of "beta coefficients" as a possible guide to assessing the cost of capital. Our theory avoids both these difficulties by building on a model which considers equilibrium simultaneously in production and in financial markets.

I. Production and the Stock Market

In [5], we developed a model of production and financial market equilibrium with the following properties:

a) Investors were typified by heterogeneous initial wealths, utility functions, and expectations;

b) Firms were typified by profit functions depending on the firms' decisions and the state of nature;

c) Equilibrium was typified by investors choosing optimal portfolios, conditional on market clearing prices of stocks and on firms' production decisions; and by the production decisions of firms being "in the stockholders' interests," conditional on the market clearing prices and optimal portfolios of investors.

Key to our theory was the proof that stockholders of each firm unanimously recommend production decisions, when the stochastic formulation satisfies a weak restriction.[3] For firms whose returns are nonstochastic, stockholders will choose profit maximizing policies. For firms with stochastic returns, profit is not well defined, but equilibrium conditions will hold given the policies chosen by stockholders. These conditions are exploited in Section IV.

We develop below a simple model of a monopolistic firm with uncertain returns. Some notation is inescapable. Let

$p(q)$ = selling price, where

q = output.

K^0 = the number of units of capital owned by the firm. Capital units are presumed tradable at a market price normalized to one. Therefore, K^0 also equals the cost of the firm's assets.[4]

K^b = the amount of additional capital hired by the firm.

r = the (riskless) rental rate per unit of capital, and therefore equals the riskless rate of return.

$K = K^0 + K^b$ = the total amount of capital used by the firm.

L = the number of units of variable input hired by the firm.

$w(\theta)$ = the price per unit of the variable input, which depends on the state of nature θ. If there is no uncertainty, then $w(\theta) = \bar{w}$ for all θ.

$F(K,L)$ = the production function of the firm, relating output to input levels of K and L.

V = total value of the firm's shares on the stock market.

For simplicity, we assume the firm has no debt.[5] Profit will be given by

$$\Pi = p(q)q - rK^b - w(\theta)L \tag{1}$$

when there is uncertainty about $w(\theta)$, and by

$$\Pi = p(q)q - rK^b - \bar{w}L \tag{2}$$

when there is no uncertainty. Of course, (2) is a special case of (1), and results we derive for the case with uncertainty will also hold for the certainty situation.

Functional form (1) introduces uncertainty in a very simple way: the cost of input L is considered random.[6] Nonetheless, other types of uncertainty are consistent with our conclusions, including output uncertainty given price.[7]

When a firm's profit function is independent of θ, indicating a riskless profit, our analysis in [5] indicated that equilibrium required firms to maximize profit and have total stock market value

(3) $$V = \Pi/r \ ,$$

where Π is maximal profit and r is the riskless return. (3) follows immediately from arbitrage considerations: if V does not satisfy (3), then a sure profit can be made by buying (or selling) the riskless asset (whose price is normalized to one) and selling (or buying) stock in the firm with the riskless profit Π. When profits involve risk, (3) is not a meaningful relation, and is replaced by different equilibrium requirements (see [5], fn. 22).

II. Fair Return

Legal precedent requires that regulatory policies assure the investor a rate of return which provides commensurate returns and is (just) "sufficient to attract capital to the firm."[8] Under certainty, this would be straightforward. Defining the rate of return as Π/K^0, a fair rate of return would be precisely the riskless interest rate which prevails throughout the rest of the system--namely, the rate r. Any higher return would be more than required to keep capital in its current use, whereas any less would lead to its withdrawal.

In the context of equilibrium in the stock market, the achievement of a "fair" rate of return has an interesting implication:

Proposition I: For any riskless firm, a fair rate of return r implies the stock market value of the firm, V, is exactly equal to the value of its assets, K^0. If the firm earns an "excess" rate of return ($\Pi/K^0 > r$), the stock market value of the firm will exceed the value of its assets.

Proof. A "fair" rate of return implies $\Pi/K^0 = r$. From (3), $V = \Pi/r$. Together, these imply $V = K^0$. An excess return implies $\Pi/K^0 > r$, which with (3) implies $V > K^0$. □

Under uncertainty, profits depend on the state of nature, and therefore the ratio Π/K^0 is meaningless. If the expectations of all investors were identical and known to regulators, then $E(\Pi)$ would be meaningful. But it would still be necessary to define an r^* such that $E(\Pi)/K^0 = r^*$ would be the fair return to the firm, given the extent of uncertainty. Myers [6] works from this point, making strong assumptions about investors' preferences and expectations. Fortunately, there is a simpler way to determine a fair return.

For firms facing either certain or uncertain profits, there may be no short run relation between the market value of a firm's stock, V, and the value of the assets it owns, K^0. But, in a competitive environment with freedom of entry and exit, we would expect these values to converge. If $V > K^0$, entrepreneurs could make a sure profit by buying K^0 worth of assets, then selling stock for V. If $V < K^0$, the entrepreneur could make a sure profit by buying the firm for V and selling its assets for K^0.[9] Entry and/or exit will eventually drive the patterns of profits across states of nature to the point where $V = K^0$. In the case of riskless firms, Proposition I demonstrates that this implies "zero" long run profits, where costs include a fair return r to capital.

At the long run equilibrium with $V = K^0$, the pattern of profits is just sufficient to attract capital to its current use. Our argument then leads to a definition of "fair" returns:

Definition: A "fair return" to capital is a pattern of profits across states of nature just sufficient to attract capital to its present use, which is equivalent to the stock market value of the firm, V, equalling the value of the firm's assets, K^0.

We might note two things:

a) Our definition coincides with the usual definition of fair return under certainty, by Proposition I;

b) Our definition is operable in the presence of uncertainty without requiring homogeneity or knowledge of subjective expectations. Thus, it avoids the pitfalls inherent in Myers' definition ([6], p. 80).

We postpone a discussion of the implications (and difficulties) inherent in our definition until Sections IV and V.

III. Regulation under Certainty

Before a meaningful discussion of appropriate regulatory behavior can be undertaken, we need a well defined objective. Conventional wisdom, based on economic theory, has generally held that regulation should seek to achieve a Pareto optimal or "efficient" use of resources in the industry in question. Efficient use of resources under certainty can be shown to require 1) A technically efficient use of inputs given the level of output, which requires cost minimization in the presence of perfect input markets; and 2) an efficient level of output, which requires that price equal marginal cost of production when inputs are optimally used. (See Scitovsky [7] or other texts for these results.)

Unregulated monopolies which maximize profits typically will achieve 1), but not 2): monopolists produce too little from the point of view of social welfare, and charge too much. Figure I indicates the profit maximizing output q_M of the monopolist, where the cost curve includes a fair return r to owned assets K^0. The presence of positive (i.e. excess) profits at $q = q_M$ implies by Proposition I that the market value of the firm's stock, V, exceeds the value of its assets, K^0.

But the achievement of the Pareto optimal output, q^0, involves a difficulty. Natural monopolies have declining average cost curves, which imply that marginal cost lies below average cost. Hence at q^0 the firm is not earning a fair return r on its investment K^0. Forcing the firm to produce at q^0 without subsidization would be in clear conflict with the Hope precedent, which requires that investors receive a fair rate of return.

The accepted "second best" goal for regulatory agencies, which can be justified on the basis of maximal net benefits,[10] seems to be the following:

(4) Regulatory Objective: the regulatory authority should seek the maximal output (lowest price) consistent with

a) A technically efficient use of inputs;

b) A fair return to investment.

Since technical efficiency is a well defined concept under cost uncertainty, and since we have defined a notion of fair return under uncertainty, the regulatory objective (4) is precisely defined under uncertainty as well as under certainty. But under certainty, we have the further knowledge that requirement (a) implies inputs must minimize costs of production, and that requirement (b) implies that $\Pi/K^0 = r$.

We now demonstrate the (well known) assertion that regulatory objectives can be achieved under certainty, if the regulatory agency sets the lowest price ceiling which is consistent with $V = K^0$. In Section IV, we show this same behavior will achieve the regulatory objectives under uncertainty.

Assume the regulatory agency sets a maximal selling price $\bar{p}$. Demand at that price will be given by $q(\bar{p})$, and it easily shown that, in the presence of decreasing average costs, the natural monopoly will maximize profits by fully meeting this demand. For any $\bar{p}$, total revenues $\bar{p}q(\bar{p})$ will be fixed. Acting in stockholders' interests, the firm will maximize profits by minimizing the cost of producing $q(\bar{p})$. But cost minimization is well known to imply, under certainty, that

$$F_K/F_L = r/\bar{w}, \tag{5}$$

where F_K is the marginal product of capital $\partial F(K,L)/\partial K$, and F_L is the marginal product of labor. Since input decisions by other profit maximizing firms also will satisfy condition (5), the ratios of marginal products of the inputs will be identical for all firms and technical efficiency will be achieved. A fair rate of return will be guaranteed by the selection of $\bar{p} = p^*$ in Figure I. At $q(p^*)$, average cost (including a fair rate of return to K^0) equals p^*. Excess profits are zero, and by Proposition I, market value $V = K^0$, which by definition implied a fair rate of return to investment K^0.

Quite contrary to observed regulatory behavior (see Klevorick [4]), some authors have suggested that regulatory agencies fix a rate of return

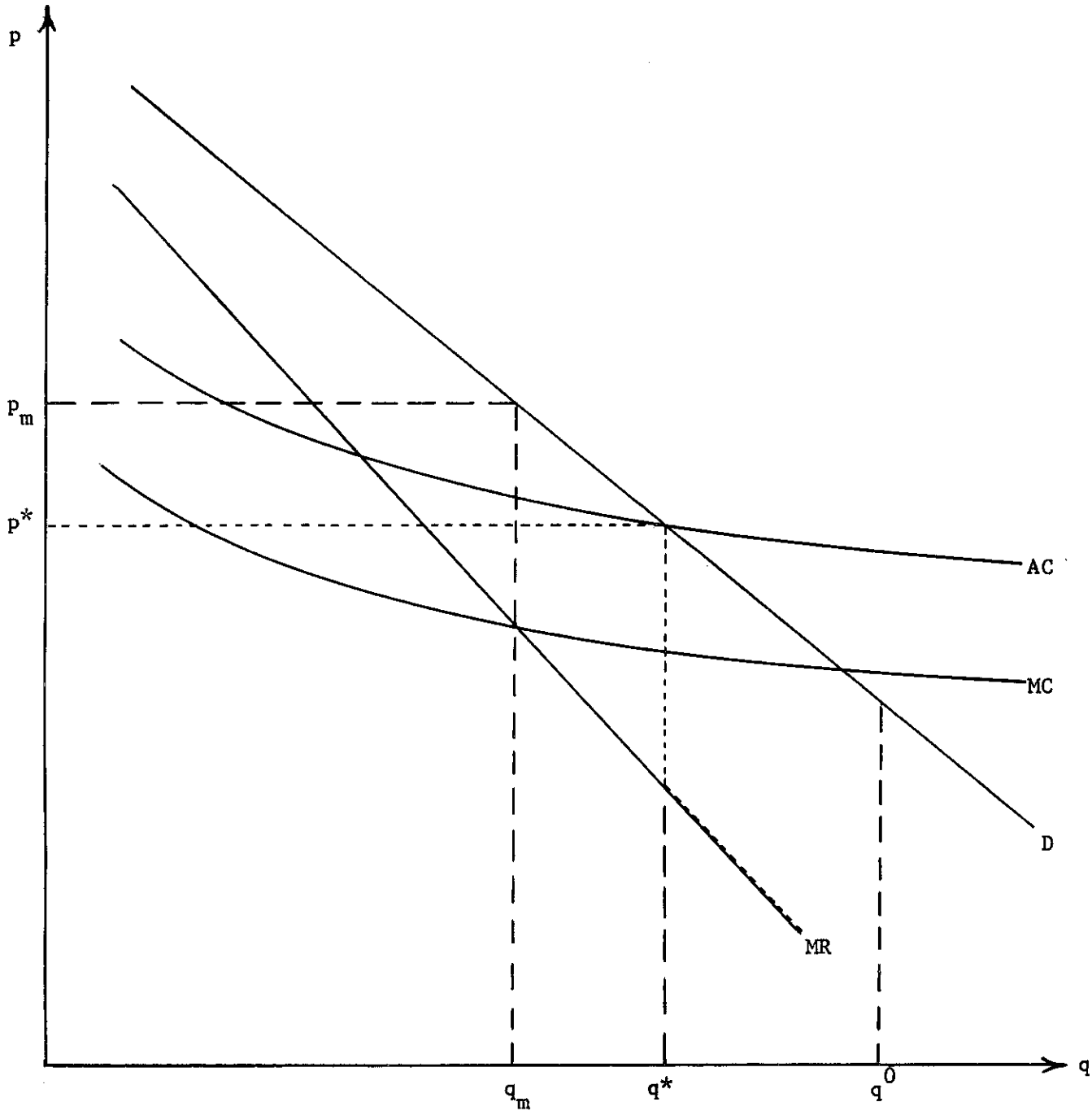

FIGURE I

------- indicates marginal revenue curve under regulated price p^*

$s \geqq r$, but do not set price ceilings ([1], [2], and [8], among others). We can readily demonstrate that, under certainty, that this approach is poor prescription as well as poor description. If the maximal return s is set equal to r , the firm will not earn an excess return, but there is no assurance of technical efficiency (or maximal output) since profit maximization is consistent with an infinite number of combinations of K and L (see Zajac [8]). If, on the other hand, s is set above r , the firm will earn an excess rate of return, it will choose an inefficient combination of inputs, and it will produce at less than the optimal output $q(p^*)$. (See Baumol and Klevorick [2].)

IV. Regulation under Uncertainty

In the previous section, we showed that, under certainty, the regulatory objective (4) could be achieved by

(6) Regulatory Behavior: the regulatory agency should set as a price ceiling the least price of output consistent with the stock market value of the firm equalling the value of its assets ($V = K^0$) .

The proof under certainty was simplified by the fact that technical efficiency is equivalent to cost minimization, and the fair rate of return condition implies $\tilde{\Pi}/K^0 = r$. Neither simplification follows under uncertainty, since costs and profits are random variables. Nonetheless, we can still prove the following:

Proposition II: Regulatory behavior (6) achieves the objective (4) when firms act in the interest of stockholders, and (random) profits assume the form (1).

Proof. Let j index firms. We note that for any increasing, strictly quasi-concave production function $F^j(K^j, L^j)$, we can derive a function

$$L^j = L^j(q^j, K^j)$$

which gives the amount of labor required to produce q^j with capital stock K^j. It is easily shown that

$$(7) \qquad \frac{\partial L^j(q^j, K^j)}{\partial K^j} \equiv L^j_K(q^j, K^j) = -F^j_K/F^j_L .$$

Assume that regulation (or in the non-regulated sector, stockholders' interests) has dictated some price $\bar{p}^j$ and output $q^j(\bar{p}^j)$. When r and $w(\theta)$ are the same for all firms, and firms' returns take the form (1), profits will be given by

$$(8) \qquad \Pi^j = \bar{p}^j q^j(\bar{p}) - rK^{jb} - w(\theta)L^j[q^j(\bar{p}^j), K^j] .$$

Different choices of K^{jb} will produce different patterns of Π^j across states of nature. Following [5], we assume the choice of K^{jb} will be "in the stockholders' interests." In equilibrium, this was shown to imply

$$(9) \qquad \frac{\partial E_i[U_i(R_i, \theta)]}{\partial K^{jb}} = E_i\{U_i'(R_i, \theta)[-r - w(\theta)L^j_K]\} = 0 ,$$

for all i and j, where i indexes investors, and R_i is the (random) return to the investor's optimal portfolio.

We can rewrite (9) as

$$(10) \qquad L^j_K = \frac{-E_i[U_i'(R_i, \theta)]r}{E_i[U_i'(R_i, \theta)w(\theta)]} .$$

The R.H.S. of (10) is independent of j (and, by the Unanimity Theorem in [5], is independent of i), and therefore (10) and (7) imply

$$(11) \qquad -L_K^j = F_K^j/F_L^j = F_K^\ell/F_L^\ell = -L_K^\ell \quad \text{for all} \quad j, \ell \ .$$

But (11) is well known to be the requirement for <u>technical efficiency</u>.

Note if $w(\theta) = \bar{w}$ for all θ , the certainty case, then (11) reduces to the familiar

$$(12) \qquad F_K/F_L = r/\bar{w} \ .$$

If $\bar{p}$ set very high, say at p^h , assume monopoly profits will exist, i.e. $V^h > K^0$ at p^h . If $\bar{p}$ is very low, say at p^ℓ , the firm will have a low value $V^\ell < K^0$.[11] It can easily be shown that V is continuous in p when investors are risk averse, which implies there exists a $p^* \in (p^h, p^\ell)$ such that $V = K^0$ at p^* , i.e. p^* generates a fair return to capital. The lowest p^* such that $V = K^0$ will be the optimum price ceiling, since $q(p^*)$ will be the largest output consistent with technical efficiency and a fair rate of return. □

Certain properties of input decisions at the regulatory optimum are also of interest.

<u>Proposition III</u>: At the optimal regulatory price p^* , the following equilibrium relationship holds:

$$(13) \qquad F_K/F_L = rL/[p^*q(p^*) - rK] \ .$$

Proof. From the portfolio equilibrium conditions in [5 , equation (8)], $E_i[U_i'(R_i, \theta)(\Pi - rV)] = 0$, or using (1) and $V = K_0$,

$$E_i\{U_i'(R_i, \theta)[p^*q(p^*) - rK - w(\theta)L] = 0 .$$

Solving for $E_i[U_i'(R_i, \theta)w(\theta)]$ and substituting into (9) gives

$$-L_K = \frac{rL}{p^*q(p^*) - rK} ,$$

which with (7) implies (13). □

Note that if the firm faces a certain price $\bar{w}$ for the variable input L , $p^*q(p^*) - rK^b - \bar{w}L = rK^0$, or $p^*q(p^*) - rK = \bar{w}L$. Substituting this into (14) gives $F_K/F_L = r/\bar{w}$.

When expectations are homogeneous and firms' profits in equilibrium are nonnegatively correlated (as would be expected when $w(\theta)$ is the sole source of uncertainty), we can prove stronger results.

Proposition IV: Let firm A face a random price of input L , $w(\theta)$, with $E[w(\theta)] = \bar{w}$, and let an identical firm B face a known price of input L , equal to the $\bar{w}$ above. Then, under optimal regulation:

(1) The ratio F_K/F_L will be higher for firm B than firm A .

(2) The price p_A^* set by the regulatory authority will exceed p_B^* .

(3) Firm A will produce a lower output under regulation.

Proof. (1) For the riskless firm B , a fair return implies

$$\Pi_B = p_B^*q(p_B^*) - rK_B^b - \bar{w}L_B = rK^0$$

where K_B^b and L_B are the cost minimizing inputs given $p = p_B^*$. Cost minimization implies

$$\frac{F_K}{F_L} = \frac{r}{\bar{w}}, \quad \text{for firm } B . \tag{14}$$

In equilibrium, it is easily seen that risk aversion on the part of investors will require a higher expected profit from firm A to generate the same market value (which under optimal regulation must equal K^0 for both firms).[12] That is,

$$E(\Pi_A) = p_A^* q(q_A^*) - rK_A^b - \bar{w}L_A > rK^0 ,$$

or

$$p_A^* q(p_A^*) - rK_A - \bar{w}L_A > 0 ,$$

or

$$p_A^* q(p_A^*) - rK_A > \bar{w}L_A .$$

Introducing the above into (13) gives

$$\frac{F_K}{F_L} < \frac{r}{\bar{w}} \quad \text{for firm } A , \tag{15}$$

which with (14) proves Proposition IV(1).

IV(2): follows immediately by noticing that for any $\bar{p} \leqq p_B^*$, $E(\Pi_A) \leqq 0$ for any combination inputs which will meet demand. Therefore $E(\Pi_A) > 0$ implies $p_A^* > p_B^*$.

IV(3): follows immediately from the presumption that the demand curve is downward sloping. □

A consequence of Proposition IV(1) is that firms which face uncertainty will not minimize expected costs, which requires $F_K/F_L = r/\bar{w}$. This consequence is hardly surprising: risk aversion would naturally lead to substitution of the less risky K for L, despite some (small) increase in expected costs. It follows that the risky firm will use (for a given output) a higher K/L ratio than the riskless firm. While Proposition IV(1) is a consequence of our stochastic formulation with uncertainty entering only through $w(\theta)$, Proposition IV(2) and IV(3) can be seen to hold more generally.

Homogeneous expectations also permit a further delineation of our concept of fair return. Recall that a fair return was defined as a pattern $\Pi^*(\theta)$ of profits across states of nature such that $V = K^0$. With identical expectations, we can talk about "the" probability of each state of nature, and therefore, about an expected profit $E(\Pi^*)$ which yields $V = K^0$. The ratio $r^* = E(\Pi^*)/K^0$ could be called an "expected fair return." But, parallel to the situation under certainty, a regulatory agency would be ill-advised to regulate by limiting expected return to r^*. Examination of first order "stockholders' interests" conditions subject to the rate of return constraint indicates that neither technical efficiency nor maximal output will be achieved.[13]

V. Some Real and Imagined Problems

A. Incentives

If price is adjusted by the regulatory agency to equate market value V with asset value K^0, will there be incentive for the firm to adopt improved techniques? A similar problem arises in the theory of competition with free entry: if new techniques lead to immediate adoption by others and to entry, instantaneously driving down the return to the previous fair rate, no firm will introduce new techniques. But if entry is slow, allowing temporary excess returns, innovation will take place. As suggested by Myers [6], a similar "conscious lag" in regulation could be used to imitate the competitive solution, and thus provide the impetus for innovation.

B. Dynamics

Our model can readily be interpreted in a multi-period framework. Profit is the discounted present value of the profit stream, dependent on the firm's decisions and the state of nature, and the regulated price p is a sequence of prices over time (which perhaps will be revised by future regulatory proceedings).[13] Even though current earnings might be very low, the firm may still be earning a fair return on its capital ($V = K^0$) because of investors' expectations of future profits given the sequence of regulated prices. Therefore estimates of fair return based on earnings/price ratios, such as the proposed method of Gelhaus and Wilson, may result in highly "incorrect" regulatory policies for long periods of time.[14]

C. Volatility of Stock Prices

Volatile stock prices could lead to rapidly changing price ceilings if a regulatory agency seeks to equate V and K^0. Yet the very realization that the agency will act in this manner should serve to reduce short run fluctuations of the firm's stock market value. Even so, if one presumes that stock movements reflect undesirable "noise" as well as underlying trends, the regulatory agency presumably should look not just at current stock market prices, but at some weighted average of stock market value over time. This averaging procedure would tend to reduce the effect of random movements about the stock's intrinsic equilibrium value.

D. Measurement of K^0

Our model has been based on the assumption that capital assets can be freely bought or sold at a market price normalized to one. Yet in fact this is rarely an accurate description. Capital is not a homogeneous good, and there are not markets for every vintage of every machine in every location. Buying and selling prices are likely to differ because of installations costs, etc. And some assets, such as "goodwill," may be genuine in the sense of having true economic values, although rarely included in book value or other proximate measures of K^0.

But the problem in estimating the economic value of assets currently confronts the regulatory agencies. Present rate determination proceedings require not only an estimation of the "fair" rate of return, but also the "rate base" to which the rate of return is applied. Our theory eliminates the problem of defining fair return, but the measurement problem associated with the rate base remains.

VI. Conclusions

The model of production and financial equilibrium developed in [5] has provided a basis for a theory of optimal regulation, when policies must guarantee a fair rate of return to investment. Central to our theory is an implementable definition of "fair return" in the presence of uncertainty and nonhomogeneous expectations.

Our principal result is that, under uncertainty as well as certainty, price regulation is capable of achieving optimal resource use, defined as the maximal industry output subject to the efficient use of inputs and a fair return to investment. Regulation by setting a maximal expected rate of return is shown to have undesirable effects on the allocation of resources. Correct measurement of the firm's rate base, a problem which currently vexes regulatory proceedings, remains a practical hurdle in the implementation of our results.

FOOTNOTES

[1] F.P.C. vs. Hope Natural Gas Company, 320 U.S. 591 (1944).

[2] Gelhaus and Wilson [3], p. 287.

[3] For unanimity, we require profit take the form $\Pi(d,\theta) = f(d) + g(d)h(\theta)$, where d is a vector of decisions. If profit does not take this form, stockholders would wish the firm to split up into firms whose profit does take this form: see [5], fn. 23.

[4] K^0 is the "true economic value" of the firm's assets, which may or may not be closely approximated by the book value of the firm. See our comments in Section V(D) below.

[5] If firms issue debt, interest on it should be included in firm's cost functions. In the analysis which follows, the presence of debt D would require that V (the stock market value of the firm) be replaced by $V+D$, the sum of current equity and debt values. If D is a decision variable and there is a possibility of bankruptcy, the analysis becomes more complicated.

[6] While the form (1) no doubt is an oversimplification, fuel and labor costs seem to be an important source of uncertainty to public utilities.

[7] See footnote 3.

[8] (1) and Proposition I imply that if the firm can rent all its owned capital K^0, at rate r, it will be guaranteed a sure profit rK^0, and therefore a minimum value $V = K^0$. But presumably not all capital can be rented out--we assume $K^b_{min} > -K^0$, implying the possibility of $V < K^0$. For simplicity, we assume the optimal K^b will occur in the interior of the feasible set.

[9] Net benefits are measured as the sum of producer's and consumers' surplus. See R. Willig, "Consumers' Surplus: A Rigorous Cookbook," IMSSS Technical Report No. , Stanford University, April 1973, for a rigorous consideration of this criterion.

[10] See footnote 8.

[11]By examining first order conditions associated every individual's portfolio selection problem, we can easily show that demand for an asset will be positive only if $E(\Pi)/V > r$, when the asset is positively correlated with other assets held in the portfolio. Therefore, $E(\Pi)/V > r$ is a necessary condition for V to clear the market for the firm's stock. Thus equilibrium for the risky firm A implies $E(\Pi^A)/V = E(\Pi^A)/K^0 > r$, or $E(\Pi^A) > rK^0 = E(\Pi^B)$.

[12]First order conditions with respect to K^b give

$$E_i\{U_i'(R_i, \theta)[-r(1+\lambda) - L_K(w(\theta) + \lambda\bar{w})]\} = 0 ,$$

where λ is the Lagrangean multiplier associated with the rate of return constraint $E(\Pi)/K^0 \leq r^*$. If $w(\theta) = \bar{w}$ with probability one (certainty), then the above equation reduces to

$$E_i\{U_i'(R_i, \theta)[-r - L_K\bar{w}](1+\lambda)\} = 0$$

or

$$-L_K = r/\bar{w} ,$$

the efficiency condition. But when $w(\theta)$ is random, $(1+\lambda)$ cannot be factored out, and the technical efficiency condition (10) will not hold.

[13]The appropriate discount rate is the certainty interest rate r. Of course, the "certainty equivalent" of present value will be lower, the more uncertainty the investor perceives.

[14]Gelhaus and Wilson [3] suggest allowing a return at time t on book value (for comparability, K^0) equal to E_t/P_t where E_t is current earnings per share and P_t is price per share. That is, regulatory authorities are instructed to set $E(E_{t+1})$, the expectation of earnings in the next period, equal to $(E_t/P_t)K_0$. Even under certainty, there is no assurance that this policy will assure $\lim_{t\to\infty} V_t = K_0$ --it depends on properties of P_{t+1} as a function of E_{t+1} (or earlier earnings). (Note $V_t = P_tS_t$, where S_t = number of shares at time t.)

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