THE REGULATORY PROCESS UNDER PARTIAL INFORMATION

by

G. Warskett
School of Public Administration
Carleton University

and

A. de Fontenay
Department of Communications
Ottawa

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INTRODUCTION

The common principle of public utility regulation in Canada is the allowed rate of return (ROR) on capital assets, and yet in most situations and in particular telecommunications the regulatory bodies have gone further and ruled on relative prices. Were the ROR the only policy goal, then the regulator need only establish an 'absolute price level' to permit the firm to achieve the allowed ROR. However, other goals are evidently on the regulator's mind, as it sets each price individually in order to first, generate sufficient revenue which is needed to cover production operating expenses plus the allowed return, and second, possibly to produce a cross-subsidy between services thought just and appropriate. In terms of relative pricing, however, these procedures are arbitrary and may be improved by adjusting prices in the appropriate way to produce savings in consumer surplus.

At the theoretical level, this problem of achieving efficiency in consumption while simultaneously satisfying cost of supply requirements has been solved (Ramsey, 1927; Baumol & Bradford, 1970). From the operational point of view, however, the task appears forbidding since it requires knowledge of every own-price elasticities and every cross-price elasticities. Even though there have been numerous attempts at calculating cross-price elasticities, at least at a very aggregate level (Corbo et al., 1979), those do not appear to be successful. In fact, just the problem of calculating own-price elasticities is formidable enough to prevent any conclusive estimates from being made (Taylor, 1980), as the range of actual results obtained testifies (CRTC, 1980; Breslaw & Smith, 1980). It seems therefore that Ramsey prices are hardly more than a theoretical ideal to wish upon public utility regulation, having little operational substance. This issue forms the subject of our paper.

An operational solution for achieving the goal of optimal pricing under a regulatory environment has been found, in a design suggested by Vogelsang and Finsinger (1979). Yet their solution does not constitute a fully satisfactory process which is ready for actual use. One problem with the process is its static formulation which makes it inapplicable to commonly occuring situations such as cost inflation or demand cutbacks. A second and most unfortunate property of the V-F procedure is its capacity to cause the regulated utility with any increasing costs[1] to experience spells of potentially severe losses, threatening the financial viability of the company. Their method will be reviewed in the first part of this paper.

The question of optimal prices under ROR regulation has still to be fully investigated. The V-F algorithm is formally based on the assumption of a zero profit regulatory goal, although the authors indicated their intention to eventually generalize the algorithm to the ROR situation. The ROR-type regulation, however, raises serious problems for achieving optimal pricing, and we shall show briefly in the next section that the ROR regulated firm, maximizing profit by adjusting relative prices, will behave in accordance with its perceived cost. Thus, in general, it will not produce socially optimal prices, because of the Averch-Johnson overcapitalization effect.

The positive profit which the regulated firm is allowed to make under the ROR return regulation can be conceptualized as a cost of regulating a monopoly.[2] An alternative approach which minimizes on these costs and at the same time avoids the problems associated with the A-J effect, can be found in an analogue to the zero profit type of regulation that gives the profit maximizing firm the incentive to move efficiently toward optimal prices (this view also constitutes an alternative justification of the V-F rule).

In the next section, we introduce an algorithm which attempts to cope with the problems found with the V-F rule, together with a demonstration of feasibility. In contrast to the V-F rule (which alternates, depending upon the sign of the profits realized by the firm), this algorithm is a two-step procedure which is independent of the characteristics of the technology. Following this, the properties of the suggested alternative rule are described, and comparisons are made with the V-F rule. Even though our approach is free of V-F's sustainability problem, nevertheless neither rule can be shown to always dominate the others in terms of consumer welfare. In the appendix, we address the important issue of the incentive to waste created by the attempt to avoid regulation through deception, and how to overcome this misinformation problem.

There is no telling whether our rule dominates the rate of return regulation, since the latter involves a differential between the market cost of capital and the allowed rate of return, as set exogeneously by the regulator. To the extent that the difference tends toward zero, the rate of return rule will clearly dominate, but at the same time the firm will lose more and more its incentive to minimize cost. Furthermore, it is important to note that the operational use of the ROR criteria has its own problems, which apparently can be quite serious (British Columbia Telephone Company, 1980).

Inherent to regulation are inescapable information problems, as was illustrated earlier. The only hope is to minimize costs associated with the regulatory body gathering information on the economic state of the firm. This can be achieved by confining information requirements to bookkeeping data and have the firm through its actions reveal the needed cost and demand characteristics. However, these incentives, in terms of profits for the keeping, at the same time constitutes a social cost, and the regulatory situation we are describing becomes one of selling or foregoing temporary welfare gains for information. The importance of the V-F analysis for practical regulation is to be found in the light they shed on this central issue.

2. THE VOGELSANG AND FINSINGER REGULATION MODEL

The V-F approach consists of an algorithm composed of instructions issued by the regulator to the firm, designed to bring the firm from a position of positive profits to one of zero profits, with prices in their optimal ratio.[3]

The algorithmic procedure consists of two loops to cover the two situations where average costs do not increase along any ray,[4]

Figure 1 about here

and the case where they do so increase. In both instances the regulator sets the price level while the firm is free to set relative prices subject to the constraints imposed in that period. In setting up the evolving series of constraints the regulator is not required to know anything about current costs or demand elasticities; only observations on last period operating costs and output levels are used.

The object of allowing the firm profits when it adjusts relative prices is to avoid the information problem mentioned earlier. In effect the firm volunteers to do the job for the regulator of finding the optimal price level, by bringing prices into line with the direction of greatest welfare increase at each iteration of the regulatory process. This it does by using its own knowledge of cost and demand conditions. As a reward the firm is allowed to keep profits taken in each step. The trick lies in the fact that profit maximizing behaviour does indeed get the prices alined in the (socially) correct ratio.

Each successive step of the algorithm applied to non-increasing ray average cost (loop 1) gives rise to a stronger constraint on profits by adjusting downward a Laspeyres (chain) price index. Eventually, the routine converges to the desired regulatory target.

To deal with the more awkward case of costs which do not conform with a nonincreasing ray average cost, a second loop to the algorithm is activated, one which mitigates the regulatory impact whenever negative profits are caused. A sequence of negative profits can in fact be elicited by the V-F rule, but at some point this must end and positive profits re-emerge. However, the process can on occasions return to the mode of negative profits and remain for an unknown number of steps.

In reviewing the assumptions and results of the V-F model, we can see that its shortcomings are of three kinds. First, the model is static in its formulation and results, and does not address the central regulatory problem of the day - inflation in operating costs, and technological change that may bring about changes in productivity. Inflation places the firm, formerly at a regulatory equilibrium, into a situation of negative profits, a situation which is explicitly excluded by the model (by restricting the starting point to positive profits). This exclusion thus constitutes a serious shortcoming of the model. Thirdly, the occasions of negative profits induced by regulation bring with them the danger of bankruptcy, making the process politically as well as economically unacceptable as a practical regulatory procedure.[5]

Moreover, under dynamic conditions created by shifts in either or both demand and supply conditions, the regulatory process could allow positive profits for an indefinite period of time, contrary to the intent of the model. This would be so if convergence occurred at too slow a rate to keep pace with exogenous changes.

From the preceeding remarks, we see that it is possible for the V-F regulation to be too harsh or too generous to the utility, sometimes allowing too little revenue or other times too much in relation to costs. Shortly we examine a different regulatory process which is designed around these concerns and problems. First, however, we consider the ROR regulation as a procedure for achieving optimal pricing.

3. THE ROR RULE AND OPTIMAL PRICES

From one point of view the allowed ROR is a recognition of less than full information on the regulated monopoly that is available to the regulators. The method of regulation would fail if the allowed rate, s, did not exceed the competitive rate r, since the bookkeeping data made available to the regulator is insufficient to guard against wasteful practices or to ensure that costs are in fact being minimized. In this light the margin the allowed rate has over the competitive rate, i.e. (s-r), is a premium to be paid for the lack of full information. The issue now becomes the following. Does this 'premium' interfere with the formation of a socially optimal price ratio? This issue is set up analytically below.

First, the prices set by the multi-output regulated natural monopoly are the solution to the constrained maximization problem

$$\max_p \{\pi(p) \mid \pi(p) \leq (s-r)k\},$$

where k is the aggregate capital stock of the firm and $\pi(p)$ is the profit function. The necessary conditions for an (internal) solution are

$$\gamma_1 \operatorname{grad} \pi(p) = (s-r)\frac{\partial k}{\partial p}$$

where $\gamma_1 = 1+\mu_1$, and μ_1 is the Lagrange multiplier. The equilibrium point will be denoted $p = p^a$, and $\pi(p^a) = \pi^a$.

In appendix 1 we develop a cost function $C = g(w,r,s,x)$ corresponding to a technical specification of production. Also, we have

$$k = g_r, \quad \text{where} \quad g_r = \partial g/\partial k .$$

Thus, the above condition can be expressed as

$$\gamma_1 \operatorname{grad} \pi(p^a) = (s-r)\left(\frac{\partial g_r}{\partial x}\right)\Big|_{x=x^a} \frac{\partial x^a}{\partial p} .$$

Now, at p^a, the firm is enjoying a certain level of profits π^a. This profit represents as it were the social cost of less than full information to the regulator. Consider now the maximization of 'social welfare', $W(p)$, subject to this information 'cost':

$$\max_p \{W(p) \mid \pi(p) = \pi^a\}$$

yielding the necessary conditions to the equilibrium solution p^b:

$$-\operatorname{grad} W(p^b) = \gamma_2 \operatorname{grad} \pi(p^b)$$

or

$$x^b = \gamma_2 \operatorname{grad} \pi^b .$$

We state the following theorem.

<u>Theorem</u>

The profit maximizing monopoly subject to ROR where $s > r$ generate socially optimal prices only if the additional condition is satisfied

$$\frac{\partial g_r}{\partial x}\frac{\partial x}{\partial p} = \alpha x$$

at the equilibrium point $p = p^e$, where $\alpha = (s-r)\gamma_2/\gamma_1$. Here the cost gradient (the gradient of the constraint) is alined in the same direction as the welfare gradient.

In the above formulation this corresponds to $p^a = p^b = p^e$.

The fact that an additional condition is needed for optimal prices under ROR regulation can be readily appreciated from the following diagram:

figure 2 about here

4. AN ALTERNATIVE REGULATORY PROCESS

This process consists of two parts, one where the regulator requires the firm to set the price level consistent with zero profits, and the other where the firm adjusts relative price under a profit ceiling. The process can be described through an example starting at positive profits. The regulator calls for a reduction in price along a ray to zero profits. In the absence of any knowledge regarding elasticities, this step on the part of the regulator represents a neutral stance. It is no more arbitrary a procedure on relative prices than the current regulatory action, and it has the virtue of a simple rule that is likely to reduce the welfare loss associated with a monopoly restriction of output in one step. Furthermore, were the regulator to have a priori knowledge regarding elasticities, this knowledge could be used to modify the rule in order to quicken convergence. The second stage allows profits under a constraint on the price level. This profit incentive will produce the appropriate adjustment in relative prices. If the firm has positive profits, the above procedure is repeated until no further adjustments are made by the firm. Thus the process converges to an equilibrium at which prices are optimal and the firm realizes zero profits.

The proof of the viability of this process consists of two parts. The first demonstrates that any ray along which prices are reduced intersects the surface in R^n corresponding to zero profits, where n is the number of services offered by the firm. The second part shows that the process converges to the desired point.

We make the following four assumptions concerning the profit function defined on the space of output prices:

A1 $\{p \mid \pi(p) = 0\} \in R^n$ is nonempty

A2 $\Pi = \{p \mid \pi(p) \geq 0\}$ is compact and convex, $\Pi \in R^n$

A3 $\pi(p)$ is continuous real valued function

A4 $\theta \notin \{p \mid \pi(p) \geq 0\}$.

Define a norm $\|p\|$ on R^n (R^n becomes a normed vector space) and define the set $S(p) \subset \{p \mid \pi(p) = 0\}$ as follows:

$$S(p) = \{p \mid \max_{p \in \pi} \|p\| \} \cap \{p \in \Pi \mid \eta p \notin \Pi, \text{ all } \eta \in (0,1)\} .$$

Note that since $\{p \mid \pi(p) = 0\} \neq \theta$, $S(p)$ is nonempty. Also, if $S(p)$ is a singleton set, write $\{p^o\} = S(p)$. Then

$$\{p \mid \pi(p) > 0\} \subset \{p \mid \theta p^o, \ \theta > 1\} .$$

If $S(p)$ contains more than a single element, write $p^1, p^2 \in S(p)$. Then for any $p \in \Pi$, $\exists \mu$, $\lambda \in R$ such that $\lambda p = \mu p^1 + (1-\mu)p^2$, $\mu \in (0,1)$. Note by convexity, $\pi(\lambda p) > 0$.

Theorem

There exists $\mu \in (0,1)$ such that for any element of $\{p|\ \pi(p) > 0\}$ we have $\pi(\mu p) = 0$.

Proof

Note that for any $p \in \pi$, $\exists p^1, p^2 \in S(p)$, $\eta \in R$, $\mu \in (0,1)$

$\eta p = \mu p^1 + (1-\mu)p^2$, with $\pi(\eta p) > 0$ (In the case where $S(p) = p^o$ the construction is obvious).

By convexity, $\exists \mu \in (0,1)$ such that $\pi(\mu\eta p) \leq \pi(\eta p)$. Since $\theta \notin \{p|\ \pi(p) > 0\}$, by continuity, there is a neighbourhood of θ, N_θ, such that $\mu \in N_\theta$ $\pi(\mu\eta p) < 0$. Using continuity again and the fact that $\Pi(p) \gg \theta$, there is one value, μ^0, such that $\pi(\mu^0 p) = 0$. QED

To show that welfare increases under the rule, whenever $p \to rp$, $r < 1$, write

$$W(rp) \geq W(p) + \text{grad } W(p) \cdot (rp-p).$$

Then $W(rp) - W(p) \geq (1-r)p \cdot x(p) > 0$, from grad $W(p) = -x$. This says that the gain in welfare is bounded from below by the revenue saving obtained from the ray price reduction, measured in the original quantities.

Under $(p-p_j)x_j = 0$, we have

$$W(p) \geq W(p_j) + \text{grad } W(p_j)(p-p_j) = W(p_j)\ .$$

The regulatory process T is characterized by two subsequences $R = \{r_0 p_0, r_1 p_1, r_2 p_2, \ldots\}$ and $P = \{p_0, p_1, p_2, \ldots\}$ such that $T = R \cup P$. The subsequence $\{r_j p_j\}$ give the sequence of ray reductions and $\{p_j\}$ give the profit maximization steps under constraint. The process starts at p_0 with $\pi(p_0) \geq 0$, continues to $r_0 p_0 (r_0 \leq 1)$, p_1, $r_1 p_1 (r_1 \leq 1)$, and so on.

We assume that the consumption patterns for the firms output and technology is such that set

$$\{p \mid \pi(p) \geq 0\} \cap \{p \mid W(p) \geq c\}, \quad \text{all} \quad c < \infty ,$$

is closed and bounded. This set is not convex in general although it is compact; therefore consider its <u>convex hull</u> H. H_j will denote the convex hull corresponding to the j step in the r subsequence.

<u>Theorem</u>

The sequence T is a convergent series with $\lim_{k \to \infty} p_k = p^*$, where p^* has the optimality property (is the solution of):

$$(p - \frac{\partial c}{\partial x}) \frac{\partial x}{\partial p} = -\lambda x, \quad 0 \leq \lambda \leq 1 .$$

Note that the sequence $\{r_j\}$ is not necessarily monotonic. However $\lim_{j \to \infty} r_j = 1$. Further, it is significant that our approach does not encounter the V-F problem of unsustainability associated with increasing costs.

Proof

First we show the strict inclusion $H_{j+1} \subset H_j$, all $j = 0, 1, \ldots$ H_j is characterized as the convex hull of

$$\{p \mid \pi(p_j) \geq 0\} \cap \{p \mid W(p_j) \geq c_j\}$$

such that $r_j p_j \in \{p \mid \pi(p) = 0\}$, i.e. $r_j p_j$ is on the boundary of H_j. Profit maximization subject to $px_j \leq r_j p_j x_j$ will produce a point in the interior of H_j, provided $r_j p_j$ is not the equilibrium point. This is because $x_j = -\text{grad } W(r_j p_j)$ and $p_{j+1} \in \{p \mid p \neq r_j p_j,\ px_j \leq r_j p_j x_j\} \subset \{p \mid W(p_j) > c_j\}$. Now by construction the point $r_{j+1} p_{j+1}$ is on the boundary of H_j but interior to $\{p \mid W(p) > c_j\}$. Write c_{j+1} to correspond to $\{p \mid W(r_{j+1} p_{j+1}) \geq c_{j+1}\}$. Then $c_{j+1} > c_j$ and $H_{j+1} \subset H_j$. The process must stop where $r_j = 1$ and $r_j p_j = p_j$. At this point the firm is earning zero profits $(p_j \in \{p \mid \pi(p) = 0\}$ though it is maximizing profits (under constraint). Also welfare is maximum subject to non-negative profits and the theorem is proved. QED

5. CONCLUSION

Any realistic dimension of optimal pricing for a regulated natural monopoly must contain some assurance of its practical application. We expressed the problem as one of lack of full information to the regulator. A beginning in this direction is offered by the V-F regulator, although, as we have seen, it suffers several severe shortcomings. For example, the V-F regulation process can jeopardize the firm's viability as a profitable business; an alternative procedure has been proposed in this paper to overcome this particular problem. Secondly, the problem of wilful waste presents itself and a procedure to meet this concern has also been proposed (see the appendix). Also we investigated the difficulty of achieving socially optimal prices under ROR regulation. Finally, there remains the problem of dynamic change or shocks (inflation, technological change, change in consumer preferences). Our proposed model appears very open to being modified so as to deal with these complications; this area will be the subject of further work.

Appendix 1. THE ROR REGULATION AND OPTIMAL PRICING

The application of ROR regulation to a multi-output natural monopoly constitutes a constraint over the level of prices, leaving to the firm (n-1) degrees of freedom in which to set relative prices. In the following, we use results developed by Fuss and Waverman (1978) to construct the cost function of the ROR monopoly. Here the firm maximizes profits in two steps; first it minimizes cost for a given bundle of outputs and second, it selects the output bundle which maximizes profits.

Consider a monopoly producing n outputs (x) and $m+1$ inputs (y,k) under the technology $F(x,y,k) \leq 0$, $(x,y,k) \in R^{n+m+1}$; k denotes aggregate capital inputs. Input prices $(w,r) \in R^{m+1}$ are given to the firm, and selling prices are denoted by $p \in R^{n}$. r here is the competitive rate of return on capital; let $s > r$ denote the allowed rate of return.

Lemma (Fuss and Waverman)

The cost function g^* dual to the technology $F(x,y,k) \leq 0$, when subject to the ROR constraint, is expressed as

$$C^* = g^*(x,w,r^*),$$

where

$$C^* = wy + r^*k,$$

and

$$r^* = r-\lambda s/(1-\lambda) \text{ where } 0 < \lambda < 1.$$

Proof

Profit maximization subject to ROR regulation is given by the solution to the Lagrangian maximization:

$$\max_{p,y,k} L = (1-\lambda)(px-wy) - (r-\lambda s)k - \gamma F(x,y,k)$$

where λ and γ are Lagrangian multipliers. By rescaling F we can set $\gamma = 1$ (for w,r,s given):

$$\frac{\partial L}{\partial p} = (1-\lambda)(x+p\frac{\partial x}{\partial p}) - \frac{\partial F}{\partial x}\frac{\partial x}{\partial p} = 0 , \qquad 0 \leq \lambda \leq 1$$

$$\frac{\partial L}{\partial y} = -(1-\lambda)w - \frac{\partial F}{\partial y} = 0 ,$$

$$L_k = -(r-\lambda s) - F_k = 0 ,$$

supposing no corner solution and constraints are binding. Here scalar differentials are denoted by subscripts, $F_k = \partial F/\partial k$, $\partial F/\partial y_i = F_i$, $i = 1, \ldots, m$. From above,

$$F_i/F_j = w_i/w_j , \qquad F_i/F_k = w_i/r^*$$

and the conditions are thus fulfilled for cost minimization with respect to the input prices (w,r^*). Assuming F satisfies the necessary regularity conditions, there exists a cost function dual to F expressed as $C^* = g^*(x,w,r^*)$, where in addition

$C^* = wy + r^*k$. QED

Notice that the cost function g^* is given in terms of the shadow price of capital. It corresponds to the cost function of an unregulated monopoly facing a market rate of return of r^*. Given the ROR regulation the observed cost level is, of course,

$$C = wy + rk \ .$$

Thus

$$C^* = (C - \lambda px)/(1-\lambda)$$

or

$$C = (1-\lambda)C^* + \lambda px \ .$$

Define

$$g(x,w,r,s) = (1-\lambda)\ g^*(x,w,r^*) + \lambda px$$

and observe that (using Shepard's lemma)

$$g_r = (1-\lambda)\ g^*_{r^*} = k \ .$$

Appendix 2. REVEALED AVERAGE COST AND WASTE

The application of the algorithm presented in the preceding section raises a major problem, that of waste. While in the $\mathcal{P}$ subsequence of $\mathcal{T}$, the firm adjusting relative prices in order to maximize profits has no incentive to waste, since any waste would curtail its profits, π. This is not the case in the $\mathcal{R}$ subsequence of the algorithm. There the firm is required to contract prices by a factor of $(1-r_j)$. As the factor r_j is dependent upon cost and demand, it is up to the firm to determine its values, yet the firm's reward is independent of r_j. Unless the regulator has some knowledge regarding the cost structure in terms of cost minimization, it has to take the firm's word that the r_j applied to eliminate the firm's profits is indeed the smallest r_j value feasible. To the extent that the firm is able to pad its cost through waste, to the extent the adjustment cost of introducing and removing waste every other period without the knowledge of the regulator is not too high,[6] the firm can in fact take advantage of waste. By introducing waste so as to moderate the proportionate reduction in prices, it decreases to the same extent the constraint in the following period. This waste strategy provides the possibility of increasing profits in each period to the extent that the waste introduced in the previous period can be eliminated. The direct cost of waste whenever profits are to be reduced to zero is then directly born by the consumers and the producer does not receive any incentive to eliminate it, except in the next period.

The problem we face with the algorithm we propose comes from its very strength in relation to the V-F algorithm, namely its independence of the firm's technology. In the first loop of the V-F algorithm, the regulator had to know that the technology exhibited increasing returns to scale. Not knowing the extent of the increase in return to scale, V-F based their algorithm on the lower bound of any increase in return to scale, namely constant return to scale. They used as information the cost level of the preceding period, as a measure of average cost. As in practice the regulator cannot be expected to know whether the average cost is decreasing or increasing, V-F introduces their second loop, and with it the possibility that the firm be unsustainable.

In practice, it would seem that the regulator must have information on cost (under conditions of cost minimization by the firm) if the firm is to be prevented from incurring waste. Moreover, bookkeeping data is not sufficient to establish whether the firm indeed is miminizing cost.[7] Our goal (the same as that of V-F) is in effect to design an algorithm with a built-in incentive for the firm to minimize cost. In our algorithm the mechanism is operative every other period, whenever the firm is left free to modify relative prices in order to maximize profits. In the other periods, a modification to the regulation rule is made whereby the information of the firm's cost structure is revealed whenever it maximizes profits (minimizes cost). Whenever average cost is decreasing, this information would cause the process to converge faster than under the V-F algorithm. This is because our approach yields a better approximation of the average cost curve than does theirs, based on the preceding period average cost.

To be able to render the average cost concept meaningful, we shall make certain assumptions concerning the technology. First of all we shall assume that there exists a cost function which can be approximated locally (i.e. over short time spans) by a separable flexible functional form and that this cost function is the relevant cost minimizing function whenever, as in every other period, the firm maximizes profits. Separability implies that there exists an output aggregator function used to define, in terms of the total observed cost, an appropriate average cost. Then we assume that the average cost function, as a function of the aggregate output, is concave to the abcissa. In other words, if X_{2j} and $X_{2(j+1)}$ denote the aggregate output level in periods 2j and 2(j+1), given any α such that $0 < \alpha < 1$, and defining X_α as $\{\alpha X_{2j} + (1-\alpha)X_{2(j+1)}\}$, then the average cost a_α, defined as C_α/X_α where C_α is the total cost corresponding to X_α, is assumed to be bounded from above by $\{\alpha a_{2j} + (1-\alpha)a_{2(j+1)}\}$. Here the average costs a_{2j} and $a_{2(j+1)}$ are defined in the same way as a_α. This corresponds to assuming that the technology is such that, over the three periods 2j, 2j+1 and 2(j+1), it is bounded by

$$C_\alpha < X_\alpha(b_0 + b_1 X_\alpha) ,$$

where b_0 and b_1 are dependent upon the observed cost in the periods 2j and 2(j+1). If b_1 is negative then the technology will be of the decreasing cost family, while a positive b_1 indicates an increasing cost technology. As the firm maximizes profit in periods 2j and 2(j+1), it will be revealing to the regulator that its technology has increasing, constant or decreasing cost, and the regulator can now use the information to set an upper bound on the firm's profit in the interim by imposing a zero profit with respect to the <u>revealed</u> upper bound to the average cost. That is, the zero profit constraint with the proportional contraction of all prices is not with respect to the effective cost C_α but in terms of the upper bound $X_\alpha(b_0+b_1X_\alpha)$, such that the constraint becomes

$$P^T_{2j+1}X_{2j+1} - X_{2j+1}(b_0+b_1X_{2j+1}) = 0,$$

where b_0 and b_1 are functions of a_{2j} and $a_{2(j+1)}$.

The firm will be able to make a profit by taking advantage of any curvature of the average cost curve and its profit, π_{2j+1}, will be

$$\pi_{2j+1} = X_{2j+1}(b_0+b_1X_{2j+1}) - C_{2j+1} .$$

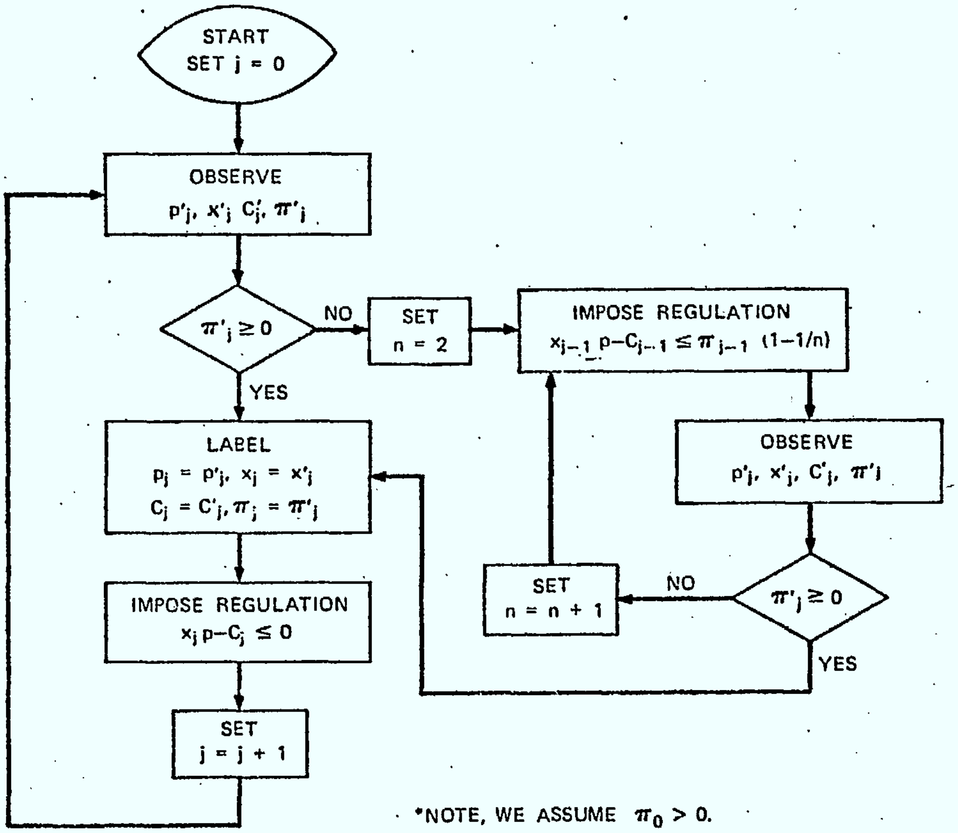
It should be noted at this stage that, even if the assumption regarding the average cost curve is invalid, the firm's sustainability is not at stake since the firm always has the option to set its cost and revenues in period (2j+1) equal to those of period 2(j+1), in which case its profits would be reduced to zero in both periods.

In practice, the regulator can obtain the estimate of X, the aggregate output, for any appropriate flexible functional form through the corresponding superlative index number (Diewert, 1976, Fontenay, 1980). It follows that the rule is easy to apply. It should also be noted that it can be enforced only every other period. The enforcement will thus be ex-post, similar to the

ROR regulation in this respect. Such a modification to our regulatory procedure is possible and most importantly it preserves the Ramsey character of relative prices.

Figure 1 : V-F Process

FLOW CHART II*



*NOTE, WE ASSUME $\pi_0 > 0$.

Source: VOGELSANG AND FINSINGER

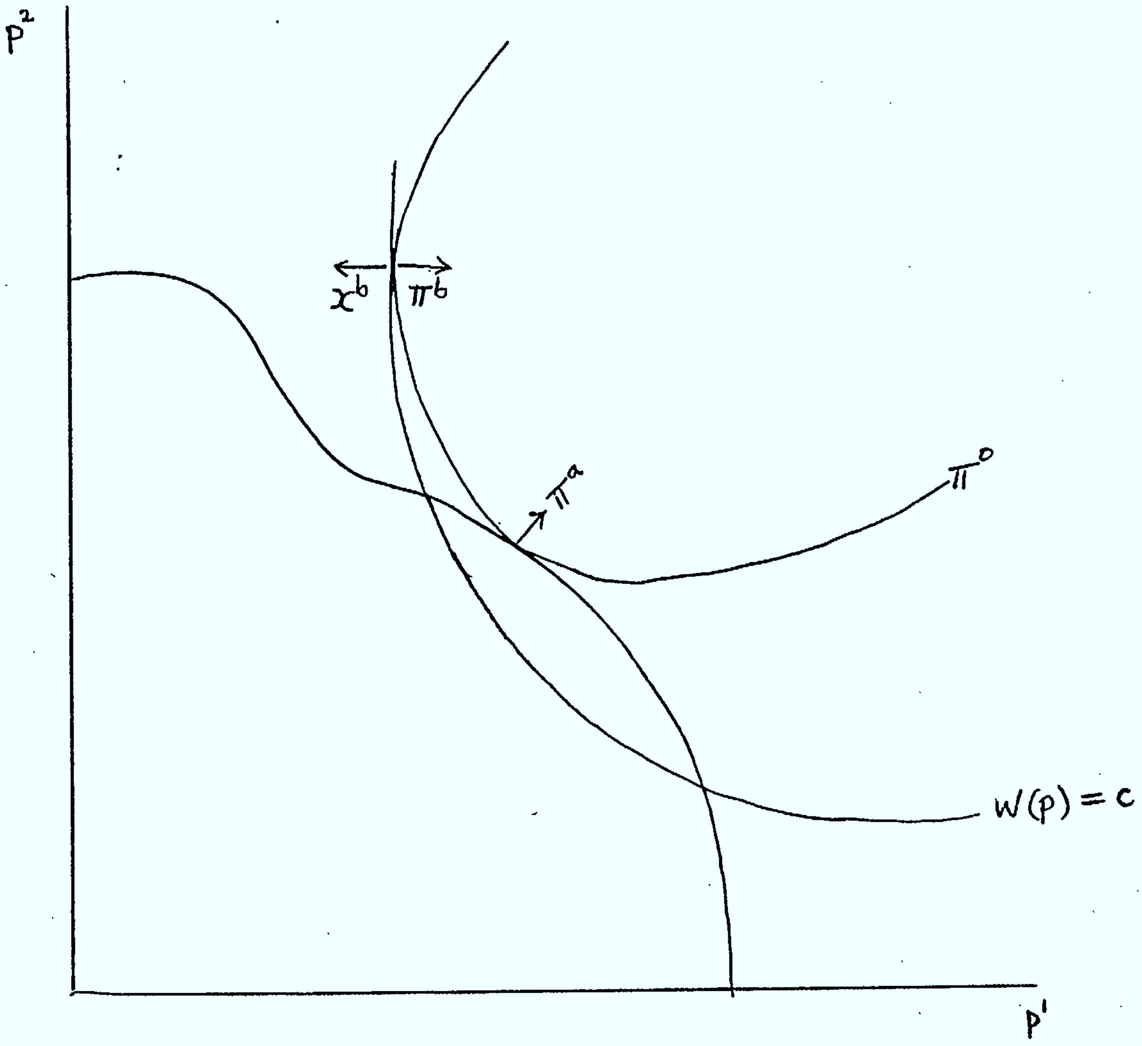


Figure 2

REFERENCES

1. Baumol, W.T. and D.P. Bradford (1970), "Optimal Departure from Marginal Cost Pricing", The American Economic Review, 60, pp. 265-283.

2. Breslaw, J. and B. Smith (1981), "Efficiency, Equity and Regulation: a Model of Bell Canada", included in this Conference.

3. British Columbia Telephone Company (1980), "General Decrease in Rate, 1980", Burnaby, B.C.

4. Corbo, V., J. Breslaw, J.M. Dufour and J.M. Vrejicak (1979), "A Simulation Model of Bell Canada, Phase II", Economic Analysis Division Working Paper, Department of Communications, Ottawa.

5. de Fontenay, A. (1980), Indexation for Telecommunications Services" in O. Anderson (ed.) Public Utilities Forecasting, North Holland.

6. Fuss, M. and L. Waverman (1978), "Multi-product Multi-input Cost Functions for a Regulated Utility: The Case of Telecommunications in Canada", Institute for Policy Analysis Working Paper No. 7810, University of Toronto, Toronto.

7. Ramsey, F. (1927), "A Contribution to the Theory of Taxation", Economic Journal, 37, pp. 4-61.

8. Sappington, D. (1980), "Strategic Firm Behaviour Under a Dynamic Regulatory Adjustment Process", The Bell Journal of Economics, 11(1), pp. 360-372.

9. Taylor, Lester D. (1980), Telecommunications Demand: A Survey and Critique, Ballinger Pub. Co., Cambridge, Mass.

10. Vogelsang, I. and Finsinger J. (1979), "A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms", The Bell Journal of Economics, 10(1), pp. 157-171.

11. Zajac, Edward E. (1978), Fairness or Efficiency: An Introduction to Public Utility Pricing, Ballinger Pub. Co., Cambridge, Mass.

FOOTNOTES

1. Econometrically, the evidence over cost structure is ambiguous (Corbo and Smith 1979, Fuss and Waverman, 1981). Secondly, the non-local adjustments involved can produce a change to another local cost structure.

2. The absence of a positive economic profit (as for example in Zajack (1978)), removes disincentives to waste, and it cannot be assumed that the profit maximizing firm thus constrained will minimize cost.

3. The V-F regulatory model is based on an allowed rate of return equal to the market rate, i.e., on a zero profit level. The non-zero profit situation under the allowed rate of return hypothesis will be considered in the next section.

Ramsey prices, under the zero profit hypothesis, imply

$$(p - \frac{\partial C}{\partial x}) \frac{\partial x}{\partial p} = -\lambda x , \qquad 0 \leq \lambda \leq 1$$

where we have followed the V-F vector notation, with p and x as the price and output vectors, C the total cost and $(\partial x/\partial p)$ the "elasticity" matrix $(\partial x_i/\partial p_j;\ i, j = 1, \ldots, n)$. λ is the Lagrange multiplier.

4. Costs have the property of non-increasing ray average costs whenever

$$\lambda C(x) \geq C(\lambda x), \qquad \lambda \geq 1,$$

where x is the output vector and C is the total cost.

5. Sappington (1980) also raises the waste problem, used by the utility as a strategic variable to deceive the regulators.

6. Note that, in practice, waste should not be expected to be a major problem since it is unlikely that, with a minimum of monitoring, the regulator would not be able to detect all but rather small shift in waste from period to period. In fact, the most likely types of waste are likely to involve a high adjustment cost and hence are unlikely to be applicable to our algorithm.

7. It is likely to be hard enough for the firm itself, even if it were in a competitive environment, to establish what are the cost minimizing parameters.

To illustrate the importance of the problem it suffices to note that Bell Canada has, on average, provided more information on its operation than any other regulated telecommunications carriers, and that, even then, the CRTC has had to institute a special committee, the Construction Program Review Committee, with the sole aim of having Bell Canada educating them and interested parties as to management process behind the construction program. Finally, if one looks at the documentation provided by Bell Canada, while it is a necessary element toward understanding the construction program since one learns how individual decisions are taken, we are no more informed as to how the firm determines the overall level of its construction expenditures.