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THE PRICE EFFECTS OF F.P.C. REGULATION: COMPARISONS OF REGULATED RESIDENTIAL AND UNREGULATED INDUSTRIAL PRICES FOR NATURAL GAS

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The interstate natural gas pipelines are in the business of purchasing natural gas in Texas, Louisiana, and other southwest states for sale to industry and municipalities along transmission routes leading to the large population centers in the Northeast and West. The terms of purchase and resale are numerous and diverse -- made more so by futures trading of gas reserves and by national or state regulation of the sellers and buyers at each level of the industry -- but the business is basically conducted according to the public utility pattern. The pipelines are said to be "natural monopolies." Profits and prices are constrained by Federal Power Commission regulation to produce the peculiar American blend of competitive performance from private companies operating in monopoly markets.

There are theoretical reasons for questioning whether this is the actual pattern. The reasons have to do with whether regulation should and could be used to accomplish this goal. The pipelines may very well not be "natural monopolies", in the present time frame of reference for pricing, because the operating costs and capacity-expanding costs of established pipelines appear to be directly proportional to gas throughput.[1] The state of

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1 Cf. S. H. Wellisz, "Regulation of Natural Gas Pipeline Companies: An Economic Analysis", LXXI Journal of Political Economy 33 (February, 1963).

affairs could be such that, not only are the pipelines not "natural" monopolies, but they are not "monopolies". Historical patterns of construction of new pipelines in the 1960's duplicated earlier lines moving gas to growing centers of population, so that there were two, three and sometimes more companies offering gas to large industrial or retail utility buyers. There are conceptual problems in finding the customary public utility "cost of service" to set regulated prices. Only part of the business is regulated, because F.P.C. jurisdiction is limited to "sales for resale in interstate commerce"; since this legalism excludes direct pipeline sales to industrial buyers, joint costs for the two categories of service have to be divided to find the costs of service provided by the pipelines to regulated firms. The methods for dividing joint costs of installed transmission lines are unknown and difficult to conceive in the regulatory process. Indeed, methods could more easily be devised to allow pipelines to quote prices set by "regulated costs" on "regulated sales" which would be the same as would occur without regulation.

There are two practical reasons for questioning price-reducing effects from public utility regulation, both based on present Federal Power Commission procedures. The F.P.C. sets profit limits on regulated sales by designating a maximum average

rate of return for the seller on the present value of his installed and working capital equipment; the designated rates of return have been justified in any number of ways, because they are the same as those in comparable regulated or unregulated industries, or are equal to previous rates of this company, or are half-way between what the company and the F.P.C. staff find appropriate. Generally, the maximum allowed rate has not been restrictive. In the last reported Commission decision in 1969, the rate was set higher than the pipeline company has been able to earn, for the fourth time in the history of that line; unless the F.P.C. consistently overestimates both competitive costs and monopoly profits in this case, the company is being allowed under regulation to keep more profits than it has been able to earn. This may be an exception, even though it is the latest decision. In earlier Commission decisions, the maximum rates were not essentially any more restrictive: the <u>average</u> rates exceeded estimated <u>marginal</u> costs of capital by more than two points, even in those years in the late 1960's when capital costs were rising sharply and far exceeded average.[1] Without regulatory

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[1] Cf. P.W. MacAvoy, "The Formal Work-Product of the Federal Power Commissioners" <u>The Bell Journal of Economics and Management Science</u>, Vol. 2, No. 1 (Spring 1971).

rules that have the tendency over a decade to reduce average allowed rates of return to equality with average costs of capital, it can hardly be expected that prices would approach competitive levels. The second set of findings raises more doubts. Practical problems arise from F.P.C. rules for cost allocation that are supposed to be the basis for actually setting regulated prices. These rules, whatever their predicted effects, have not been applied consistently. The controversial <u>Atlantic Seaboard Formula</u> should have imposed costs on unregulated sales -- whether or not they could be covered by returns in "competitive" industrial fuel markets -- that should have reduced accounting costs on regulated sales and ultimately regulated prices.[1] But the <u>Formula</u> has been "tilted" every which way in case decisions during the last decade, so that by 1968 it no longer applied even on the Atlantic Seaboard Pipeline Company itself.[2] Inconsistent application of the rules on costs

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[1] More precisely, the Formula reduced costs allocated to peak load service, relative to off-peak service, when compared to costs allocated on a volume basis. If peak-load service -- that on the three days of the year of greatest demand -- was entirely for retail utility buyers, then their costs would be reduced.

[2] Cf. <u>Atlantic Seaboard versus F.P.C.</u> 404 F 2nd 1268 (1968) and the detailed discussion in A.E. Kahn <u>The Economics of Regulation</u> (Wiley, 1970) Vol. 1, p. 99.

to set prices, or the bending of the rules to make ea cation an exception, should result in sporadic and weak from regulation. If this is the case, the theoretical and practical problems are overwhelming: the regulators deal with non-monopolists in an inconsistent fashion, with no consequent effects on "costs of service" and ultimately prices.

The means for assessing these possible -- and contradictory -- effects of Federal Power Commission regulation is by comparison of prices under regulation with those on unregulated industrial sales. The next section outlines the logical basis for such a comparison. This necessarily involves description and synthesis of economic models of the effects of regulation, in particular those termed "A-J-W models" which were in part derived from *a priori* analysis of regulated pipeline behavior.[1] The description is for the purpose of finding testable propositions about regulated as compared to unregulated prices. The second section describes the data to be used for testing regulated against unregulated prices, and the third section reports initial tests -- regression equations and accompanying observations -- on the

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[1] After H. Averch and L. Johnson, "Behavior of the Firm Under Regulatory Constraint" American Economic Review 52, (December 1962), pages 1052-69, and S. Wellisz, *op. cit.*

effects of F.P.C. regulation of pipelines. The report, while tentative, leads to the conclusion that the effects are slight but in the expected direction. While they follow closely the directions of the A-J-W theory, the extent of effects from regulatory constraint is almost unnoticed in the midst of much more important cost, demand, and institutional factors in pricing.

1. Hypotheses on Regulated versus Unregulated Prices

The pipeline enterprise faces demands for gas by retail public utility companies seeking to deliver to home consumers a total amount q_1 in a year's service commitment, and demands for direct consumption q_2 by industrial consumers during the same period. Both are contract demands with expressed or implied volumes (implied by commitment of capacity) and the major considerations are price $P_1 = f(q_1)$ and $P_2 = f(q_2)$. Conditions of supply on the regulated sales to home consumers could be monopolistic or similar to monopoly in price behavior where there are only two or three pipelines. Although there are no more sources of gas for industrial consumers than for retail public utilities serving home consumers, control of industrial prices conceivably could be more limited on industrial sales by extensive interfuel substitution and by the lack of regulatory

mechanisms for reporting and delaying price turns including "discounts" by any transporter. The pipeline enterprise incurs total costs $C = f(q_1,q_2,K)$ for operating existing capacity to provide q_1 and q_2, and for adding to capacity K. There are three types of constraints on the pipeline's control of prices: the first being capacity constraints, the second those implied by the extent of market competition, and the third in F.P.C. regulation of profits.

1(a) <u>Prices without regulation</u>: the pipeline enterprise is the sole source of supply, and maximizes profits subject only to constraints on capacity utilization. Gas is difficult or expensive for the buyer to transport and resell, so that discrimination can be practiced without "leakage" from the low priced buyer to the high priced buyer. This pipeline company has the opportunity to charge different prices for each unit-volume sold to the same consumer, given that resale can be prevented even on the last units purchased by low-priced users which might be turned over to high-priced users for the intra-marginal units. Different prices can be charged by the expedient of setting different initial lump sum charges for the initiaton of service which, when added into the marginal prices

P_1 and P_2, results in profits

$R = \int P_1 dq_1 + \int P_2 dq_2 - C(q_1, q_2, K)$ subject to $q_1 + q_2 \leq K$.

The company sets outputs and prices according to the first order conditions from[1]

$G = \int P_1 dq_1 + \int P_2 dq_2 - C(q_1, q_2, K) - \gamma(q_1 + q_2 - K)$ such that

$$P_1 - \partial C/\partial q_1 - \gamma = 0$$

$$P_2 - \partial C/\partial q_2 - \gamma = 0$$

$$q_1 + q_2 - K = 0$$

$$-\partial C/\partial K + \gamma = 0$$

so that relative prices are

$$P_1 = P_2 + (\partial C/\partial q_1 - \partial C/\partial q_2) \qquad (1)$$

and quantities are

$$q_1 + q_2 = K. \qquad (2)$$

1(b) Competitive constraints on pricing: these can take many forms, but the most likely first appearance of alternative sources of supply would be marked by the disappearance of perfect discrimination, as the high-priced buyer from one pipeline seeks to become a lower-priced buyer at another pipeline. The two-part tariffs cannot

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[1] This follows closely on W.J. Baumol and A. Klevorick "Input Choices and Rate of Return Regulation: An Overview of the Discussion" and I. Pressman "A Mathematical Formulation of the Peak-Load Pricing Problem", both from the Bell Journal of Economics and Management Science, Vol. 1, No. 2, pages 162-190 and 304-327 respectively (1970). Here the discussion is centered on pricing, rather than input factor ratios, for testing purposes, so that propositions appear to be different while they are not.

be put into effect so that the firm operates as if limited to

$G = P_1q_1 + P_2q_2 - C(q_1, q_2, K) - \gamma(q_1 + q_2 - K)$.

The first order conditions are

$$P_1(1 + 1/e_1) - \partial C/\partial q_1 - \gamma = 0$$

$$P_2(1 + 1/e_2) - \partial C/\partial q_2 - \gamma = 0$$

$$q_1 + q_2 - K = 0$$

$$\partial C/\partial K + \gamma = 0$$

where $e_i = -(P_i/q_i)\,\partial q_i/\partial P_i$, the price elasticity of demand, so that relative prices are

$$P_1 = \frac{(1 + 1/e_2)}{(1 + 1/e_1)} P_2 + \frac{1}{(1 + 1/e_1)} (\partial C/\partial q_1 - \partial C/\partial q_2) \tag{3}$$

and quantities are

$$q_1' + q_2' = K'.[1] \tag{4}$$

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[1] These conditions differ if q_1=K and q_2=K in separate periods. The firm maximizes $G = P_1q_1 + P_qq_2 - C(q_1, q_2, K) - \gamma_1(q_1 - K) - \gamma_2(q_2 - K)$ and the first order conditions are:

$$P_1(1 + 1/e_1) - \partial C/\partial q_1 - \gamma_1 = 0$$

$$P_2(1 + 1/e_2) - \partial C/\partial q_2 - \gamma_2 = 0$$

$$q_1 - K = 0$$

$$q_2 - K = 0$$

$$-\partial C/\partial K + \gamma_1 + \gamma_2 = 0$$

so that relative prices are

$$P_1 = -\frac{(1 + 1/e_2)}{(1 + 1/e_1)} P_2 + \frac{1}{(1 + 1/e_1)} (\partial C/\partial q_1 + \partial C/\partial q_2 + \partial C/\partial K). \tag{5}$$

1(c) Prices when only residential sales are regulated: the effects of regulation on pricing of course depend on the nature of the controls applied by the regulatory commission. There are many ways of controlling the firm, including setting price directly, but the F.P.C. generally follows policies of setting dollar limits on profits through the artifice of finding fair rates of return on investment. We will avoid the artifice here in the simple model, by assuming that the Commission holds profits on regulated sales q_1 to M, so that $P_1q_1 - \alpha C = M$, where α is the proportion of total costs attributed by the F.P.C. to regulated sales.

The profits on industrial sales are not constrained, so that with

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(footnote continued) Here each class of service receives full capacity supply, and costs of capacity are "shared" in the same way that peak load capacity is shared in optimal electricity pricing -- with the sum of marginal revenues equal to long run marginal costs. The conditions for setting these prices are unreal, in that the two classes of sales are segmented by period and both classes fill the pipeline to capacity; more probably if not likely, residential sales fill the line in some periods and push industrial sales to other periods. Then $q_1 \leq K$ and $q_2 < K$, so that without γ_2

$$P_1 = \frac{(1+ 1/e_2)}{(1+ 1/e_1)} P_2 + \frac{1}{(1+ 1/e_1)} (\partial C/\partial q_1 - \partial C/\partial q_2) + \frac{1}{(1+ 1/e_1)} \frac{\partial C}{\partial K} \qquad (6)$$

and the residential consumers pay for all of the additional costs of capacity.

$$G = P_1q_1 + P_2q_2 - C(q_1,q_2,K) - \gamma(q_1+ q_2- K) + \lambda[P_1q_1 - \alpha C(q_1,q_2,K) - M] ,$$

the first order conditions are

$$(1+\lambda)[P_1(1+ 1/e_1)] - (1+\alpha\lambda)\partial C/\partial q_1 - \gamma = 0$$

$$P_2(1+ 1/e_2) - (1+\alpha\lambda)\partial C/\partial q_2 - \gamma = 0$$

$$q_1 + q_2- K = 0$$

$$P_1q_1 - C - M = 0$$

$$-(1+\alpha\lambda)\partial C/\partial K + \gamma = 0$$

and $$P_1 = \frac{1}{(1+\lambda)}\frac{(1+ 1/e_2)}{(1+ 1/e_1)}P_2 + \frac{(1+\alpha\lambda)}{(1+\lambda)}\frac{1}{(1+ 1/e_1)}\left(\frac{\partial C}{\partial q_1} - \frac{\partial C}{\partial q_2}\right) \tag{7}$$

with $(1+\lambda) < 1.$[1] (8)

Equation (7), for relative prices under regulation, can be compared with equation (3) for the same market and production conditions. They differ by the factor $1/(1+\lambda)$ in the coefficient of P_2, and the factor $(1+\alpha\lambda)/(1+\lambda)$ for the coefficient of the cost difference $(\partial C/\partial q_1 - \partial C/\partial q_2)$. The first factor is > 1, given equation (8), and the second factor is > 1, given that

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1 As shown by the Lemma: "if the firm maximizes its total profit (1) subject to the regulatory (inequality) constraint (2), in which $s > r_1$, and if, in addition, the regulatory constraint is binding and $x_1 > 0$ and $x_2 > 0$, then we must have $0 < \lambda < 1$." Baumol and Klevorick, op. cit., page 166.

$\alpha - 1$ (i.e., that not all the costs are attributed to regulated sales). Thus, regulation results in higher relative prices for sales coming under Commission jurisdiction.

The higher regulated price, relative to the direct-sale unregulated price, is not counter-intuitive. In the short run, with full use of capacity, the new application of regulatory rules would require profit reductions on regulated sales that could take place only by reducing regulated output and consequently increasing regulated price. In the long run, the profit constraint applied to retail utility purchases would, in the A-J-W model, increase the profitability of capital relative to other inputs and thus the level of total investment. If there were economies of scale, increased capacity would reduce marginal costs and thus the absolute level of prices on both regulated and unregulated sales. The increased capacity would be more fully devoted to the unregulated sales because, whatever the relative levels before the application of regulation, marginal output in the unregulated sector would now be relatively more profitable. This follows from attributed costs being lower [as shown by the $(1+\alpha\lambda)$ term on unregulated costs] and from relative profit reduction on regulated sales (as shown by M). Marginal output in the regulated sector should have reduced profits, in other words, so that there should be a long run <u>relative</u> decline in regulated sales and a <u>relative</u> increase in regulated prices.

1(d) Prices when regulation requires specific cost allocation procedures: the rules for apportioning costs between regulated and unregulated sales are more complex than suggested by α in the $(1+\alpha\lambda)$ expression, and the added complexity may directly affect quantities and prices. This is likely with respect to the regulatory rule applied with wide discretion by the F.P.C., the Atlantic Seaboard Formula for pipeline cost allocation. Only costs on sales q_1 going to local public utilities are used to find regulated "costs of service" and prices. The designated costs for delivery on these sales are made up of a portion of total variable costs $C(v)$, which Atlantic Seaboard prorates on the basis of relative volume $q_1/(q_1+q_2)$, and a portion of capital costs $C(K)$ which the Formula prorates to regulated sales only partly on the basis of volume. The capital costs are divided into two equal parts and prorated as follows: (1) the first half is attributed to regulated sales q_1 according to volume, so that regulated capital costs are $C(K)\cdot q_1/2(q_1+q_2)$; (2)the second half is attributed to regulated sales according to peak-load volume so that, if these sales $q_1 = \beta K$ at peak capacity K, then regulated capital costs also include $C(K)\beta/2$. The Atlantic Seaboard Formula limits earnings to

$$P_1q_1 - C(v)\cdot q_1(q_1+q_2) - C(K)q_1/2(q_1+q_2) - C(K)\beta/2 \leq M.$$

When this regulatory constraint is applied to the profit function, it should have some effect on relative price P_1. Consider profits $R = P_1q_1 + P_2q_2 - C(q_1,q_2,K)$ subject to the <u>Atlantic Seaboard Formula</u> and to the capacity constraint $q_1+q_2 \leq K$. Then the first order conditions are

$$(1+\lambda)P_1(1+ 1/e_1) - \partial C/\partial q_1 + \lambda[-(\partial C(v)/\partial q_1)q_1/(q_1+q_2) - C(v)q_2/(q_1+q_2)^2 - C(K)q_2/2(q_1+q_2)^2] - \gamma = 0$$

$$P_2(1+ 1/e_2) - \partial C/\partial q_2 + \lambda[-(\partial C(v)/\partial q_2)q_1/(q_1+q_2) + C(v)q_1/(q_1+q_2)^2 + C(K)q_1/2(q_1+q_2)^2] - \gamma = 0$$

$$P_1q_1 - C(v)q_1/(q_1+q_2) - C(K)q_1/2(q_1+q_2) - C(K)\beta/2 = M$$

$$q_1 + q_2 - K = 0$$

$$-\partial C/\partial K - \lambda(q_1+\beta q_1+\beta q_2)/2(q_1+q_2)\frac{\partial C}{\partial K} + \gamma = 0$$

so that relative prices are

$$P_1 = \frac{(1+ 1/e_2)}{(1+\lambda)(1+ 1/e_1)} P_2 + \frac{1}{(1+\lambda)(1+ 1/e_1)}(\partial C/\partial q_1 - \partial C/\partial q_2) + \frac{\lambda}{(1+\lambda)(1+ 1/e_1)}\left\{\left[\frac{\partial C(v)}{\partial q_1} - \frac{\partial C(v)}{\partial q_2}\right][q_1/(q_1+q_2)] + C(v)/(q_1+q_2) + C(K)/2(q_1+q_2)\right\} \tag{9}$$

a rather special version of the general price results from regulating only one class of service. Here the regulated price is less than that from allocation of costs according to the α rule posited for equations (7) and (8) under certain conditions. If the second and third terms on the right hand side of equation (9) together are less than the second term on the right side of equation (7), this will be the case. This is to require that, assuming $\alpha \sim q_1/(q_1+q_2)$ and the λ constraint lies between 1 and 0, then the average variable costs $C(v)/(q_1+q_2)$ along with average capital costs $C(K)/2(q_1+q_2)$ both have to be positive. These conditions should hold. The sense of this is that forcing some of the costs of additional regulated output over onto the unregulated output has the effect of reducing the regulated price.

1(e) Rate-of-return regulation: merely setting rates of return with an arbitrary α is less ambiguous in its effects on relative prices than regulation by Atlantic Seaboard cost allocation. This procedure has the effect of raising the regulated price at least when the regulated sales are at a farther distance from gas field reserves. Consider the profit function to be

$P_1q_1 + P_2q_2 - r_1x_1 - r_2x_2$, where x_1 are capital resources and x_2 non-capital resources available to the regulated firm at prices r_1, r_2 respectively.[1] The restraint on profits is that

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[1] This follows directly from Baumol and Klevorick, op. cit.

$P_1q_1 - \alpha s_1x_1 - \alpha r_2x_2 = M$, where s_1 is the allowed rate of return on capital such that $s_1 - r_1 = V \geq 0$. The first order conditions for

$$G = P_1q_1 - P_2q_2 - r_1x_1 - r_2x_2 - \delta(q_1+q_2-x_1) + \lambda(P_1q_1-\alpha s_1x_1-\alpha r_2x_2 - M)$$

include

$$(1+\lambda)P_1(1+ 1/e_1)-(1+\alpha\lambda)(r_1\partial K/\partial q_1 + r_2\partial L/\partial q_1)-(1+\alpha\lambda)(s-r_1)\partial K/\partial q_1 = 0$$

$$P_2(1+ 1/e_2)-(1+\alpha\lambda)(r_1\partial K/\partial q_2 + r_2\partial L/\partial q_2)-(1+\alpha\lambda)(s-r_1)\partial K/\partial q_2 = 0.$$

If marginal costs $\partial C/\partial q_1$ are defined as $(r_1\partial K/\partial q_1 + r_2\partial L/\partial q_2)$, then

$$P_1 = \frac{1}{(1+\lambda)}\,\frac{(1+ 1/e_2)}{(1+ 1/e_1)}P_2 + \frac{(1+\alpha\lambda)}{(1+\lambda)}\,\frac{1}{(1+ 1/e_1)}\left[\frac{\partial C}{\partial q_1} - \frac{\partial C}{\partial q_2}\right] + \qquad (10)$$

$$\frac{(1+\alpha\lambda)}{(1+\lambda)}\cdot\frac{1}{(1+ 1/e_1)}\cdot(s-r_1)\cdot\left(\frac{\partial K}{\partial q_1} - \frac{\partial K}{\partial q_2}\right),$$

the same expression for relative prices as in (8), but with the addition of the last term on the right hand side of this equation. This last term is greater than zero if $\partial K/\partial q_1 > \partial K/\partial q_2$ -- if the distance from purchase of the gas to final delivery is greater for regulated sales than unregulated sales, for one -- so that the relative price of regulated gas transmission is even greater when rate of return limits are set only on the regulated sales. This last term is negative if $\partial K/\partial q_1 < \partial K/\partial q_2$, or if the unregulated sales occur at greater distance from field reserves, so

that relative regulated prices are reduced even more from this type of regulation. The pattern of residential-industrial location sets these relative capital expenditures; but given that they have taken place, then their effects on relative regulated prices are always greater under this regimen.

These are equilibrium conditions for relative prices, assuming that demands and costs are known and that regulation is continuous as well as certain. These assumptions do not always hold in all markets for gas transmission, and do not hold often enough that questions can be raised on the usefulness of an analytical apparatus based on them.

The answers to the questions are not well developed at this time. They depend on the extent to which models with uncertainty and with dynamic regulatory conditions differ from the certainty-static models, and these more complex models remain to be developed. At this point, of the many promising but only partially developed analyses, those based on conditions most similar to actual market and regulatory conditions differ little from the certainty-static models. The reasons for this assertion are two. First, with respect to uncertainty, cost and demand conditions different from those expected must occur at all levels of prices and volumes of service, but it

seems plausible to assume that variation from expected cost and price levels is going to be greater when gas demand is highly elastic with respect to prices of other sources of energy. These demand conditions should occur most widely in unregulated markets -- almost as a matter of classifying these markets as competitive enough not to be regulated. That is, uncertainty has the greatest effects in unregulated markets. Second, with respect to regulation, the commissions operate with a lag, but not an extended lag, given that F.P.C. staff seeks to bring about price adjustments resulting in profits at the regulated level <u>within the year</u>. That is, the imperfections of regulation may not require variations in the model structure for year-to-year analysis. Then *ex post* profits should come close to *ex ante* regulated profits, on the categories of service -- the regulated categories -- least subject to uncertainty.

At this point, the rather extended array of price variations might well be summarized. The price hypotheses differ quite markedly from each other, when there are differences in degrees of market control and in the nature of regulation. These differences are shown in Table 1. When it is possible

Table 1: Hypotheses on Relative Prices

$$P_1 = aP_2 + b(\partial C/\partial q_1 - \partial C/\partial q_2) + c[C(v)/(q_1+q_2) + C(K)/2(q_1+q_2)] + d(\partial K/\partial q_1 - \partial K/\partial q_2)$$

Pricing Policies	No Regulation	Profit Regulation	Cost-Allocation Regulation	Rate of Return Regulation
1. perfect discrimination so that buyers pay marginal prices different from average prices	$a = 1$ $b = 1$	$a = \frac{1}{(1+\lambda)}$ $b = \frac{(1+\alpha\lambda)}{(1+\lambda)}$	$a = \frac{1}{(1+\lambda)}$ $b = \frac{1}{(1+\lambda)}$ $c = \frac{\lambda}{(1+\lambda)}$	$a = \frac{1}{(1+\lambda)}$ $b = \frac{(1+\alpha\lambda)}{(1+\lambda)}$ $d = \frac{(1+\alpha\lambda)}{(1+\lambda)} \cdot \frac{(s-r_1)}{1}$
2. marginal price equals average price	$a = \frac{(1+1/e_2)}{(1+1/e_1)}$ $b = \frac{1}{(1+1/e_1)}$	$a = \frac{1}{(1+\lambda)} \frac{(1+1/e_2)}{(1+1/e_1)}$ $b = \frac{(1+\alpha\lambda)}{(1+\lambda)} \frac{1}{(1+1/e_1)}$	$a = \frac{1}{(1+\lambda)} \frac{(1+1/e_2)}{(1+1/e_1)}$ $b = \frac{1}{(1+\lambda)} \frac{1}{(1+1/e_1)}$ $c = \frac{\lambda}{(1+\lambda)} \frac{1}{(1+1/e_1)}$	$a = \frac{1}{(1+\lambda)} \frac{(1+1/e_2)}{(1+1/e_1)}$ $b = \frac{(1+\alpha\lambda)}{(1+\lambda)} \frac{1}{(1+1/e_1)}$ $d = \frac{(1+\alpha\lambda)}{(1+\lambda)} \frac{1}{(1+1/e_1)} \frac{(s-r_1)}{1}$
3. competition: marginal prices equal average prices, which in turn equal marginal costs	$a = 1$ $b = 1$	$a = 1$ $b = 1$	$a = 1$ $b = 1$ $c = 0$	$a = 1$ $b = 1$ $d = 0$
Effects from Regulation on P_1, regulated price:	a. coefficient of P_2, unregulated price	b. coefficient of $(\partial C/\partial q_1 - \partial C/\partial q_2)$ transport cost difference	c. coefficient of average total costs allocated to regulated sales [in (9)]	d. coefficient of $(\partial K/\partial q_1 - \partial K/\partial q_2)$ transport capital cost difference in (10)

Sources: as derived in the text.

for pipelines to charge a different price to each retail distributor or industrial buyer, and there is no regulation, elasticities of demand do not enter the coefficients of the equation $P_1 = aP_2 + b(\partial C/\partial q_1 - \partial C/\partial q_2)$, as can be seen from reading across the first row. When, for reasons of rivalry between pipelines in the same market, prices turn out to be uniform to all industrial or all retail utility buyers -- to all buyers of q_2, or all buyers of q_1 -- the relative elasticities of demand enter both coefficients a and b, as shown in the second row. The price behavior of perfect competitors is shown in the third row, for contrast. Here again, there should be contrast, because in the long run, profit constraints, if effective, can only cause firms to leave the industry.

Regulation results in testable differences in coefficients -- the last three columns in Table 1 show this. Terms including the regulatory constraint λ are found in both a and b, and additional variables also enter the equations with λ terms in coefficients c and d. These λ terms increase the size of the coefficients, except in "cost-allocation regulation," so that the regulated price is increased relative to the unregulated price, and transport cost differences are "marked up" with a regulatory premium.

2. <u>Data for Testing Regulated Against Unregulated Prices</u>

The information on prices charged by the interstate pipelines is voluminous, complicated and not altogether useful for testing the effects of regulation. The regulatory process may itself be responsible, since the demands of the F.P.C. for information are for detailed statements on assets and liabilities at specified (at least annual) time periods, but for less detailed statements on flows of expenditures and income by contract, or on amounts of gas delivered. Also, the demands are for rather complete information on regulated but only partial information on unregulated sales (for cost allocation purposes). There are data on volumes of gas delivered under contracts with the regulated retail gas distributing companies, and in the <u>Form 2 Annual Reports</u> to the F.P.C. on the "demand charges" (annual or monthly charges for providing service, where these charges are not related to the rate of delivery at that time) and on the "commodity charges" (the prices per mcf of gas delivered) on each retail gas sale. There are annual statistics in the <u>Form 2 Reports</u> on the volume and total revenues from unregulated direct industrial sales; these have been supplemented by interviews and special surveys of particular pipelines, to find the actual prices charged

on the average rate of delivery for unregulated sales in 1969.

The price information is to be used to test the coefficients a,b in $P_1 = aP_2 + b(\partial C/\partial q_1 - \partial C/\partial q_2)$ for the effects of pipeline and inter-fuel competition, and for the effects of regulation. Since this expression has been derived with respect to marginal prices, the commodity charge on regulated sales is designated to serve as P_1 and the commodity charge on unregulated sales should be P_2. Without a commodity charge on direct sales, however, the average or unit price is used and designated P_2^*. With $P_2^* = P_2 + w/q_2$ where w is any additive to the marginal (discounted) charge on unregulated sales, the equation is still the same -- that is, $P_1 = aP_2^* + b(\partial C/\partial q_1 - \partial C/\partial q_2) + d$ with a,b as given above -- but with the possible addition of a constant term d.[1]

The tests call for computation of a and b by least squares regression, so that data are required on the marginal costs of transport $\partial C/\partial q_1$ and $\partial C/\partial q_2$ as well. The tests require independent

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1 This equation can be derived by substituting $P_2^* = P_2 + w/q_2$ in the appropriate objective functions in the preceding section of this paper. If $\partial w/\partial q_2 \neq 0$, or charges in fact do vary with the amount of gas delivered, then an additional term appears (for example) in equation (3) above.

estimates of e_1 and e_2 so as to be able to separate the λ and e_i effects found in both a and b. These requirements will be discussed and met in turn.

2(a) <u>The marginal costs of transport</u>: these costs can take on many different values, and the proper measure depends on the relevant time period, and location of the pipeline, and the unit prices of capital and of pumping fuel at the time estimates are made. For purposes of studying recent prices, the time period chosen is a "recent year" in the interval 1952-1967 and an observation is "expenditures on operations, maintenance, administration, transmission, storage and depreciation" in one of those years for each of eight large interstate pipelines.[1] The pipelines have been chosen for similarity in the timing and technology of construction of the main pipeline; each had more than 1,000 miles of total pipeline, 75 per cent of which had diameter equal to or greater than 15 inches, and the main lines were constructed over roughly the same types of terrain.[2] The length of

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[1] The Federal Power Commission <u>Statistics for Interstate Natural Gas Pipeline Companies</u> 1952 through 1967, annual volumes.

[2] The pipelines were: The Atlantic Seaboard Corporation, Colorado Interstate Natural Gas Pipeline, Michigan-Wisconsin Pipeline Company, The Natural Gas Pipeline Company of America, Tennessee Gas Transmission Company (a division of Tenneco), Texas Eastern Transmission Company, Transcontinental Gas Pipeline Corporation, and Trunkline Gas Corporation.

the main line of each transporter was estimated by inspection of maps and engineering drawings, to provide data for the variable "m = mileage", and throughput of gas was recorded as "q = volume."[1]

The most general equation form chosen was $C = \alpha + \beta m \cdot q$, which when fitted to the sample, proved to be $C = 44.7(10^3) + .57 m \cdot q$, $R^2 = .958$ with α and β in cents per thousand cubic feet of gas transported for 100 miles. Attempts were made to account for differences in factor prices among the transporters, and for the "mix" of combinations of volume and mileage, as well, but they did not improve the fit as measured by R^2. The introduction of variables to account for the year of the observation and/or to account for the particular pipeline in that observation did not change the values of α or β nor increase the value of R^2. The measure of marginal costs is .57 cents per hundred miles, so that values of transport cost differences ($\partial C/\partial q_1 - \partial C/\partial q_2$) are taken to be $.57(m_1 - m_2)$ where m_1 and m_2 are mainline mileages from a common gas field origin point to the points of resale of regulated gas q_1 and unregulated gas q_2.

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[1] Volume is recorded as annual sales in F.P.C. <u>Statistics</u>, <u>op. cit</u>.

2(b) <u>The elasticities of market demand</u>: the price-sensitivity of gas demands of home and industrial consumers has been discussed and analyzed in a number of recent studies, but mostly for the purpose of analyzing the effects of regulatory policies in the field producing areas.[1] There have been no studies of the specific elasticities of demand of those buying gas directly from natural gas pipelines. In order to find first crude estimates of e_1, e_2 here, a sample of contract prices and quantities has been constructed and a regression analysis of the sample completed with equation forms suggested by the more detailed studies.[2]

The markets for gas in which the pipelines are sources of supply probably encompass whole metropolitan regions in most cases. The purchasing retail distributors can go to alternative sources of gas that deliver within their metropolitan regions,

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[1] Cf. J. D. Khazzoom "The F.P.C. Staff's Econometric Model of Gas Supply" <u>Bell Journal of Economics and Management Science</u>, Vol. 2, No. 1 (Spring 1971) and P. MacAvoy "The Regulation-Induced Shortage of Natural Gas" <u>Journal of Law and Economics</u> (Spring 1971).

[2] See P. Balestra, <u>The Demand for Natural Gas in the United States</u> (North Holland, 1967) and H.S. Houthakker and L.D. Taylor, <u>Consumer Demand in the United States 1929-1970</u> (Harvard University Press, 1966).

whether pipeline company or LNG company; the industrial consumer can go to the same sources, as well as suppliers able to provide large volumes of coal and fuel oil, in the same locations or with access to transportation to these locations. Data on 1969 prices of all fuels, and on the contract volumes of delivered natural gas, have been collected for 17 metropolitan areas in which there were purchases by retail public utilities, and for 49 locations in which there were purchases by industrial buyers.

With a single year's data, the demand function takes the form

$$\log(q_i) = \alpha + \beta\log(P_{gi}) + \gamma\log(P_F) + \partial\log(Y) + \epsilon\log(N) + \ldots.$$

where q_i is annual gas consumption of consumers i, P_{gi} is the marginal gas price to these consumers, P_F the price of an alternative fuel, and Y and N the "market size" variables such as per-capita income and population.[1] The residential demand function, as found by fitting a least squares regression, proved to be:

$$\log(q_i) = 8.106 - \underset{(1.342)}{1.907}\log(P_{gl}) + \underset{(0.816)}{0.390}\log(P_F) + \underset{(2.792)}{0.545}\log(Y)$$
$$+ \underset{(0.337)}{0.564}\log(N) - \underset{(0.711)}{0.445}\log(TTD)^{2}; \quad R^2 = .374 \qquad (11)$$

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[1] That is, in the absence of more than one year's data, lagged terms in q, P_g to account for adjustment processes had to be deleted.

[2] TDD denotes "temperature degree days" in 1969 at each of the 17 locations.

a relationship noted for its general agreement with empirical regularities in economics -- gas price decreases have the effect of increasing quantity demanded, and income, population and fuel price increases have the effect of increasing the annual quantity demanded. But the regularities are not strong: the coefficients are not statistically significant and the equation only explains 37 per cent of the variation in the dependent variable. The price elasticity, in particular, seems quite high -- the coefficient is -1.907, clearly in the elastic range -- but it is not statistically significantly different from zero. The estimate is subject to change; after collecting 1968 data on q_1 and N for these 17 locations, the regression was refitted for $q_1 = f[q_1(t-1), P_{g1}, N_{t-1}, \ldots)$ with the result that the coefficient for $\log(P_{g1})$ equaled -0.950 and for $\log q_1(t-1)$ equaled +0.970; both were statistically significant, and $R^2 = .998$. The conclusion must be that the residential distributor elasticity e_1 lies between zero and -1.9, with the most likely value between -1.0 and -1.9, so that demand is "elastic".

The 1969 data on industrial demand proved to be much more extensive. Price and quantity information have been collected on 49 direct sales, and using corporate employees as a measure

of "size of market," the regression equation was found to be:

$$\log(q_2) = 11.372 - \underset{(0.980)}{1.785} \log(P^*_{g2}) - \underset{(0.114)}{0.249} \log(S32) - \tag{12}$$

$$\underset{(0.125)}{0.144} \log(S33) - \underset{(0.168)}{0.205} \log(S29) + \underset{(0.192)}{0.681} \log(EES);$$

$$R^2 = 0.306 \quad .$$

Here the coefficients of P^*_{g2} and EES are statistically significant, and the first of the dummy slope coefficients (for industry classification 32) is also different from zero. The remaining coefficients do not differ from zero, and R^2 indicates that only 30 per cent of the variance in q_2 is explained by the regression. Demand is somewhat more elastic than for retail distribution: the elasticity for the base industry (chemicals) is -1.785, for industry 32 (stone-clay-glass) is -1.785 - .249 = -2.034, for industry 33 (primary metals) is -1.785 - .144 = -1.929, and for industry 29 (petroleum refining) the estimate is -1.785 - .205 = -1.990. Each of these is different from zero, and seems to be close to -2.0, approximately twice the elasticity of retail distributors demand.

Further regression analysis suggests that industrial demand is more elastic -- particularly where there are close gas substitutes. Data were available for a more limited sample of 39 gas

price and quantity observations (excluding sales to companies in the petroleum refining industry) that included industrial coal prices at those locations, and the regression from this sample was:

$$\log(q_2) = 10.954 - \underset{(0.918)}{3.471} \log(P^*_{g2}) - \underset{(0.542)}{0.962} \log(S32) - \underset{(0.673)}{1.007} \log(S33) + \underset{(1.346)}{1.578} \log(P_c);\ R^2 = .378 \tag{13}$$

Here the estimated elasticities varied from -3.47 (on sales to firms in the chemicals industry) to -4.54 (on sales to companies in the primary metals industry). Gas demand is less elastic where the use of gas is as a process raw material with poor substitutes (as in chemicals) and more elastic where the use is as a boiler fuel with good substitutes (as in metals).[1]

Equations have also been fitted for two of the industries separately (given that there were sufficient data). These show substantial price elasticities, and also show differences between them sufficient to explain in part the low values of R^2 in the

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[1] A more complete but not necessarily illuminating form is as follows:

$$\log(q_2/EES) = 0.757 - \underset{(1.175)}{2.168} \log(P^*_{g2}/P_F) - \underset{(0.542)}{1.109} \log(S32) - \underset{(0.689)}{1.049} \log(S33) + \underset{(0.821)}{2.958} \log(P_c/P_F);\quad R^2 = .364$$

where P_c equals price of coal and P_F equals a fuel price index.

combined-industries equations. The equation for demand for gas in the chemicals industry is

$$\log(q_2) = -2.021 - \underset{(2.118)}{3.486} \log(P^*_{g2}) + \underset{(0.315)}{0.839} \log(EES) + \underset{(1.938)}{4.049} \log(P_c) \; ; \qquad R^2 = .567 \tag{14}$$

for 12 observations, and demand in the stone and glass industries is

$$\log(q_2) = 11.641 - \underset{(1.371)}{2.778} \log(P^*_{g2}) + \underset{(0.239)}{0.819} \log(EES) + \underset{(0.998)}{1.163} \log(P_c) \; ; \qquad R^2 = .232 \tag{15}$$

for 19 observations. They indicate values of $e_1 = -3.49$ and -2.78 respectively, and as such add to the impression that industrial demand elasticity lies in the range from -2.0 to -3.5. This range, along with values of e_1 between -1.0 and -2.0, will be used in the calculations for the λ effects from regulation.

2(c) <u>Elasticities of demand and individual pricing decisions</u>: the elasticities of <u>market</u> demand may not determine individual pipeline pricing decisions, when there are a number of pipelines serving the same metropolitan region. These differ from market elasticity in some circumstances for any one transporter because prices reduced below the joint-profit-maximizing level result in a disproportionate market share which can be maintained for a

long enough period to more than compensate for the reduction. The greater elasticity could provide the incentive for lower prices on either residential or industrial deliveries, so that final contract prices are below those consistent with e_1, e_2. How great the further reduction should be depends on the oligopoly firms' interaction, and there are any number of theories on the results of that interaction. These, if testable, show relations between relative firm size, the quality of information on prices, and approach a lower bound on price designated by the Cournot theory. This replaces e_i by ne_i for "n" equivalent sized firms in all cases described above, where now ne_i is equilibrium market elasticity for market-wide price determination (even though individual firm elasticity is larger at each stage of price setting).[1] A first measure of the extent of any such interaction, in terms of replacements for e_1, e_2 as ne_1 or ne_2 where $n \geq 1$ in the relative price equations, can be made by observing the coefficients in price equations where no regulatory effect enters.

Consider the relative price equation $P^*_{2a} = aP^*_{2b} + b(\partial C/\partial q_{2a} - \partial C/\partial q_{2b})$ where P^*_{2a} and P^*_{2b} are both samples of industrial prices, one for

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[1] Cf. W. Vickrey, Microstatistics (New York, 1964), pages 337-38.

industry a and the other for industry b, and $\partial C/\partial q_{2a}$, $\partial C/\partial q_{2b}$ are the marginal costs of transporting to each of the points in the sample. There are 49 observations of 1969 annual sales of four pipelines to companies in the chemicals industry and the electricity generating industry. The prices are $P_2^*(28)$ for chemicals and $P_2^*(49)$ for electricity generating, the marginal costs are $\partial C(28)/\partial q_2$ and $\partial C(49)/\partial q_2$ for transporting along any one of the four pipelines. With the relationship fitted in the regression form[1]

$$P_2^*(28) - P_2^*(49) = \Delta P_2 = (a-1)P_2^*(49) + b[\partial C(28)/\partial q_2 - \partial C(49)/\partial q_2] + d$$

the first comparative equation for price is

$$\Delta P_2 = \underset{(0.086)}{-0.633}\, P_2(49) + \underset{(0.662)}{2.231}[\partial C(28)/\partial q_2 - \partial C(49)/\partial q_2] + 276.7; \quad (16)$$
$$R^2 = .608$$

and the implied elasticity of demand of buyers in chemicals from a single pipeline is $b = 1/(1+e_1)$ or $e_1 = -1.83$. The second comparative price equation is [for $P_2(29)$, petroleum refining, against $P_2(32)$ stone-clay-glass]

$$\Delta P_2 = \underset{(0.026)}{-0.957}\, P_2^*(32) + \underset{(0.149)}{2.071}[\partial C(29)/\partial q_2 - \partial C(32)/\partial q_2] + 273.755$$

$$R^2 = .993 \quad (17)$$

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1 The constant term accounts for pipeline-to-pipeline differences in transport costs, providing a rough net difference due to depreciation expenses in the different transporters.

and the elasticity of demand $b = 1/(1+e_2)$ for e_2 in petroleum equals -1.93.

The third comparative price equation is as follows, for 39 observations of contracts with stone-clay-glass manufacturers (32) and the electricity generating companies (49):

$$\Delta P_2 = \underset{(0.175)}{-0.784}\, P_2^*(49) + \underset{(0.881)}{2.303}[\partial C(32)/\partial q_2 - \partial C(49)/\partial q_2] + 305.638$$

$$R^2 = .359 \tag{18}$$

with the elasticity of demand equal to $b = 1/(1+ 1/e_1) = -1.76$. All three equations suggest that $n \leq 1$, or that the elasticity of demand for the purposes of individual pipeline price setting is the same as the industry-wide demand elasticity. There would seem to be no price-reducing effect from the presence of a second (and perhaps third) pipeline on the supply side of most individual gas purchase markets.

The price setting practices in retail utility gas markets seem quite different from those in industrial markets. The pipelines have long set two-part prices on contracts with retail utility companies, under the jurisdiction of the Federal Power Commission. The marginal price or "commodity charge" has not been set at a level in keeping with the residential market elasticities of demand, but as if marginal prices were being used to add to marginal consumption

while the initial or demand charges determined the bulk of the profits. This can be seen from using a sample of 26 paired residential sales for 1969 to fit the regression[1] $\Delta P = b(\partial C/\partial q_{1a} - \partial C/\partial q_{1b})$ for sales at locations a and b. First, $\Delta P = +0.869(\partial C/\partial q_{1a} - \partial C/\partial q_{1b})$; $R^2 = .312$ and given that $b = 1/(1 + 1/e_1)$, the implied elasticity of demand e_1 is undefined. This would seem to suggest that prices are in the inelastic range of the demand function. However, this would not seem to be the case for the combined initial and marginal prices together. To the contrary, a second regression was fitted as follows: $\Delta AR = +2.451(\partial C/\partial q_1 - \partial C/\partial q_2)$; $R^2 = .317$ for AR equal to the average revenue from demand and commodity charges, and the elasticity implied by the fitted value of b is -1.70. The two regressions indicate commodity prices in the inelastic range of the market demand function, but the average of demand and commodity prices comes close to the equivalent "best profit" single charge if market demand elasticity were close to -1.70. This is not unlikely; the value of -1.70 is within the range of elasticities observed for retail gas utility markets in 1969.

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[1] Here $P_1 - P_2 = \Delta P = (a-1)P_2 + b(\partial C/\partial q_1 - \partial C/\partial q_2) + d$, with a=1, d=0 because the samples q_1, q_2 both have the same price elasticity and are carried on the same (or almost identical) pipelines.

The contrast between industrial and retail gas utility pricing by the pipelines is fairly evident, even if based only on first round evidence. The prices for industries seem to be set with regard to market (rather than individual) demand elasticities. This is to suggest that the number of pipelines at any industrial consumption location does not make a difference for the level of prices there. Two-part tariffs seem to be set for retail utilities, so that the marginal retailer's price more closely approaches marginal costs than do industrial prices approximate marginal costs on those sales. This is important for the analysis of regulation, since it leads to two conditions: (1) the industrial elasticities contained in a,b in the relative price equations are within the range -2.0 to -3.5; (2) the retail gas utility market elasticities should be between -1.0 and -2.0, but two-part pricing makes these elasticities for individual pipeline <u>marginal pricing</u> effectively equal to zero.

3. <u>The Testing of Regulated Against Unregulated Prices</u>

The expectation is that profit or rate-of-return regulation increases the prices of regulated sales relative to unregulated sales. The more stringent the regulation -- the closer gross

revenues come to costs, or the closer the allowed rate of return on capital comes to the marginal costs of capital -- the more apparent the relative price difference should be.[1] The place to look for these effects is in the coefficients a,b in $P_1 = aP_2 + b(\partial C/\partial q_1 - \partial C/\partial q_2)$, since $a = f[1/(1+\lambda)]$, $b = f[(1+\alpha\lambda)/(1+\lambda)]$ and λ ranges from zero without regulation to -1 with the rate of return set exactly at the marginal cost of capital. Now that other factors in a,b have been assessed and presumably quantified, this approach to finding the regulated price effects can be undertaken.

The full sample of contracts of five pipelines with industrial and retail utility buyers can be used to fit a regression of regulated marginal price P_1 on unregulated unit price P_2^*, the difference in costs of transport $(\partial C/\partial q_1 - \partial C/\partial q_2)$, and a constant. In this least squares equation

$$P_1 = aP_2^* + b(\partial C/\partial q_1 - \partial C/\partial q_2) + d_1L_1 + d_2L_2 + d_3L_3 + d_4L_4 .$$

The constant term is a series of dummy variables, $L_1,\ldots,L_4$ for four of the five pipelines (to account for the effects of

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[1] Cf. W. Baumol and A.K. Klevorick, op. cit.

differing field gas purchase prices on the absolute levels of resale regulated prices).[1] The observations have been paired randomly to make up a sample of 137 and the least squares regression from this sample is:[2]

$$P_1 = .730P_2^* + 1.296(\partial C/\partial q_1 - \partial C/\partial q_2) + 8.923L_1 - 62.551L_2 - 18.703L_3 + 84.632L_4 \ . \quad (19)$$

The price relationship would seem to show lower prices on regulated sales, and higher prices on sales with greater transport costs. There are indications that this is a superficial view of the pattern, however. The coefficient a is perhaps too large: if $a = \frac{1}{(1+\lambda)}\left[\frac{1+ 1/e_2}{1+ 1/e_1}\right]$ and $e_2 = -2.0$, e_1 undefined (for reasons given above), then $\lambda = -.31$, and F.P.C. rate of return controls have succeeded in somewhat increasing relative prices on regulated

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[1] The logic of this can be seen from separating pipeline costs into (a) field purchase price, and (b) transmission costs, and then deriving first order conditions for maximum profit resale prices. The field purchase price enters as a constant in the expression for P_1. This constant will differ for each pipeline.

[2] This regression was fitted with P_2^* as the dependent variable, as follows:

$$P_2^* = \underset{(0.060)}{1.372}P_1 - \underset{(0.360)}{1.778}(\partial C/\partial q_1 - \partial C/\partial q_2) - \underset{(19.560)}{12.324}L_1 + \underset{(17.587)}{85.725}L_2 + \underset{(19.493)}{25.669}L_3 - \underset{(27.745)}{116.116}L_4; \qquad R^2 = .109$$

The reason for the reversal of variables was that more serious errors in data were expected to occur on unregulated sales, and these could better be relegated to the dependent variable.

sales. On the other hand, if $e_2 = -3.5$ and $e_1 = 0$, then $\lambda = -.02$ and the effects from regulation are negligible. Within the range of "reasonable market demand conditions", the residual effects from regulation are negligibly to moderately price increasing.

The process of regulatory control here might be viewed as taking place in two steps. First, the price setting procedure under regulation involves two-part tariffs, which increase initial charges from zero to some higher amount while reducing marginal charges. The reduced marginal prices appear to be lower than comparable unit prices on unregulated sales. Second, the rate-of-return review procedure raises the marginal regulated price <u>above</u> the level that that marginal price would have without regulation but with two-part tariffs. The second step alone can be said to involve a relative regulated price increase, reducing regulated sales.

The other parts of the equation are revealing of the price-setting process, and perhaps of the effects of profit regulation, as well. The coefficient b for $(\partial C/\partial q_1 - \partial C/\partial q_2)$ appears to be quite large -- there seems to be much more price variation with distance than called for by "costs of transport" differences. This could be entirely a matter of appearance, caused by under-

estimation of $\partial C/\partial q_1$ and $\partial C/\partial q_2$. Another explanation could be that the value of α, the portion of costs allocated to regulated sales, is very high, since $b = [(1+\alpha\lambda)/(1+\lambda)] \cdot [1/(1+ 1/e_1)]$ and, with $e_1 = 0$ and λ estimated from a, the values of α in keeping with b are close to .8. This is to suggest that 80 percent of costs are allocated to regulated sales -- a percentage that is not inconceivable, but somewhat removed from present practice. The third explanation comes from closer examination of the data: it appears that sales at the "farther distance" are predominantly sales to retail public utilities, and the relatively higher prices on these sales, resulting from regulation, are confounded with the "distance" effect. This explanation of b, which seems most likely, is an indirect test of "Atlantic Seaboard" and "rate of return" effects from regulation, since coefficients to test these effects are confounded with b.[1] If "Atlantic Seaboard" prevailed

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[1] These variables, P_2^*, $\partial C/\partial q$. L, confound attempts to measure the effects of more complicated regulatory procedures, such as "Atlantic Seaboard" cost allocation or "direct rate-of-return" (as in equations (9) and (10)). Further work will have to be done to deal with complicated cost allocation and rate of return regulation directly, because the relevant variables when specified turn out to be collinear with the transport cost variables used here to find b. At this point, there is no evidence of leveling of prices with respect to costs, as expected from "Atlantic Seaboard" allocation; indeed, the last paragraph was to the contrary. It is not likely that,as the case decisions indicate, the Formula is not consistently honored in the costing and pricing decisions of the large pipelines.

the coefficient of b should be "too low", but if "rate of return" regulation with arbitrary α allocation prevailed, then the b coefficient should be "too high". In fact, it is too high, so that none of the regulatory constraint effects from regulation are shown.

There are a few further tests possible with the remaining coefficients. The different pipelines have entirely different price levels for home sales, perhaps because of different degrees of regulation applied by the F.P.C. but more likely because of historical chance in the purchase of field supplies of gas at lower or higher prices than paid by other pipelines.

The effects on retail consumers versus particular regulated industries are similar to those shown by the pooled industry-retail sample. But the differences all tend to show less effects from regulation. For unregulated prices to buyers in the chemicals and stone-clay-glass industries, versus regulated prices, the regression equations were as follows:

Chemicals, N = 38

$$P_2^* = \underset{(0.065)}{1.576}P_1 - \underset{(0.454)}{1.714}(\partial C/\partial q_1 - \partial C/\partial q_2) - \underset{(20.440)}{45.493}L_1 + \underset{(18.387)}{50.294}L_2 \tag{20}$$

$$- \underset{(23.777)}{7.476}L_3; \qquad R^2 = .687$$

Stone-Clay-Glass, N = 35

$$P_2^* = \underset{(0.082)}{1.459P_1} - \underset{(0.513)}{1.828}(\partial C/\partial q_1 - \partial C/\partial q_2) - \underset{(26.664)}{46.388L_1} + \underset{(24.545)}{56.086\,L_2} \tag{21}$$

$$+ \underset{(31.383)}{1.382L_3}; \qquad R^2 = .644$$

which imply values of λ somewhat lower than those derived from the all industries-all retail regression: here $\lambda \sim -.2$ for $e_2 = -2.0$, and $\lambda \sim 0$ for $e_2 = -3.5$. The equations for primary buyers in the electricity and metals industries versus retail utility buyers are similar to that from the pooled data. They are as follows:

Electricity N = 27

$$P_2^* = \underset{(0.092)}{1.015P_1} - \underset{(0.547)}{0.493}(\partial C/\partial q_1 - \partial C/\partial q_2) + \underset{(30.034)}{13.865L_1} + \underset{(24.948)}{149.650L_2} \tag{22}$$

$$+ \underset{(25.368)}{31.237L_3}; \qquad R^2 = .841$$

Primary Metals, N = 37

$$P_2^* = \underset{(0.045)}{0.858P_1} - \underset{(0.886)}{0.432}(\partial C/\partial q_1 - \partial C/\partial q_2) + \underset{(27.985)}{147.609L_1} + \underset{(31.974)}{215.586L_2} \tag{23}$$

$$+ \underset{(29.999)}{215.448L_3}; \qquad R^2 = -.307 \quad .$$

These two regressions show slight effects from regulation, as slight as the all-industries regressions, even though the values of the a coefficients are lower. This occurs because the calculated elasticities in these industries are less ($e_2 < -1$).

The coefficients for P_1 imply values of λ close to -.30, and any great differences would be difficult to take seriously.[1]

The basic question -- whether regulation raises relative prices, or whether the effects of λ constraints can be observed -- cannot be dealt with unless the influence of the two-part tariff is separated from the effects of rate-of-return controls. This is necessary because there may be a number of reasons for two-part tariffs on sales to retail utilities. They are in keeping with state regulatory requirements on the buyers' resale prices. It is conceivable that they serve as an institution to provide "peak-load" insurance at the cheapest rate. To make the two-part tariff an effect from F.P.C. regulation alone confuses the assessment of that Commission's activities.

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[1] There is no reason for regulation to appear to be more stringent from one sample regression to another, given that the only differences between samples are in the unregulated industries with which comparisons of regulated prices are being made. Rather, the rationale might be that, in particular industry regressions, we are observing price variations having to do with particular competitive conditions in these samples of unregulated sales -- conditions not directly incorporated in measures of elasticity of demand. This rationale takes away credit given to "regulation" that is due to "competition" in the unregulated markets.

Separation is not possible, because prices are prices, and the two-part tariffs that are there cannot be eliminated. Only the crudest of indications can be formulated of the effects of rate-of-return regulation alone. This indication follows from comparing average revenue P_1^*, the average of initial and commodity charges weighted by volumes delivered, with the unregulated unit price P_2^*; this "price" P_1^* could be considered the "equivalent" one-part tariff given that the F.P.C. set rates of return on capital so that the same profits were made as are now collected under the two-part tariffs. The equation $P_1^* = aP_2^* + b(\partial C/\partial q_1 - \partial C/\partial q_2) + d$ might show the price-increasing effects from regulation in the a,b coefficients.

This equation has been fitted to the 137 observation sample of pooled industrial-retail utility sales in 1969. The regression is as follows:

$$P_1^* = .900P_2^* + 1.558(\partial C/\partial q_1 - \partial C/\partial q_2) + 35.585L_1 - 65.513L_2 + 32.955L_3 + 40.261L_4$$

indicating higher relative prices for regulated sales than shown in the marginal price comparisons above.[1] But this is deceiving,

[1] The fitted equation was

$$P_2^* = \underset{(0.034)}{1.110P_1^*} - \underset{(0.265)}{1.773}(\partial C/\partial q_1 - \partial C/\partial q_2) - \underset{(0.265)}{39.509L_1} - \underset{(14.572)}{39.509L_2} + \underset{(12.830)}{70.723L_3} - \underset{(15.326)}{36.583L_4}; \qquad R^2 = .519$$

because the implied values of λ have to be much closer to zero in this case given that the assumed elasticity e_1 -- without a two-part tariff -- lies in the range from -1.0 to -2.0. In fact, the estimated values of λ are positive, ranging from .60 for $e_2 = -3.5$, $e_1 = -2.0$ to 7.8 for $e_2 = -2.0$, $e_1 = -1.1$ so that the measurable effects from rate regulation alone are perverse. To be more specific, these effects are contrary to expectations from the theory of the constrained firm, since there are relative price reductions on sales to retail public utilities.

There are of course other alternatives than setting the calculated P_1^* for the pipelines to consider, if ever faced with the necessity of charging unit prices. There is little chance that, given a regulatory profit constraint, they would charge the price exactly equal to the average revenues from the two-part tariffs. This price would be too low -- it now occurs at elasticities too close to -1.0 to be profit-maximizing -- so that there would be more regulatory price increasing effect than is shown here. All that can be said with these findings on P_1^*, P_2^* is that the effects from <u>profit regulation alone</u> are most likely negligible, and perhaps even perverse.

These views have to be brought together with those in the P_1, P_2^* equations, and on the earlier price equations on industrial sales free of the effects of regulation. The assessments of P_1^*, P_2^* alone are quite tentative, since it is not possible to define precisely what is being measured by "price" in the average revenue equations. They do not contradict earlier assessments, however. Overall, the effects of regulation are found in calculated values of λ in the range from 0.0 to -0.3 which is rather low but implies that there has been creation of price disparities by regulation. In economic terms, there has been a tendency towards higher relative prices under regulation, but not a strong tendency. Prices charged by pipelines on regulated retail utility sales and on unregulated industrial sales tend to vary with costs of transport, with elasticities of demand, and with the field purchase prices of gas transported by the different pipelines. Prices at the margin on regulated sales are lower when there are two-part tariffs; but after accounting for the effect of the two-part tariff, charges for regulated sales are greater than on unregulated sales. That is, after these _strong_ tendencies for prices to vary with costs, with demand elasticities and with tariff structure, prices seem to be only _somewhat higher_ on regulated

sales and as expected from the theory of the firm subject to the λ regulatory constraint.