Potential Effects of State Regulatory Agencies on the Post-Decontrol Natural Gas Market

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I. Introduction

Prices for most categories of natural gas are currently scheduled for deregulation under the Natural Gas Policy Act (NGPA) between 1985 and 1987. Approximately 60 percent of all gas will be deregulated in 1985 under the current plan, and the share of gas that is regulated will steadily diminish. Even if gas is not decontrolled prior to 1985 through explicit Congressional action, therefore, gas prices are likely to be deregulated sometime this decade unless controls are extended. Given the support of the Reagan Administration for more rapid decontrol plans to replace NGPA, it is not likely that recontrol plans will be passed.

In spite of the high probability of decontrol, there has been surprisingly little investigation into the possible structure of the natural gas market in the absence of federal price controls. In nearly all studies of natural gas deregulation, the current NGPA scenario is compared to a "free market" case.[1/] The assumption invariably used is that the elimination of price controls embodied in NGPA will result in a market structure that is relatively free (with the exception of severance taxes) from interference by policymakers.

This assumption may be very inaccurate. Given that deliverable supplies currently exceed demand, the situation may be more reminiscent of the oil market prior to 1972 -- a period in which production curtailments by the Texas Railroad Commission effectively established the price of crude oil for the U.S. Over 80 percent of marketed production of gas and 63 percent of domestic proven reserves are located in Louisiana, Texas, Oklahoma, and New Mexico. Texas, in particular, had 25.6 percent of total proven domestic reserves of natural gas at the end of 1981.[2/] The potential exists, therefore, for similar market interference from state regulatory agencies which, rather than competition alone, would set the price of gas in the market.

The probability of such interference is fairly high. If decontrol results in any perceived inequities between gas producers (for example, integrated pipeline companies only buying from producers owned by the same parent company), there will be calls from those denied access to markets via pipelines for renewed prorationing by the state. The Oklahoma Corporation Commission (OCC), it should be noted, exercised its prorationing power in 1983 to compensate for a major surplus of deliverable gas in the state.

If a state chooses to use prorationing, ostensibly to ensure the access of all gas producers to markets (at least all those that can profitably produce at the market price), the goals of the regulatory body become very important. Although agencies, such as the TRC or OCC, cannot by law set prices, any decision to prorate at less than 100 percent of the allowable level results in higher than "free market" prices.

The purpose of this paper is to explore the consequences of a set of alternative goals that a state regulatory agency might pursue in setting a prorationing strategy. The results indicate that assumptions about the objectives of the agency have important effects on the ultimate depletion path of natural gas and on the distribution and level of profits across states. The results also indicate that the ability of gas producing states to coordinate policies directly affects the magnitude of prices, production, and profits.

The rationale behind state regulation of production is presented briefly in Section II. A general analytical model of the optimal depletion policies facing a regulatory body under alternative sets of objectives is then developed in Section III. After deriving the optimal policies for a single state agency, the gains from pursuing a coordinated strategy to producing states (as well as the forces working against its stability) are explored in Section IV. Finally, the implications of the results are briefly discussed in Section V.

II. The Rationale for State Control of Exhaustible Resource Depletion

State governments have been endowed with the right to control the depletion rates of exhaustible resources located within their borders. In the case of oil and natural gas, several reasons are generally cited in support of this authority. Two reasons in particular are used to defend the need for state regulation: conservation and the protection of property rights, and the stabilization of markets.

The need for conservation in the case of oil and gas can be seen in the development of the authority of the Texas Railroad Commission (TRC).[3/] Oil and gas are often found in reservoirs that have many leases associated with the formation. Furthermore, the oil or gas flows freely across lease boundaries in reaction to changes in pressure throughout the field. Because it is not possible to assign property rights to the various leaseholders for a resource that is continuously shifting its position relative to the surface, the problem can be considered an example of the "problem of the commons" (Hardin 1968). As long as production quotas are based on the "rule of capture," each owner has the incentive to produce as rapidly as possible in order to obtain a larger share of the possible production. As a result, the depletion of the reservoir occurs inefficiently.

Two major sources of inefficiency created by rapid depletion can be identified. First, oil and gas are most easily brought to the surface through the use of the natural pressure within the reservoir, often caused by either natural gas or water. If the reserve is depleted too rapidly, the geological formation breaks down prematurely, leading to a reduction in the potential recovery of oil or gas from a given reserve. Second, the incentive to produce as rapidly as possible leads to excessive drilling of wells as producers attempt to beat their competitors to produce oil or gas. As a result, costs of production are higher than they would be with optimal drilling activity.

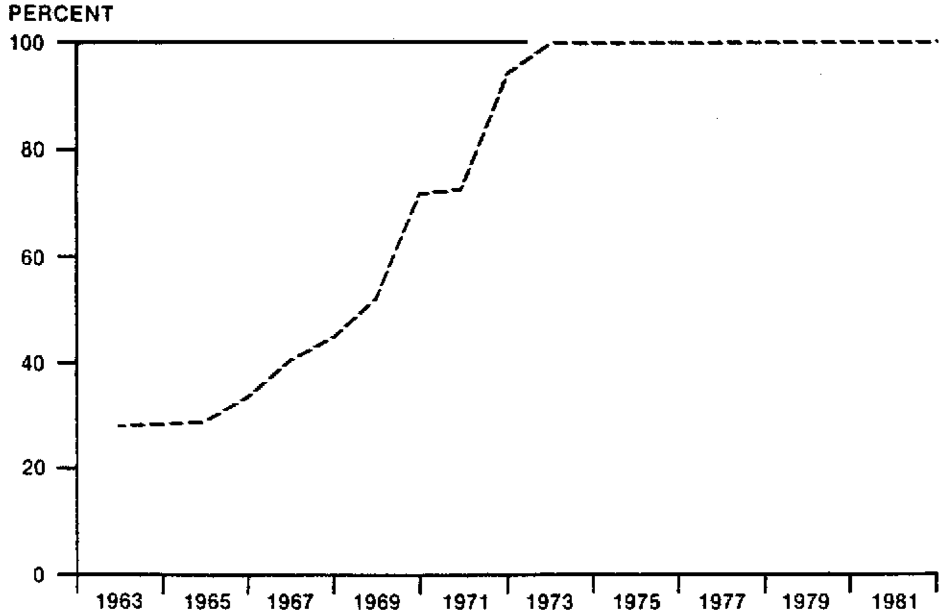
These symptoms of the "problem of the commons" were demonstrated in 1930.[4/] The discovery of a major reservoir in East Texas coupled with the lack of a strong regulatory body led to excessive drilling and production. Between October 1930 and the end of 1933, over 12,000 wells were drilled in the East Texas field. Prices for East Texas crude, which had been $1.10/barrel in 1930, dropped to as low as $0.10 by the end of 1931. To stabilize production and prices, the Governor sent troops to occupy the field. In response to this action, the TRC was granted the authority to proration wells in each field and to determine the minimum spacing required between wells to control excessive drilling.

The conservation function of the state regulatory body is currently accomplished in Texas by the establishment of the "maximum allowable" production for each well. This maximum allowable is determined by geologists as the maximum rate of extraction that could be conducted without breaking down the formation prematurely. Production from all wells for the field are then restricted by that level, so all owners are given equal rights and limitations on extraction.

In addition to preventing waste and protecting the rights of owners, however, regulation has been used to "stabilize disorderly markets." In the 1930's, the TRC, to protect the owners from cutthroat competition, instituted "prorationing." Prorationing, along with well spacing rules (which limit the number of wells that can be drilled on a given lease), limits production from a particular field by setting the maximum production as a percentage of the maximum allowable. In doing so, the state intervenes in the market to limit the supply of oil or gas available for sale.

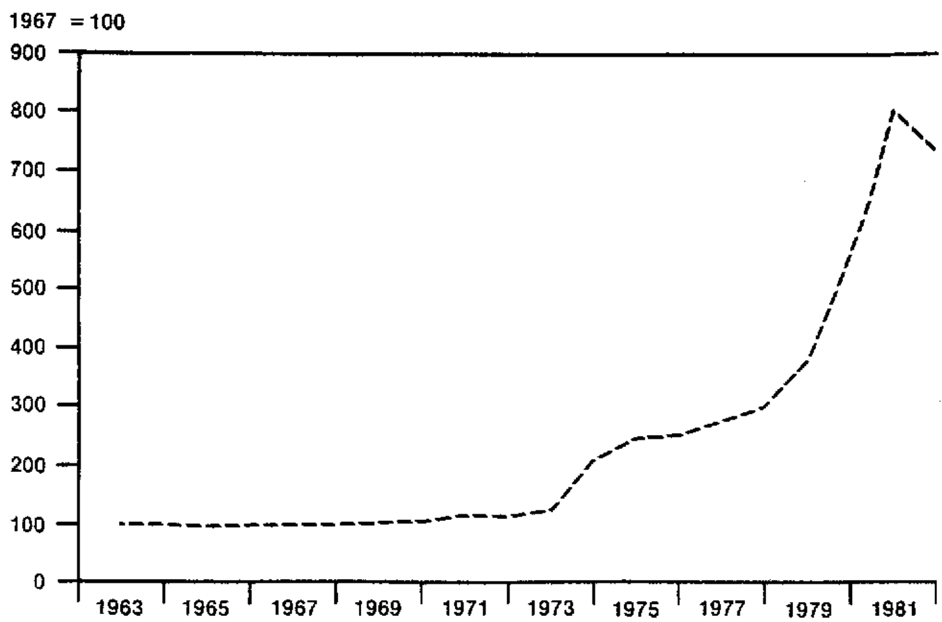
It is this latter motivation for the imposition of state regulations that is the most controversial. Although states are not allowed to set prices by law, the process of prorationing can result in <u>de facto</u> price regulation. As shown in Charts 1 and 2, oil prices remained virtually constant as long as the TRC maintained prorationing at less than 100

CHART 1
THE PERCENT OF THE MAXIMUM EFFICIENT RATE OF PRODUCTION
ALLOWED BY THE TEXAS RAILROAD COMMISSION



SOURCE: Texas Railroad Commission.

CHART 2
CRUDE OIL PRICE INDEX



SOURCE: Citibank Economic Data Base.

percent. It is not a coincidence that OPEC was able to double prices in the year that the TRC began setting allowables at 100 percent.

Natural gas prorationing at less than 100 percent of the maximum allowable is quite possible subsequent to price decontrol. As mentioned earlier, arguments can be raised that many producers, especially independents, may not be guaranteed access to markets unless pipeline companies are forced to take gas from all fields. In order to accomplish this, it may be necessary to use prorationing. Furthermore, from the perspective of both owners and state tax revenues, there are incentives to use the power of prorationing to maximize the value of the gas reserves. From the perspective of end-users, on the other hand, the goal of the state may be defined differently to be that of cost minimizers, or price stabilizers. As shown in the next section, each of these objectives implies very different policies toward the use of prorationing.

III. Optimal Prorationing Policies for a State Regulatory Agency

In order to characterize the optimal prorationing policies of an agency operating in the interests of a state agency, it is first necessary to specify the goals of that agency (i.e., its objective functional). Several objectives could be considered plausible in the case of natural gas depletion. For the purpose of this analysis, only three objectives will be considered.[5/] First, the goal of maximizing the present value of rents from the reserve will be used. In addition to representing the objective of a state interested in the well-being of its natural gas industry, it is equivalent to the goal of maximizing the present value of natural gas production taxes in the case of a state that assesses taxes on the basis of the sale price at the wellhead.

Second, the objective of maximizing the present value of consumer's surplus is examined. The objective reflects a desire on the part of the state to look after the needs of its consumers, as well as a desire on its part to prevent the imposition of federal regulations by gas importing states.

Third, the implications of maintaining a fixed price is explored. This procedure would be consistent with the policy followed by the TRC in the case of oil for the period prior to 1973. Depletion paths aimed at avoiding price fluctuations are often considered by legislative leaders.

The problem of determining an optimal depletion path for an exhaustible resource like natural gas has been studied extensively in the literature. Variants of Hotelling's (1931) seminal treatment have proliferated since the early 1970's, with major contributions by Dasgupta and Heal (1974), Stiglitz (1974), and others. The case of imperfect competition in oil markets (especially related to the theory of cartels with a competitive fringe) has been studied extensively by Pindyck (1978a,1978b), and provides a useful point of departure for the current analysis.

Assuming that the reserve stock is known with certainty, the general problem can be modeled as the following system:

(1) $$\underset{q}{\text{Maximize}}\int_0^T e^{-rt}(U(q(t)+q_a(P,t))dt$$

subject to: (2) $\dot{R}(t) = - q(t)$

and (3) $\int_0^T q(t)dt \leq R(0)$

where $U(\cdot)$ = the objective functional for the decisionmaker,

q = the current production of the resource by the state,

q_a = the production of the resource by producers outside of the state which is a function of the output price,

r = the discount rate,

R = proven, extractable reserves in the state, and

P = the output price of the resource.

In order to simplify the problem, two additional restrictions are placed on the problem. First, extraction costs are assumed to be zero. Although marginal extraction costs could be embedded into the problem, their inclusion would only complicate the solution without changing the substance of the argument. Second, oil and gas are assumed to be imperfect substitutes, and the price of oil is assumed to be exogenous. As a result, it is possible to determine a downward sloping demand for natural gas without explicit consideration of the oil market. Although this assumption of no feedback from natural gas prices to oil prices is rather strong, OPEC's pricing behavior in the past has evidenced relatively little oil price responsiveness to changes in natural gas prices.

The objective functional, $U(\cdot)$, can be defined for the three experiments listed above in the following forms:

(4) $U(\cdot) = P(q(t)+q_a(t))\ q(t)$,

(5) $U(\cdot) = \int_0^{q^*} D(q)dq$, and

(6) $\dot{P} = c$

where D(q) is the demand for the output, q* is the output at time t, and c is a constant. Equation 4 corresponds to that of a profit maximizing cartel with a competitive fringe. Equation 5 relies on aggregate consumer surplus from consumption of the resource as a welfare measure. The final form used in equation 6 establishes a price rule that allows a constant price increase over time. (Note that if c = r, that the latter rule is Hotelling's "r-percent" rule and is equivalent to the solution to 5).

Case 1: The Profit Maximizer Objective

Using the form of $U(\cdot)$ given in equation 4, it is possible to solve for the optimal depletion path facing a profit maximizer. Defining $P^*(q(t))$ as the demand curve for the state's production (total demand net of production by the competitive fringe), the current value Hamiltonian can be written:

(7) $H = e^{-rt}[P^*(q(t))\ q(t)] - \lambda(t)q(t)$.

Setting the derivative of 7 with respect to q equal to zero yields the equation:

(8) $e^{-rt}MR(t) = \lambda(t)$,

where $MR(t)=[(dP^*/dq)q(t) + P^*]$. Because the derivative of 7 with respect to the state variable, R, is equal to zero, $\dot{\lambda}$ is equal to zero. Therefore, differentiating 8 with respect to time yields the optimal path for prices in this case:

(9) $\dot{MR}/MR = r$.

Assuming that tax revenues are a constant share of revenues received by producers, it is easily shown that 9 is an optimal path for a government attempting to maximize the present value of its tax revenues.[6/]

Case 2: Maximizing Consumer Surplus

By using the social welfare function defined above by 5, the optimal price path is equivalent to Hotelling's rule for a competitive economy. Because the derivative of the social welfare function with respect to q is equal to the price, P, the optimal rule for this case can be shown to be:

(10) $\dot{P}/P = r$,

which is Hotelling's rule.

Case 3: Constant Price

To present the extreme case, let c=0 in equation 6 (i.e., the state chooses to peg prices at a constant level). The optimal price path, by assumption, is given by:

(11) $\dot{P}/P = 0$.

Comparison of the "Optimal" Paths

The optimal quantity trajectories implied by the price paths in 9, 10 and 11 are quite different. Note that although the optimal policies are stated in terms of prices, the instrument used by the regulatory body is a trajectory of quantity restrictions over time that satisfies the desired price path. In order to determine the optimal quantity path, as well as the initial price, it is necessary to use the resource constraint equation in 3.

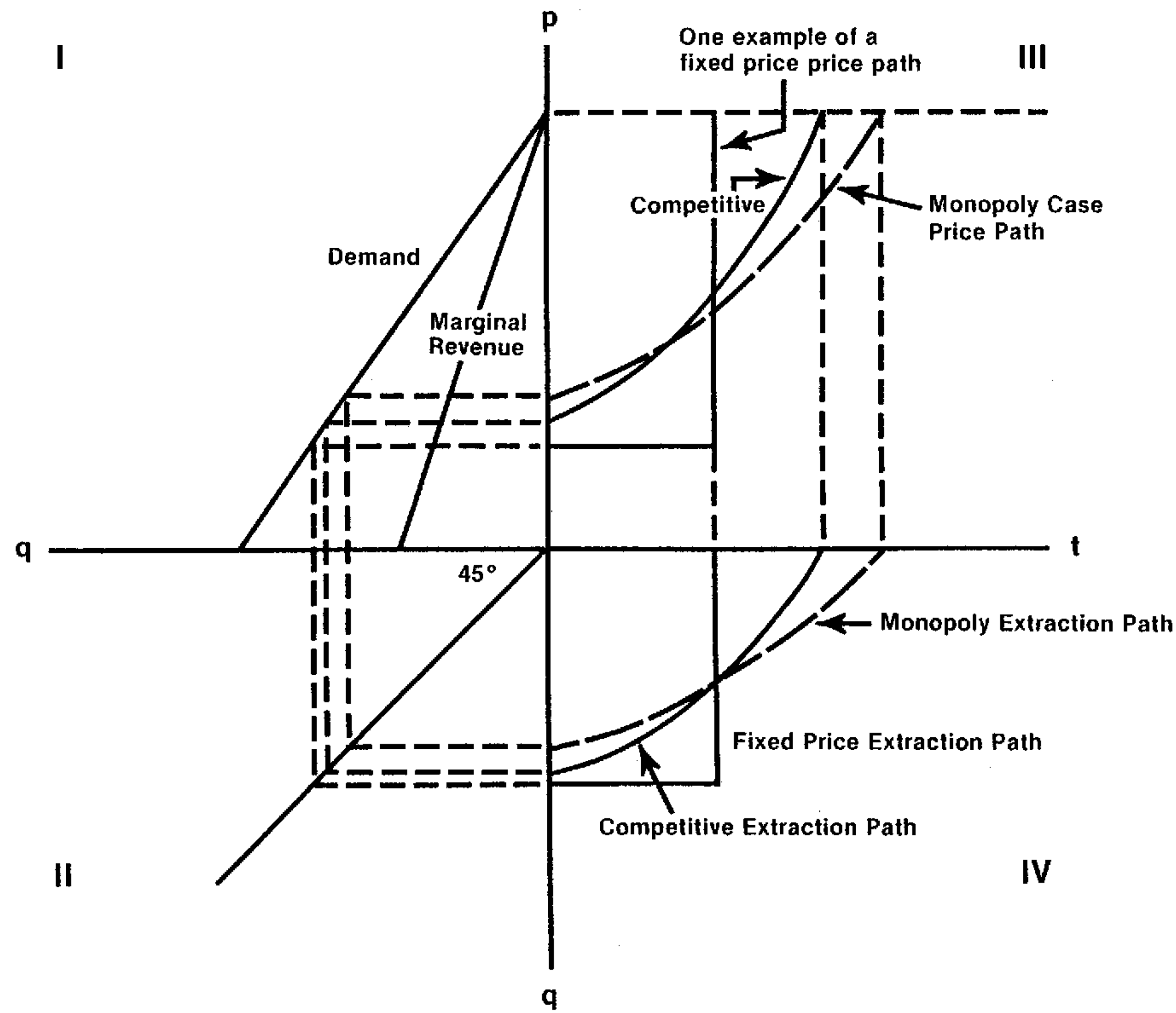
The three alternative policies are compared in Chart 3. The first quadrant maps the price paths over time, with the net demand curve displayed in the second quadrant. The third quadrant maps production from the price/quantity dimension to the quantity/time dimension shown in quadrant IV. This last quadrant maps the aggregate production path over time for each specified price path.

The optimal price and quantity paths shown in the chart are determined using two equations. First, the slope of the price path is determined from the optimal path derived above in 9, 10, and 11, respectively. Second, the endpoints (initial and final prices) are fixed using the optimal path and the resource constraint. This constraint is represented graphically by the area bounded by the function in quadrant IV and the axes, and represents cumulative use over time.

Given the price paths, endpoints are established by choosing an initial price path (at t=0), applying the Euler equation, and comparing the total stock used conditional on that starting point to the total stock available. If the aggregate use over time exceeds (is less than) the total stock, the starting price is raised (lowered) so that the use in all periods is decreased (increased). This procedure is followed until the starting price and the Euler equation exactly exhaust the resource stock.

A comparison between the first two cases reveals the usual difference between depletion paths of a competitor and a monopolist: Because the price path for a monopolist is slower (assuming that the time derivative of the slope of the demand curve is greater than or equal to zero), the initial price must be higher (implying a greater reduction in production),

CHART 3
COMPARISON OF THREE DEPLETION STRATEGIES



but the price increase is slower and results in greater production in later periods.[7/]

The last case, however, cannot be uniquely determined. Because that case is not based on a present value calculation, there is no criterion with which to rank the various price paths. If it is assumed that the policy should be established such that the maximum value (in undiscounted terms) should be extracted, or equivalently in this case, that the production should be shared by all future generations, then the price should be set at the maximum price at which there is still some demand. In that case, an infinitely small production level would be regulated forever.

On the other hand, if the goal were to maximize production in the short run, the state could set prices (again net of extraction costs) close to zero. Production would then occur at the maximum level for which there was sufficient demand until the resource was completely depleted, after which zero production would occur. In this case, producers would have every incentive to produce as quickly as possible because the present value of reserves in the ground would be declining over time. This latter rule could be optimal for a state government if it desired to maximize the present value of tax revenues from the resource and used a fixed tax on each unit (as opposed to the unit's value).

IV. Gains to Collective Prorationing

In the first case examined above, the revenue maximization case implied that gains could be obtained from using the monopoly power that the state possessed through control of a significant share of total production. In this section, the benefits from expanding that power through the coordination of prorationing by regulatory bodies in the major producing states are examined.

The gains to coordinating policies (i.e., basing decisions about prorationing levels in a collective agreement) can be seen by expanding equation 4 to include other producing states explicitly. Redefine $U(\cdot)$ by:

$$(12) \quad U(q(t)) = P(q(t)+q_a(t)+q_b(t))q(t),$$

where q_a is the production by a producer outside of the "cartel" and q_b is the production from another state that chooses to coordinate prorationing policies. The optimal price path equation that would result from this formulation of the objective functional is unchanged from that in 9, but the path itself would be shifted. The optimal price path still satisfies the condition that marginal revenue grows at the rate of discount, but the marginal revenue function is changed.

To see this, marginal revenue corresponding to 12 can be written:

$$(13) \quad MR(t) = P + q(t)[(\partial P/\partial q) + (\partial P/\partial q_a)(\partial q_a/\partial q) + (\partial P/\partial q_b)(\partial q_b/\partial q)].$$

In the previous section, it was assumed that $\partial q_a/\partial q$ and $\partial q_b/\partial q$ were equal to zero, implying that there would be no output response of other producers to a change in the state's production level except in response to changes in price. In this case, while $\partial q_a/\partial q$ is still assumed to be zero (except insofar as prices change), $\partial q_b/\partial q$ is assumed to be positive: a reduction in the other member's production would be accompanied by a reduction in the production of b's output because of the assumed coordination of prorationing plans.

Given positive $\partial q_b/\partial q$, the slope of the marginal revenue function is greater than before. Because the joint decisions increase the market power of the joint regulators, monopoly profit potential is increased. As a result, the ability of producing states to coordinate prorationing policies would lead to a higher price (and therefore greater supply restriction) initially, followed by a slower growth rate in prices than that experienced in the cases described in Section III.

The forces working against cartelization, however, can also be seen in equation 13. Increases in market power are obtained through the assumption that a reduction in q will be matched at least partially by a reduction in q_b. This feature of the solution implies that some of the decisionmaking power of the regulators is lost. Furthermore, if one producing state can renege on its agreement without the others retaliating, that state stands to benefit even more: as long as other states restrict supply to some degree, states that do not restrict production benefit from the price effect without sacrificing output.

V. Implications

The results of the simple model presented above cast some doubt on the degree to which the natural gas market can be expected to be free from regulations after price deregulation. As shown in Section III, only if regulators adopt an objective functional that maximizes consumer surplus is the optimal production path allowed by the regulator equivalent to that generated by a free market. If the state is instead interested in either preventing prices from changing (or pegging them to a price outside of the natural gas market) or in maximizing revenues, the optimal policy for the state requires intervention to restrict production.

Indeed, from the perspective of maximizing tax revenues or promoting the health of its natural gas industry, regulatory agencies such as the TRC are encouraged to restrict production. To the extent that producer state agencies are able to collude in prorationing regulations, the ability of the agency to realize monopoly profits is increased.

Two considerations, however, affect the ability of the TRC or OCC to control the price of natural gas through quantity restrictions. First, the constitutionality of explicit prorationing collusion by producing states could be questioned. Even if such collusion were not found to be unconstitutional, there would be considerable pressure by non-producing states to eliminate the agreements, possibly by threatening to return to federal price regulations.

Second, although Texas and Oklahoma currently possess a large share of total proven reserves, the major new discoveries of natural gas are occurring in other states (such as California and Alaska) where the tradition of prorationing is less established. Therefore, while in the short run the TRC and OCC may be able to act as the cartel, further relative gains in productive capacity in other areas of the country may either dilute their market power, or yield a new cartel. As a result, the development of regulatory structures and mandates in these other states should be of increasing importance in the long run.

Footnotes

1. Examples of this implicit assumption can be found in most studies of the potential effect of natural gas deregulation. For examples, see U.S. Department of Energy (August 1981) and Muzzo (1982). Although studies often include continued regulation after 1985, they inevitably model continued price regulation at the federal level.

2. Source: World Oil, February 15, 1983, p. 144.

3. For an excellent analysis of the forces shaping the development of the Texas Railroad Commission and its subsequent actions toward oil and gas prorationing, see Prindle (1981).

4. See Chapter 2 of Prindle (1981) for a description of the events leading to these actions.

5. Other goals can also be considered. For example, Prindle (1981) details a conflict between the interests of independent and integrated producers. Concerns about future generations may also affect the characterization of the objective functional if the discount rate is deemed insufficient. Furthermore, the spillover effects of gas exploration and development on the environment may play a larger role under certain assumptions.

6. This equivalence holds as long as the tax rate is assessed on value and is invariant with respect to time. To demonstrate this, equation 7 can be altered to represent tax revenues by multiplying the term in brackets by T (the tax rate). Differentiating the new Hamiltonian with respect to q yields the same expression found in 8 multiplied by T. Because T is a constant, it drops out of equation 9, resulting in the same growth rule shown in 9.

7. This result was first established by Hotelling (1931). After rearranging terms, equation 9 can be written in the form:

$$\frac{\dot{p}}{p} = r + \frac{[r(dp/dq)q - (d\dot{p}/dq)q - (dp/dq)\dot{q}]}{p}$$

The relative speed of the competitive and monopoly price paths depend on the sign of the term in brackets. The first term is negative as long as the demand curve slopes downward. The final term is also negative as long as quantity supplied falls over time and the demand curve slopes downward. The middle term, however, could be positive or negative. As long as d(dp/dq)/dt is nonnegative (or outweighed by the other terms), monopoly prices increase at a slower rate than competitive prices. If the slope of the demand curve is stationary over time, this condition is satisfied.

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