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OPEC Behavior: A Test of Alternative Hypotheses

By JAMES M. GRIFFIN*

Just as the Great Depression characterized the 1930's, the Energy Crisis marked the 1970's. But what role will history ascribe to OPEC? Will it be considered a cartel, a loose confederation of producers who only ratified competitive prices, a group of producers seeking noneconomic goals, or whatever? While most students of energy economics label OPEC a cartel, increasingly this view has been challenged.[1] Recently, Paul MacAvoy (1982) has argued that the long-run trend of oil prices can be adequately explained by a competitive model. Proponents of the target revenue model (David Teece, 1982, and Jacques Cremer and D. Salehi-Isfahani, 1980) claim that rising oil prices and production cutbacks in the 1970's were not the result of collusive behavior, but rather each exporting country facing a backward-bending supply schedule, which results if exporting countries try to satisfy a target revenue for internal investment purposes. Walter Mead (1979) and A. D. Johany (1978) set forth a property rights explanation, arguing that the transfer of concession ownership from the international oil companies to the exporting countries in the 1970's lowered the effective discount rate leading to the observed price-output behavior. Finally, Theodore Moran (1982), a political scientist, rejects the conventional cartel interpretation in favor of an oil pricing model guided by Saudi Arabia utilizing its market power to maximize its security and influence rather than its wealth.

The standard practice to date has been to reach onto the shelf of economic models, to select one, to validate its choice by pointing to selected events not inconsistent with the model's predictions, and then to proceed with some normative exercise. For all practical purposes, the model is treated as a maintained hypothesis. Now, it is time to test these models since our interpretation of past and future oil price patterns depends critically on the model chosen. As a first step, the emphasis here is on testing the simplest version of the various models.

Section II outlines the determinants of an individual country's oil production level under the following four models: cartel, competitive, target revenue, and property rights. Section III compares the ability of each theoretical model to explain production levels in the various OPEC countries. Section IV considers the limitations of these results, contrasting them with non-OPEC oil producers. Section V recapitulates the principal findings.

I. Determinants of Production under Alternative Models

A. *Cartel Models*

The existing literature exhibits a variety of cartel models, each with unique empirical implications for an OPEC country's production decision. For example, Robert Pindyck (1978) has modeled OPEC as a monolithic wealth-maximizing monopolist solving an optimal control problem.[2] In contrast, Dermot Gately and John Kyle (1977) suggest OPEC follows a rule-of-thumb approach to pricing. Cartel models vary not only in their treatment of the nonrenewability of the re-

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[1] For a literature review, see my study with David Teece (1982) and Dermot Gately (1984).

[2] Even though Pindyck (1982) now rejects the predictive value of his early approach, it is an important piece because it demonstrates that the monopoly price path will be initially much greater than the competitive price path.

source,[3] but also in the behavior of various OPEC countries.[4] The proliferation of models is not surprising, according to Morris Adelman (1982), because he contends OPEC's actual behavior wobbles between the dominant firm and market-sharing models depending on market conditions.

Following Adelman's suggestion, the empirical formulation of production is based on a market-sharing cartel model that allows for changing market shares over time. The simplest version of the market-sharing model posits constant market shares. The demand for OPEC oil (Q^O), is a derived demand, being the difference between world demand ($Q^W(P, A)$) and non-OPEC supply ($Q^{NO}(P, Z)$).

$$(1) \qquad Q^O = Q^W(P, A) - Q^{NO}(P, Z)$$

World demand depends on the real price of oil (P) and economic activity (A) while non-OPEC production depends on real price (P) and exogenous supply variables (Z). Given the cartel price (P), OPEC production is determined. Individual country production (Q_i) is some fraction (α_i^*) of total OPEC production (Q^O).[5]

$$(2) \qquad Q_i = \alpha_i^* Q^O \qquad i = 1, \ldots, n$$

To avoid simultaneity between Q_i and Q^O, equation (2) can be expressed as a fraction of other OPEC nations' production ($Q_i^{OO} = Q^O - Q_i$) as follows:

$$(3) \qquad Q_i = \alpha_i' Q_i^{OO} \qquad i = 1, \ldots, n$$

where $\alpha_i' = \alpha_i^*/(1 - \alpha_i^*)$.

Under a variety of cartel models, market shares could vary with price, reserves, and other factors (see P. L. Eckbo). To allow for heterogeneous behavior, the market-share coefficient (α_i') is assumed to be a function of price:

$$(4) \qquad Q_i = \alpha_i^O P_t^{\gamma_i} Q_{it}^{OO}$$
$$i = 1, \ldots, n; \quad t = 1, \ldots, T.$$

The empirical model to be estimated follows directly from equation (4):

$$(5) \qquad \ln Q_{it} = \alpha_i + \gamma_i \ln P_t + \beta_i \ln Q_{it}^{OO} + \varepsilon_{it}$$
$$i = 1, \ldots, n; \quad t = 1, \ldots, T,$$

where ε_{it} is the standard error term. Tests for the following three variants of equation (5) were performed: constant market sharing ($\beta_i = 1$, $\gamma_i = 0$); market sharing ($\beta_i = 1$, $\gamma_i \gtrless 0$); and partial market sharing ($\beta_i > 0$, $\gamma_i \gtrless 0$). Partial market sharing suggests a looser cartel model since market-sharing considerations partially affect production decisions, but production cutbacks need not be proportional.

B. *The Competitive Model*

MacAvoy has added considerable credibility to the view that oil prices can be best explained by a model focusing on supply and demand rather than on cartel behavior. MacAvoy carefully avoids labeling his simulation model as competitive, choosing instead the terms "market fundamentals," "open market conditions," and "supply and demand." Nevertheless, the positively sloped supply functions for OPEC countries implicitly embody competitive behavior. MacAvoy primarily attributes price increases to supply disruptions unassociated with cartel ambitions: "Because of the supply interruptions prices would have risen to four-fifths or more of present prices under open market conditions... these conditions, and not OPEC, caused most of the crude oil price increases in the 1970's" (p. 57).

Besides MacAvoy's analysis, changing perceptions of user costs in the 1970's might well explain the large price increases. The 1960's and early 1970's experienced rapid demand growth and declining worldwide oil discovery rates which may have raised expected user costs.

The competitive model would specify current production (Q_{it}) as a function of price

[3] For examples, see Partha Dasgupta and Geoffrey Heal (1979) and Karim Pakravan (1984).

[4] See P. L. Eckbo (1976) for a description of the cartel core, the price pushers, and the expansionist fringe.

[5] For textbook examples, see my study with H. B. Steele (1980).

(P_t), perceived user costs (U_{it}), and current extraction costs (M_{it}):

$$(6) \quad Q_{it} = S_i(P_t, U_{it}, M_{it}) \qquad i = 1, \ldots, n; \quad t = 1, \ldots, T.$$

Unfortunately, data limitations do not allow estimation of equation (6) because user costs are unobservable and time-series data on extraction costs are not available.[6] Therefore, the empirical model is a simple log linear specification in which production is a positive function of the real oil price:

$$(7) \quad \ln Q_{it} = \alpha_i + \gamma_i \ln P_t + \varepsilon_{it} \qquad i = 1, \ldots, n; \quad t = 1, \ldots, T.$$

The underlying test is whether γ_i is positive, indicating a positively sloped supply schedule. It should be remarked that equation (7) is not devoid of cost and reserve phenomena as α_i and γ_i vary across producers, reflecting intercountry differences in cost and reserve conditions.

C. *The Target Revenue Model*

A popular, noncollusive explanation for oil pricing is the target revenue theory (Ali Ezzati, 1976; Cremer-Isfahani; and Teece). This theory argues that internal investment needs effectively determine "oil revenue needs." The former are constrained by the economy's ability to absorb investments and, for given prices, determine oil production. Once oil revenues satisfy the investment target, there is no incentive to produce more. Three critical assumptions underlie this model:[7] (*i*) a fixed and slowly expanding set of investment projects; (*ii*) the unacceptability of foreign investments; and (*iii*) oil revenues are the sole source of investment funds. The target revenue theory argues that production cutbacks occur in response to rising oil prices to equate oil revenues with investment needs. More formally, let I_{it}^* represent investment needs, the target revenue proponents postulate:

$$(8) \quad I_{it}^* = P_t Q_{it}.$$

By assumption, oil prices are exogenous to the producer as are investment needs, so we take logarithms and rearrange equation (8):

$$(9) \quad \ln Q_{it} = \alpha_i + \gamma_i \ln P_t + \delta_i \ln I_{it}^* + \varepsilon_{it} \qquad i = 1, \ldots, n; \quad t = 1, \ldots, T.$$

Increases in investment needs, *ceteris paribus*, result in proportionate ($\delta_i = 1$) increases in production.[8] For given investment needs, a price increase implies a proportionate output decrease ($\gamma_i = -1$). This constitutes the "strict version" of the target revenue theory. If OPEC countries are heavily influenced by target revenue considerations, but occasionally produce in excess of investment needs, I also test for a "partial version" of the theory ($\delta_i > 0$, $\gamma_i < 0$).

D. *The Property Rights Explanation*

Mead and Johany have adapted the property rights literature to provide yet another noncollusive explanation for world oil prices. Not only were the 1970's a time of rising oil prices, they also saw transfer in ownership and control of the oil concessions from the international oil companies to the producing countries. According to this theory, the transfer of ownership from the oil companies, who because of their impending loss of production were applying high rates of time discount, to the host countries, who tend to apply much lower discount rates, resulted in

[6] In the absence of producers' future oil price predictions, user costs are not observable. Lease bonus prices in competitive auctions may form the basis for approximations to future price expectations, but are themselves limited to countries with (a) competitive leasing and (b) reasonably homogeneous prospects. For an attempt to estimate user costs in OPEC countries, see Pakravan.

[7] See Teece, pp. 66–67.

[8] Since investment needs are not directly observable, I use as a proxy real fixed domestic capital formation, converted to US $ and lagged one quarter, as reported in the IMF *International Financial Statistics*.

sharp production cutbacks and rising prices. In a Hotelling model with zero extraction costs, the real price of oil will rise at the real discount rate. The switch from a high real discount rate to a low real rate leads to sharply higher prices and lower current production (see Dasgupta and Heal). After full adjustment to the lower discount rate, prices rise at the new real rate of discount. Under the property rights explanation, production will be primarily influenced by the percentage of government controlled production (G_{it}); increases in the percentage of government controlled production result in production cutbacks ($\varnothing_i < 0$).[9]

$$(10) \quad \ln Q_{it} = \alpha_i + \varnothing_i G_{it} + \varepsilon_{it}$$

$$i = 1, \ldots, n; \quad t = 1, \ldots, T.$$

II. Empirical Tests

This section examines the empirical evidence supporting these four hypotheses. With the exception of the property rights model, quarterly data for the period 1971:I through 1983:III were utilized. The sample period is particularly rich as it includes a substantial period prior to the October 1973 Arab-Israeli war and the quadrupling of crude prices. Likewise, the data through 1983:III contains observations including the decline in crude prices from $34 to $29 in the spring of 1983. Quarterly, as opposed to annual, data allow a much closer examination of short-run production adjustments in response to price and other factors. Due to data deficiencies for Ecuador and Gabon, only 11 of the 13 OPEC countries are examined. The sample is truncated for Iran to delete the period following the revolution in Iran (1978:III) and for Iraq after the start of the Iran-Iraq war (1980:III). Price and production data are taken from *Petroleum Intelligence Weekly* and the *U.S. Monthly Energy Review*.[10]

A. *The Cartel Model*

Table 1 reports the relevant *OLS* regression estimates for the four models and Table 2 shows the results of hypothesis tests. The latter are based on *t*-tests for individual parameters and for joint hypotheses, an *F*-test is applied. Beginning with Table 1, Part A, note that the coefficient for other OPEC production (Q_{it}^{OO}) is statistically significant and positive in 10 of the 11 OPEC countries. Only Iraq, long noted for independent behavior, exhibits a negative but insignificant coefficient. Also, the cartel model exhibits frequent statistically significant price terms, indicating that market shares change with price. Consequently, the constant market-sharing model is decisively rejected (see Table 2). On the other hand, the market-sharing model ($\beta_i = 1$, $\gamma_i \gtrless 0$) cannot be rejected for 5 of the 11 countries including Qatar, United Arab Emirates (U.A.E.), Libya, Iran, and Nigeria.[11] Even Saudi Arabia appears to vary production in concert with other OPEC countries. This result contradicts dominant firm models where Saudi Arabia would act as the market leader and vary production inversely to the competitive output levels of other producers, including the rest of OPEC. Based on this evidence, OPEC appears to be a real cartel with at least partially effective output coordination. Although it was not possible to test Moran's security maximization model directly, these results indicate that OPEC is much more than Saudi Arabia.

The coefficients on price suggest some interesting behavioral implications about market shares. Kuwait, Qatar, Libya, and Venezuela appear willing to accept lower market shares in a high price regime. For Libya and Venezuela, their preferences for higher prices

[9]As a measure of the percentage of government controlled oil production, I use the percent of government equity oil as reported in the OPEC Annual Statistical Bulletin. While seemingly a perfect measure, government equity oil is not synonymous with government controlled production. The decision to produce and sell government equity oil is not necessarily made by the government as the remaining concessonaires may make the production decision and simply compensate the government. There is, however, no better measure available.

[10]A copy of the data appendix is available on request.

[11]Additionally, the models were corrected for first-order autocorrelation and the conclusions were not found to be affected. Results are available on request.

TABLE 1—ESTIMATES OF ALTERNATIVE MODELS APPLIED TO 11 OPEC COUNTRIES[a]

	A. Cartel			B. Competitive		C. Target Revenue			D. Property Rights	
Country	$\ln Q_{it}^{OO}$ (β_i)	$\ln P_t$ (γ_i)	$\bar{R}^2$	$\ln P_t$ (γ_i)	$\bar{R}^2$	$\ln I_{it}^*$ (δ_i)	$\ln P_t$ (γ_i)	$\bar{R}^2$	G_{it} ($\varnothing_i$)	$\bar{R}^2$
Saudi Arabia	.74	.29	.49	.15	.17	−.004	.14	.12	.61	.74
	(.13)	(.04)		(.04)		(.07)	(.11)		(.11)	
Kuwait	1.41	−.39	.90	−.48	.59	−.15	−.39	.59	−.61	.51
	(.12)	(.03)		(.05)		(.10)	(.09)		(.18)	
Qatar	.88	−.03	.73	−.11	.14	N.A.	N.A.		−.03	−.09
	(.08)	(.02)		(.04)					(.03)	
U.A.E.	1.00	.20	.80	.09	.09	.11	−.06	.11	.66	.74
	(.08)	(.02)		(.04)		(.06)	(.08)		(.12)	
Iraq	−.06	.29	.49	.30	.50	.27	−.02	.67	.55	.46
	(.48)	(.05)		(.05)		(.06)	(.08)		(.20)	
Libya	.72	−.27	.59	−.33	.45	−.38	−.06	.45	−.57	.27
	(.18)	(.05)		(.05)		(.22)	(.16)		(.26)	
Algeria	.74	.005	.69	−.07	.07	.34	−.28	.22	.39	−.05
	(.07)	(.02)		(.03)		(.10)	(.07)		(.55)	
Iran	.88	.05	.69	.09	.32	−.004	.08	.25	.21	.75
	(.15)	(.02)		(.02)		(.05)	(.04)		(.05)	
Nigeria	1.13	.10	.68	−.01	−.02	−.05	−.008	−.03	.18	.001
	(.11)	(.03)		(.05)		(.11)	(.07)		(.18)	
Indonesia	.56	.26	.83	.19	.54	.14	.08	.52	1.49	.87
	(.06)	(.02)		(.03)		(.09)	(.07)		(.18)	
Venezuela	.17	−.25	.75	−.26	.73	−.25	−.15	.78	−.33	.68
	(.08)	(.02)		(.02)		(.06)	(.03)		(.07)	

[a]Standard errors are shown in parentheses.

TABLE 2—SUMMARY OF HYPOTHESIS TESTS

	A. OPEC Countries		B. Non-OPEC Countries	
Models	Do Not Reject	Reject	Do Not Reject	Reject
1. Cartel				
Constant Market Sharing	1	10	0	11
Market Sharing	5	6	2	9
Partial Market Sharing	11	0	8	3
2. Competitive	6	5	10	1
3. Target Revenue				
Strict Variant	0	10		
Partial Variant	9	1		
4. Property Rights	6	5		

match their traditional positions at OPEC meetings. Of those countries found to increase market share in response to rising prices, we find a curious mixture ranging from Saudi Arabia to Indonesia. The results for Saudi Arabia seem consistent with a willingness to use production increases to attenuate price increases whereas a positive coefficient for Indonesia and Nigeria reflect some tendency to increase production at higher prices as would be expected from small producers with competitive fringe tendencies. In sum, the evidence favoring a partial market-sharing model is impressive.[12]

[12] Even the addition of lagged oil reserves to equation (5) does not alter this basic conclusion, as its coefficient

B. *The Competitive Model*

The results for the competitive model in Table 1 reveal generally anomalous results. The hypothesis of a positive coefficient ($\gamma_i > 0$) on price is rejected in 5 of the 11 countries. Significantly negative estimates are observed for Kuwait (−.48), Qatar (−.11), Libya (−.33), Algeria (−.07), and Venezuela (−.26).[13] Furthermore, comparison of the $\bar{R}^2$ for both the cartel and the competitive models reveals a sharp dichotomy in explanatory power. Additionally, it is possible to test the competitive model as a nested case of the cartel model. Even for the 6 countries in Table 2 for which the competitive model could not be rejected, the competitive restriction is rejected for all but Iraq. Attempts to improve the performance of the competitive model by the introduction of a lagged oil reserves variable in equation (7) failed to alter this conclusion.[14] Even experimentation with a dynamic demand formulation, allowing for lagged price effects, likewise failed to alter the overall conclusion.[15]

C. *The Target Revenue Model*

Of the 10 OPEC countries for which investment data is available, all 10 are found to reject the strict formulation of the target revenue theory ($\delta_i = 1$, $\gamma_i = -1$). On the other hand, these factors could be influencing production decisions through a partial version of the target revenue model ($\delta_i > 0$, $\gamma_i < 0$). Table 1, Part C, shows there are only 3 countries for which investment is statistically significant and positive, and only one country (Algeria) with both variables having correct, statistically significant coefficients. Interestingly, Algeria is the country Cremer and Isfahani cite as an example of their theory. The null hypothesis test in Table 2 (H_O: $\gamma_i < 0$, $\delta_i > 0$) reveals that the partial version of the model, unlike its strict counterpart, is difficult to reject statistically despite the lack of evidence to support the theory.[16] Attempts to utilize a trended investment series to better approximate investment "needs" failed to improve the model's performance.

D. *The Property Rights Model*

The data set for this test utilized annual observations for the period 1971 to 1981, the last year for which annual data on the percent of government equity oil production (G_{it}) is available. Table 2, Part B, reveals a statistically significant and negative coefficient for 3 of the 11 countries (Kuwait, Libya, and Venezuela). Nevertheless, as indicated in Table 2, the null hypothesis (H_O: $\varnothing_i < 0$) could not be rejected for 6 of the 11 countries. The mixed performance of the property rights model is not unexpected since, for example, in 1972 Iraq nationalized the Iraq Petroleum Company and expanded capacity from 1.7 to 4.0 million barrels per day. In sum, this simple test of the property rights model provides little support for this hypothesis.

III. Caveats and Extensions

The preceeding results give considerable support to the cartel model. Not only does this model apply to a greater number of countries, but the overall level of explanation dominates other models. But to what degree are these results dependent on the test devised for each model? Perhaps due to spurious correlations, any randomly selected country's observations might fail to reject the cartel model. Alternatively, the power of the

is positive and statistically significant in only 3 countries (and none under the autoregressive model). In such cases, the conclusions concerning β_i are unaffected.

[13] With the autoregressive model, price tended to be positive and statistically significant in only four cases.

[14] Here the reserves coefficient was positive and statistically significant in 5 countries, causing a sign change in γ_i for U.A.E. from .09 to −.14, strengthening the conclusion a bit.

[15] In the dynamic formulation, γ_i was not positive and significant for any of the OPEC countries.

[16] Estimation using the autoregressive model found only Iraq to have a positive, statistically significant coefficient on I_{it}^*(.28), and no country showed both variables having the signs suggested by the target revenue theory.

TABLE 3—ESTIMATES FOR CARTEL AND COMPETITIVE MODELS APPLIED TO 11 NON-OPEC COUNTRIES[a]

	A. Cartel			B. Competitive	
Country	$\ln Q_{it}^{O}$ (β_i)	$\ln P_{it}$ (γ_i)	$\bar{R}^2$	$\ln P_{it}$ (γ_i)	$\bar{R}^2$
Argentina	−.17	.04	.19	.05	.16
	(.15)	(.03)		(.03)	
Brunei/Malaysia	.32	.32	.59	.30	.60
	(.37)	(.08)		(.07)	
Canada	.32	−.04	.20	−.06	.08
	(.20)	(.04)		(.04)	
China	.72	.62	.89	.57	.85
	(.31)	(.06)		(.07)	
Egypt	−1.16	.34	.32	.41	.28
	(.89)	(.18)		(.18)	
India	−.05	.22	.66	.28	.46
	(.36)	(.07)		(.09)	
Mexico	−1.29	.67	.83	.75	.75
	(.54)	(.11)		(.13)	
Norway	.75	1.73	.70	1.68	.72
	(1.66)	(.34)		(.31)	
U.K.	−.61	3.32	.61	3.36	.65
	(3.98)	(.81)		(.73)	
USSR	−.34	.19	.79	.19	.82
	(.15)	(.03)		(.03)	
U.S.	−.14	−.06	.62	−.05	.50
	(.07)	(.01)		(.02)	

[a]Standard errors are shown in parentheses.

cartel model may be sufficiently weak that most countries would fail to reject it. This section examines such questions in order to assess the confidence one can attach to the preceeding results.

A. *Non-OPEC Producers*

To test the conjecture that any oil producer would fail to reject the cartel model, I apply both the competitive and cartel models to non-OPEC producers with daily production rates in excess of 300,000 barrels in the 1971–82 period. The data set consists of 11 countries, which include Argentina, Brunei/Malaysia, Canada, China, Egypt, India, Mexico, Norway, United Kingdom (U.K.), USSR, and the United States (U.S.). Annual data (1971–82) were utilized in place of quarterly data due to limited data availability. One would expect, *ex ante*, the behavior of these countries to reject the cartel model and to not reject the competitive model. Table 3 presents the parameter estimates of the two competing hypotheses for the non-OPEC producers and Table 2, Part B, reports the hypothesis test results. Table 2, Part B, reveals that the power of the partial market-sharing hypothesis is not strong as for 8 of the 11 non-OPEC countries cartel behavior could not be rejected. These results can be directly traced to the fact that H_O: $\beta_i > 0$ is virtually equivalent to H_O': $\beta_i = 0$. Consequently, it is noteworthy that the cartel model is rejected for 3 countries. On the other hand, the competitive model is rejected for only one country, the U.S., which was subject to price controls over much of the sample period.

A closer comparison of the cartel and competitive models for these non-OPEC countries reveals some striking differences. Whereas for the 11 OPEC countries, the coefficient on OPEC output, β_i, was positive and statistically significant for 10 of the 11 countries, only in one (China) of the 11

non-OPEC countries was this true.[17] Additionally, whereas for OPEC countries, the explanatory power of the cartel model substantially exceeds that of the competitive model, this is not the case for non-OPEC countries.

B. *Divergent, Disequilibrium Price Expectations*

The competitive label might be resurrected for the OPEC countries by appeal to a Hotelling story linking rising prices to current production cutbacks. As the discussion of the competitive model indicated, if changes in perceived user costs are correlated with price changes, the competitive model's price coefficient may be biased downward. Suppose OPEC producers altered their perceived user costs during the early 1970's in anticipation of future shortages. They would then have cut production, but the effect may have been incorrectly attributed to price, since user costs are omitted in equation (6).

There are several problems with such an explanation. First, one must wonder why the non-OPEC suppliers were not appreciably influenced by such a change in user cost perceptions since they rather uniformly exhibit a positive relationship between price and production in Table 3. Second, even if the expectations of the OPEC nations diverged from the non-OPEC producers, such expectations seem likely to be confined to the period 1971–74, since, thereafter, prices had effectively quadrupled. Thus, if the negative relationship between price and production is due to divergent expectations, one would expect to observe a positive price/quantity relationship for the period excluding these possibilities (1975–83). Tests of the competitive model for the period beginning 1975:I are quite revealing. Instead of showing a greater preponderance of positive price coefficients, as implied by disequilibrium price expectations, the competitive model was rejected for all countries except Iraq. Hence, the positive price coefficients in Table 1 which are supportive of the competitive model originated primarily from the period 1971–74. Such a result is quite plausible if cartel behavior only began with the 1973 Oil Embargo. In sum, divergent expectations of user costs do not appear capable of salvaging the competitive model.[18]

C. *Attempts to Group OPEC Countries*

With the recognition that OPEC cannot be treated in monolithic terms, researchers have found it convenient to group OPEC countries by behavioral characteristics. For example, Eckbo postulated three groups—the "price pushers" (Iran, Venezuela, Algeria, and Gabon), the "expansionist fringe" (Indonesia, Nigeria, Iraq, and Ecuador), and the "cartel core" (Saudi Arabia, Kuwait, U.A.E., Qatar, and Libya). In a statistical sense, is it meaningful to form such groups? Tests on Eckbo's groupings, excluding Ecuador and Gabon, were performed using the cartel model and allowing for differential country intercepts to see if common values for β_i and γ_i could be maintained within each of these three categories. In each group, the hypothesis of similar responses was decisively rejected.[19] While behavioral groupings are superior to a monolithic view of OPEC, such groupings must be viewed as rough approximations, useful for pedagogical purposes.

IV. Summary and Implications

The scope of this paper—to test these alternative theories of OPEC—is necessarily ambitious and controversial. Nevertheless, resolution of these differences is critical, not only for historical purposes, but also for the methodology of economics and its implications for public policy. Methodologically,

[17] Canada's coefficient β_i becomes marginally significant when correction for autocorrelation is made.

[18] For a similar conclusion, see Pakravan.

[19] For the price pushers, $F = 39.6$ with $F^*_{01}(4,124) = 3.47$; for the expansionist fringe, $F = 17.5$ with $F^*_{01}(4,132) = 3.47$; and for the cartel core, $F = 53.2$ with $F^*_{01}(8,240) = 2.65$.

tests of these competing theories should produce clear differences unless, of course, monopolistic and competitive models yield scientifically indistinguishable differences. The approach has been to formulate simple models reflecting the key determinants of production behavior under alternative OPEC theories. These models are inherently simplifications of each theory in a variety of ways. Clearly, the proponents of each theory could postulate more elegant and complete empirical specifications of their positions. While the results here must be viewed as a first step, it appears doubtful that more elegant specifications will overturn the principal findings here.[20]

Perhaps the most striking aspect of the empirical tests is the clear-cut nature of the results. First, among OPEC countries, the partial market-sharing cartel model could not be rejected for all 11 countries, whereas frequent rejections are observed for the other theories. Second, in terms of the ability of the various models to explain production, the partial market-sharing cartel model dominates the competitive model. Third, in comparisons with 11 non-OPEC countries we observe the opposite tendency—the competitive model could not be rejected for 10 of the 11 non-OPEC producers.

This prompts the all important unanswered question: "If OPEC is indeed a cartel, why have Friedman's predictions proven so wide of the mark?" Traditionally, economists have viewed cartels as fragile entities with limited power to raise price appreciably above competitive levels and, if successful for a time, unable to sustain such increases over the longer run. Why do OPEC countries ostensibly follow some form of market-sharing behavior, especially since many of them have very small market shares and large incentives to cheat? Hopefully, future research will provide a richer cartel model, better capable of explaining the surprising stability of OPEC.

[20] Interestingly, C. W. Hope and P. H. Gaskell (1984) reach a similar conclusion using an optimal control approach.

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