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WHAT MOTIVATES OIL PRODUCERS?:  
TESTING ALTERNATIVE HYPOTHESES

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Carol Dahl\*  
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Mine Yucel\*

April 1991

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# Research Paper

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Federal Reserve Bank of Dallas

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What Motivates Oil Producers?:  
Testing Alternative Hypotheses

by

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Abstract: Conventional wisdom holds that OPEC is a weakly functioning cartel with non-OPEC producers forming a "competitive fringe". However, several studies have challenged the cartel hypothesis for OPEC, and a few have even challenged the competitiveness of the fringe. In this paper we test competing hypotheses using recently developed cost data that allows the most general model to date. Because economic theory suggests that natural resource producers should dynamically optimize, we explicitly incorporate and test whether various oil producing countries do. Under our specification there was no evidence for dynamic optimization. Although formal target-revenue models were rejected, there was some evidence that targeting may influence production for OPEC countries. There was no evidence that any of the oil-producing countries in OPEC behaved in a competitive manner. On the other hand, we were unable to detect any formal evidence of coordination among countries. More surprisingly, we do not find evidence that the fringe is competitive either.

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\*The authors would like to thank, without implicating, Professor Dermot Gately, Professor Clifton Jones, and anonymous referees for comments on earlier drafts of this paper, and Professor James Griffin for encouragement and for generously providing us with his data.

The large oil price increases of 1973 focused considerable attention on the Organization of Petroleum Exporting Countries (OPEC). With this attention came a debate on OPEC market structure that continues to this day. Although conventional wisdom suggests that OPEC is a weakly functioning cartel groping toward an optimal level of revenue, the cartel argument is not universally accepted.<sup>1</sup>

Analysts have put forth a variety of arguments to explain OPEC behavior. Because simulations of OPEC as a cartel or a monopoly did not simulate the high prices of the 1980s, some modelers explained continuing high prices with political arguments (Moran (1982)), changing OPEC behavior (Geroski et al. (1987)), or changing OPEC perceptions ((Roumasset et al. (1983))). MacAvoy (1982) argues that competition and market forces led to high prices and then to lower prices. Property-rights arguments suggest that higher prices resulted from shifting property-rights from the multinational oil companies with a higher discount rate to OPEC countries with a lower discount rate (Mead (1979) and Johany (1978)). A competitive target-revenue model, which yields backward-bending supply curves once target revenue has been attained, suggests that higher prices lead to lower OPEC output (Teece (1982), Crémer and Salehi-Isfahani (1980), Salehi-Isfahani (1987)).

Griffin (1985) is the first to systematically test OPEC market structure across numerous competing hypotheses at the country level.<sup>2</sup> Using quarterly data from 1971:I to 1983:III, Griffin estimates four simple static econometric

models that represent four competing theories of OPEC behavior -- a cartel model, a competitive model, a target-revenue model, and a property-rights model. He concludes in favor of a partial market-sharing cartel model for OPEC but competitive behavior for non-OPEC oil producers. Salehi-Isfahani (1987), using Griffin's data and model, allows for expectations with a lagged price and finds more evidence of a target-revenue model for individual OPEC countries than does Griffin. Jones (1990) reconsiders the cartel and competitive theories by estimating the Griffin model through 1988:IV. He concludes, as did Griffin, in favor of the partial market sharing model for OPEC and competitive behavior for the non-OPEC countries tested.

In all the above studies, static behavior was assumed. Downward-sloping supply was taken as a rejection of competition, and a correlation between outputs was a sign of partial market sharing. However, in a Hotelling (1931) world, both competition and downward-sloping supply could occur, while correlation between variables could imply that the countries were competitors responding to similar exogenous signals. Therefore, we extend Griffins's work by trying to capture and test dynamic decision-making in the context of a more complete specification of noncompetitive behavior, which includes recently available cost information.

The outline of the paper is as follows. Section I describes the estimation models, section II has the hypothesis testing for OPEC, section III has the hypothesis testing for non-OPEC countries, and section IV is a summary of the conclusions.

## I. Model

In a simple competitive, static, world price equals marginal cost,

making quantity supplied (Q) a function of oil price (P). Because there are heavy capital requirements involved in finding and developing oil, past decisions and lags in adjustment are represented by wells drilled (W), giving us

$$Q = f_1(P, W) \quad (1)$$

In a competitive dynamic world user cost (price minus marginal cost (C)) in the current period should equal user cost next period discounted back to the present with discount rate r. This leads us to formulate a competitive dynamic model as

$$Q = f_2(P, W, C, r) \quad (2)$$

In a static monopolistic world, the monopolist will produce where marginal revenue equals marginal cost. Marginal revenue is represented by variables in OPEC's demand equation. These variables are the price of oil and income of the industrial nations (Y), minus supply of the non-OPEC fringe ( $Q_w$ ). We formulate this model as

$$Q = f_3(P, W, Y, C, Q_w) \quad (3)$$

In a dynamic monopolistic world the monopolist should equate marginal revenue minus marginal cost in the current period with discounted marginal revenue minus marginal cost next period. We formulate this dynamic monopoly model as

$$Q = f_4(P, W, Y, C, Q_w, r) \quad (4)$$

We formulate the above models assuming profit maximization. The last hypothesis, which does not assume profit maximization, is the target-revenue model in which quantity equals the target investment (I) divided by net profits (price minus cost)

$$Q = f_5(I, P - C) \quad (5)$$

We will examine the last model first to determine whether investment should be included in the more general model or whether strictly profit-maximizing goals provide complete information on behavior. After deciding how best to deal with investment, we will test model 4 against the other three variants, which are nested in model 4, to determine the model most consistent with each country's behavior.

## II. Hypothesis Testing of OPEC

Two variants of the target-revenue model are tested first to determine whether investment should be included in the more general model. In the strict target-revenue model,  $(P-C)*Q = I$ , while in the weaker variant,

$$(P-C)*Q = \beta I.$$

Both of these hypotheses can be tested in the following estimation model: <sup>3</sup>

$$\ln Q = \beta + \beta_I \ln I + \beta_p \ln(P-C) \quad (6)$$

### Hypothesis 1: Strong Target-Revenue

$$H_0: \beta = 0$$

$$H_1: \beta_I = +1, \quad \beta_p = -1$$

### Hypothesis 2: Weak Target-Revenue

$$H_0: \beta > 0$$

$$H_1: \beta_I = +1, \quad \beta_p = -1$$

As can be seen by the results of these tests given in Table 1, both variants of the model are strongly rejected in all cases. However, because investment is always highly significant, it is included in the general market model (equation 4) to give

$$Q = \alpha + \alpha_p P + \alpha_w W + \alpha_y Y + \alpha_{qw} Qw + \alpha_c C + \alpha_r R + \alpha_I I. \quad (7)$$

Two simultaneity issues must be addressed before estimating and testing equation 7. The first issue is whether price is endogenous, requiring the use of instrumental variable techniques. The second issue concerns investment. If investment is exogenous and is helping to drive production decisions, including it in the estimation equation may add information. If investment is endogenous and is being driven by production decisions, it is better excluded from the estimation. Exogeneity tests did not reject the hypothesis that price or investment were exogenous, hence we proceed to test the remaining hypotheses using the complete model in equation (7) with seemingly unrelated regressions.<sup>4</sup>

We next test whether or not individual countries behave dynamically. Dynamic optimizing implies a positive coefficient on the interest rate because raising the interest rate makes oil above ground more valuable than oil in the ground. Our formal test is

### Hypothesis 3: Static vs. Dynamic Behavior

$$H_0: \alpha_{ri} = 0 \text{ for each } i$$

$$H_1: \alpha_{ri} > 0 \text{ for each } i$$

As can be seen from the t-statistics on  $\alpha_r$  in Table 1, dynamic behavior is strongly rejected in all cases. In no case is the coefficient on interest rate positive, let alone significant.<sup>5</sup> However, both the countries and the multinational oil companies have produced over the sample period with the control of exports transferred over time from the multinationals to OPEC. Property ownership arguments suggest that the companies and countries may have different discount rates. The companies, risking nationalization, may have had a higher interest rate than the countries' social rate of interest.



Alternatively Adelman (1986) argues that countries whose economies are very dependent on an unstable oil market should have had higher discount rates than the companies had. In either event, the use of one interest rate might result in a failure to detect dynamic behavior.

Therefore, to test the property-rights framework, we allow separate discount rates for the companies and countries. We hypothesize that the countries' social rate is some constant percent of the private rate  $r$ . The rate of interest in the estimation equation then becomes  $r^*$ , which is a weighted average of the private company rate ( $r$ ) and the country's social rate ( $\tau r$ ):

$$r^* = [r(1-G) + \tau rG].$$

$G$  is the percent of OPEC output controlled by the OPEC countries (the country participation rate) and  $(1-G)$  is the share controlled by the multinationals. Substituting this expression into equation (1) gives us our testing equation

$$\begin{aligned} \text{Ln QOIL} = & \beta_0 + \beta_p \text{Ln POIL} + \beta_w \text{Ln WELLS} + \beta_r [r(1-G) + \alpha_r G] \\ & + \beta_y \text{Ln GDP} + \beta_I \text{Ln Inv} + \beta_c \text{Ln COST} \end{aligned} \quad (8)$$

This equation allows us to test property-rights arguments. We first test whether the countries and the multinationals behave the same, against the alternative that they behave differently. We then consider signs of coefficients to determine whether either group dynamically optimizes. Our formal test is

**Hypothesis 4: Multinationals and OPEC Countries Have the Same Discount Rate**

$$H_0: \beta_{ri} = \alpha \beta_{ri} \quad \text{for each } i$$

$$H_1: \beta_{ri} \neq \alpha \beta_{ri} \quad \text{for each } i$$

We cannot reject the null hypothesis that countries and companies have the same discount rate, except for Algeria and Indonesia. For data before

1982, we never reject the null hypothesis. Examining the signs on the coefficients, we find that the companies' discount rate is most often positive but never significant, and the coefficient on the countries' discount rate is always negative.

Because these tests provide no evidence of dynamic behavior for OPEC, we proceed to test in a static framework whether a perfectly competitive or a monopoly model is more consistent with each country's behavior. In a competitive world we would expect supply to slope upward and the variables included to capture marginal revenue (industrial countries' Gross Domestic Product (GDP) and non-OPEC output) and marginal costs to have zero coefficients. We first test these coefficients to determine if they are all zero. Then we investigate whether their signs are compatible with the market structure suggested by the tests.

**Hypothesis 5: Static Competitive Behavior versus Static**

**Noncompetitive Behavior**

$$H_0: \alpha_{yi} = 0, \alpha_{qwi} = 0, \alpha_{ci} = 0 \text{ for each } i.$$

$$H_1: \alpha_{yi} \neq 0, \alpha_{qwi} \neq 0, \alpha_{ci} \neq 0 \text{ for each } i.$$

The above equality tests of static competitive behavior are rejected for all countries but Nigeria on the full sample and are rejected for all countries on data before 1983 (see tests in Table 1). On the full sample, we find that the Nigerian supply equation does not slope upward and we reject the competitive model for Nigeria as well.

Given that the tests do not favor the competitive model, we investigate compatibility with monopoly. For all countries, either the coefficient on marginal cost or income is significant, which could suggest monopoly behavior. Although a supply function does not exist for the monopoly case, comparative

statics shows that a nonpositive coefficient on Y will require a negative coefficient on P to conclude in favor of monopoly (see Appendix B).

For every country, both on the whole sample and on data before 1983, a negative coefficient on Y is associated with a negative coefficient on P. Positive coefficients on Y can be associated with either positive or negative coefficients on P, and we find that both cases occur. We have weak results only for Nigeria and Indonesia. Hence, we conclude in favor of noncompetitive behavior with reservations in only a couple of cases, as did Griffin (1985) and Jones (1990) in their simpler framework.<sup>6</sup>

Noncompetitive behavior can take on a variety of forms depending on the degree of coordination. With duopoly we would expect little coordination. If a country was acting as a swing producer, we would expect that country to have larger percentage variations in output than for nonswing countries. In a strict cartel we would expect the following: higher-cost countries producing less than lower cost countries; similar-cost countries producing similar amounts; and coordination of production behavior for countries with similar relative production costs.

We first consider the strict cartel version. In Figure 1, average production is ranked by cost, where costs are average costs for the whole sample for each country. Iranian production is average pre-revolution production and Iraqi production is pre-war production.

There are three groupings of countries. Iraq, Saudi Arabia, Iran, and to a lesser extent Kuwait, have low costs. Libya, Indonesia, the United Arab Emirates (UAE), and Algeria have medium costs. Nigeria and Venezuela have high costs. If we omit Iraq and regress production on costs using a log linear function, we get a significantly negative relationship as seen by the

solid line in Figure 1. Furthermore, because Iraq Kirkuk production is a considerable distance inland and is exported through a shallow Mediterranean port, it has up to a \$.50 per barrel transport disadvantage to Western Europe, where the bulk of its production is sent. Including transport would then put Iraqi costs closer to those of Kuwait, giving these two countries similar costs and production.

Thus, there is some loose evidence that lower-cost countries produce higher amounts and that similar cost countries produce similar amounts. On the other hand, there is quite a high range of costs over which production is fairly similar, and the two highest-cost countries average higher production than the middle cost countries. These facts could argue for a production-sharing cartel in which the low-cost producers Saudi Arabia and Iran had high output and the rest of the market was more or less apportioned among the remaining producers. Alternatively, a model in which low-cost countries acted as swing producers, leaving higher-cost countries to produce as they wished would also be feasible.

There is also some within-country cost evidence that could be consistent with a cartel. For five countries -- Indonesia, Iraq, Libya, Nigeria, and the U.A.E. -- the cost coefficient is significantly negative, suggesting rising costs are associated with declining production. Except for Iraq, these countries tend to have the highest cost variance over the sample.

More formal testing to determine whether similar countries behaved in similar ways was done using equation 7. In pairwise testing, there was no evidence on the whole sample that any two countries had similar coefficients.<sup>7</sup> Because strict cartel behavior is not strongly supported but noncompetitive behavior is, we test for other coordinating behavior. In a

market-sharing model, the changes in production for individual countries would be in similar proportions. In a swing-producer model, swing countries would be expected to have larger proportionate changes in their production than total OPEC production (See Libecap 1989). As a measure of proportionate change, the numbers given in parentheses after the country names in Figure 1 are standard deviations  $\sigma$  of oil production divided by the mean production  $\mu$ , or  $\sigma/\mu$ . The overall mean for OPEC is 23.5 million barrels per day with a standard deviation of slightly more than 6 million barrels per day. A  $\sigma/\mu$  higher than the average for all of OPEC (.255) suggests the country may have been a swing producer (see Figure 1).

Under this criteria, Venezuela and the four low-cost producers are swinger candidates. Of these five countries, high relative variation characterized Iranian production only after the revolution. Saudi Arabia, the chief candidate for swing producer because of large absolute swings, does not have the largest relative swings in production.

Libecap (1989) suggests a more formal way to test the hypothesis that a particular country is behaving as a residual or swing producer. He argues that a country being a swing producer would imply a long-term relationship between a country's output and total OPEC output. If the two variables are co-integrated, (a linear combination of them are a stationary time series), then such a long-term relationship exists between them. We argue that such a relationship would be even more likely to prevail in a market-sharing cartel. Hence, tests of co-integration will be used to detect evidence of market sharing or other coordination among members of OPEC.

The basic model in this test is

$$Q_i = \alpha + \beta Q_{OPEC} \quad (9)$$

where both variables are in logs and each country's output  $Q_i$  is tested to determine if it is co-integrated with total OPEC output (QOPEC).<sup>8</sup> Hypothesis 6 is that each country's output is not co-integrated with total OPEC output, against the alternative that it is co-integrated or that there is long-term coordination among members of OPEC. As seen by the test statistics in Table 1, coordination was found to hold over the entire sample only for Algeria, a rather insignificant producer. No co-integration was found on data before 1983 or on tests using a linear form.

Hence, if there was coordination, it did not seem to take on a linear or log linear form. Although a small group of countries tended to take the brunt of the production changes, which would qualify them as swing producers, they did not swing in a linear beat, and each country appeared to swing to its own rhythm. The rejection of competition in all cases along with the co-integration tests suggests noncooperative duopoly behavior. More informal evidence is consistent with loose cooperation, with some countries playing a large role.<sup>9</sup>

Table 2 presents the preferred specification of the model that results from the completed tests. The  $R^2$ s imply that between 24 percent and 87 percent of the variation in production in the various countries is explained by the model's variables. Surprisingly, but perhaps spuriously, the variables included in the model explain the most for war-torn Iran and Iraq. For these countries, investment tends to be more significant and has the highest coefficient of all countries, reflecting the dependence on oil revenues to finance investment during war. Indonesia is atypical relative to the rest of the countries. Although we cannot reject monopoly behavior for Indonesia, it is the only country with a significant upward-sloping supply. Output is

negatively related to non-OPEC production, and investment is not found to be a significant factor determining oil production.

Indonesia and Algeria have positive and significant coefficients on wells, suggesting that these two countries were operating close to capacity. The insignificant coefficient on wells for the rest of the countries likely reflects excess capacity in the later part of the sample.

Although we did not find evidence of similar behavior or coordination across countries there are still some qualitative similarities across countries: 1. We could not reject monopoly behavior; 2. Investment tends to be the most significant variable for each country, lending some support to the target-revenue model; 3. Supply is downward sloping; and 4. Each country's production is most often positively correlated with non-OPEC free world production.<sup>10</sup>

#### IV. Non-OPEC Producer Behavior

We perform the same tests as above on Griffin's (1985) eleven non-OPEC producers to determine whether their behavior is consistent with a particular market structure. These countries are Argentina, Brunei/Malaysia, Canada, People's Republic of China (China), Egypt, India, Mexico, Norway, the United Kingdom, the United States and the U.S.S.R. Tests on non-OPEC countries are on annual data, using single equation techniques because we do not have the degrees of freedom to estimate all the cross equation correlations. OLS is used unless the Durbin Watson statistic indicates that a correction for serial correlation is appropriate. Because data were missing for several of the countries, as indicated in Appendix A, the model was estimated as closely as data permitted.

The hypotheses are tested in the same order with the tests statistics given in Table 3. Both the strong and weak target-revenue, hypothesis 1 and hypothesis 2 are rejected. The coefficient on investment is significant for Egypt, Norway, India, and Brunei/Malaysia. When investment is included for these four countries in the complete model (equation 7), it was found only to add information for Brunei/Malaysia where it was retained in further testing.

Hypothesis 3 tests whether the coefficient on the interest rate is significantly positive, implying dynamic optimization. As with OPEC, we reject the null hypothesis of dynamic behavior.<sup>11</sup> Hypothesis 4 is not relevant and is omitted from the tests.

Hypothesis 5 is the test for static competitive versus static noncompetitive market structure. With limited degrees of freedom the results in general tend to be weak. However, we cannot reject noncompetitive behavior for any country except Canada.<sup>12</sup> We find Canada to be compatible with no model tested, and the general model explains almost none of the variation in Canada's output as measured by an  $R^2 = .01$ .

Hypothesis 6 is a test to determine whether any non-OPEC countries coordinated their output with OPEC. Although the sample size is very small for such tests, co-integration tests were performed with no evidence that any country's output was co-integrated with OPEC output. The same tests found no evidence of coordination of each country's production with total free world production including OPEC, or total free world non-OPEC production.

We do not find much support for the target-revenue model among non-OPEC producers. Brunei/Malaysia is the only country in which there is evidence that they may be targeting some production to investment.

If we examine the results in Table 4, we find that the coefficient on



income is most often positive. The coefficient on other free world production is of mixed sign but is always positive when costs are missing and is more often negative when costs are included. We see that supply slopes up whenever cost is unavailable in the model and most often slopes down when costs are included. The results on cost coefficients and wells are quite weak. These two coefficients have significantly correct signs only for Argentina.

Overall, we find that non-OPEC producers do not dynamically optimize, nor do they target-revenues in their production decisions. There is no evidence that they coordinate their output with OPEC or with other free world production. Most interesting of all, they do not seem to behave in a competitive manner either.

#### IV. Conclusions

A lot of uncertainty still surrounds OPEC decision-making, and data limitations are an obvious constraint in resolving the controversy. Using the available data, our econometric modeling and testing supports the conventional wisdom and earlier studies that OPEC countries are noncompetitive. We investigate whether this noncompetitive behavior is more consistent with duopoly or whether a higher degree of coordination such as market sharing, swing production, or cartel behavior might be occurring.

There is some tendency for low-cost countries to produce more than high-cost countries, as would be true in a cartel, but there is only loose informal evidence that similar-cost countries behave in a similar way. Co-integration tests provide no formal evidence of coordination across OPEC producers to support a strict market-sharing cartel hypothesis or that individual countries act strictly as swing producers. Only informal evidence supports the

conventional wisdom that some degree of loose coordination, with larger-than-average relative swings in output might imply the role of swing producer for Iraq, Saudi Arabia , Kuwait, Libya, and Venezuela.

Economic theory suggests that natural resource producers should dynamically optimize, and OPEC has been widely modeled under this framework. However, we found little econometric evidence to support dynamic optimizing. One might argue that such myopic behavior might well be quite rational in a highly uncertain environment or that it supports Adelman's (1989) arguments that a limited oil resource is a myth. Not surprisingly, there is little evidence that companies dynamically optimized either, because the majority of the multinational production in these nations was gradually nationalized. Nor was the property-rights argument supported. There is some evidence that target-revenues might be a goal for many countries.

Although data limitations are a problem for the OPEC countries, the limitations are even more severe for the eleven non-OPEC countries, and the results are correspondingly weaker. However, the tests on available data suggest that the non-OPEC producers do not dynamically optimize. Target-revenues do not appear to be an important factor for any country except Brunei/Malaysia. There is no evidence that non-OPEC countries coordinate their output with OPEC or with other free world production. The most surprising result for conventional wisdom's "competitive fringe" however, is that we do not find them to behave in a manner that is consistent with competition.

### Appendix A. Data Definitions and Sources

Quarterly data from 1971:I to 1987:IV have been developed for Algeria, Indonesia, Iran, Iraq, Kuwait, Nigeria, Saudi Arabia, and Venezuela; from 1971:1 to 1982:IV for Libya; from 1972:I to 1987:IV for the UAE. Gabon, Qatar, and Ecuador are left out of the analysis because they have too much missing data.

We take production data from Griffin (1985) and update it using monthly data from the Oil and Gas Journal and the Basic Petroleum Data Book by the American Petroleum Institute.

We compiled oil prices in dollars for each OPEC country by taking official prices from the OPEC Annual Statistical Bulletin through 1985. Official prices were chosen because they are the only ones available from 1971 and they were found to be highly correlated with both free on board (f.o.b.) and landed costs to the United States through 1985. Thereafter, official prices diverge widely, and price is taken as the f.o.b. prices to the United States for 1986 and 1987 from the U.S. Department of Energy Monthly Energy Review. These prices are adjusted for inflation by the U.S. GDP deflator, base year 1982. U.S. wellhead prices are taken from the Basic Petroleum Data Book, and Canadian prices are taken from McLachlan (1989). Prices for all other countries are weighted averages of the real prices of OPEC countries.

Investment, price deflators, interest rates, and exchange rates are taken from the International Financial Statistics by the International Monetary Fund. Wells drilled are taken from World Oil, and rig counts from the Oil and Gas Journal. Government participation rates were taken from the OPEC Annual Statistical Bulletin.

Annual wells drilled for OPEC countries are made into quarterly data using interpolations based on monthly rig counts for post-1980 data. The proxy for the interest rate facing OPEC is the real rate of return on U.S. treasury bills, and the proxy for GDP for buyers of crude oil is an index of real GDP for the industrial world. Because developing countries have capital restrictions and the industrialized countries may tend to invest in their own capital markets, the interest rate for non-OPEC producers is their own government bond yield or the nearest available substitute adjusted by the rate of inflation. Interest rates were available only for 1976-87 for Egypt, Malaysia and Mexico; for 1977-87 for Argentina, and were not available for the Peoples Republic of China (China), Brunei, and the U.S.S.R. Interest rates for Malaysia were used for Brunei/Malaysia.

Investment is gross fixed capital formation or the closest available substitute. For OPEC countries investment is made into quarterly data by interpolations based on oil revenues. Because of missing domestic price indexes, investment is converted into U.S. dollars using the exchange rate and deflated by the U.S. fixed investment deflator, base year 1982. Investment for non-OPEC countries is left in the original currency but deflated by the wholesale price index or the nearest available substitute index. Investment is missing for China, the U.S.S.R., and Brunei and is available only through 1983 for Argentina. Investment for Malaysia is used for Brunei/Malaysia.

Real costs for the United States are taken from Dahl (1990). Real costs for Canada are taken from McLachlan (1989) and Eglington and Uffelman (1983). Additional real cost data in U.S. dollars are taken from Adelman and Shahi (1989) for 1971-85 and are updated by the authors using the Adelman and Shahi algorithm and data sources. Given the random variation in costs for each

year, we took a five-year moving average of the costs and interpolated to make it quarterly for OPEC. Costs are missing for China, the U.S.S.R., the United Kingdom, and Canada.

The above quarterly interpolations that use additional variables are based on a lag structure that provided the best regression fit on annual data. Several alternative data definitions were tried such as oil exports vs. oil production, investment in local currency vs. investment in dollars, total wells drilled vs. oil wells drilled, and domestic vs. U.S. interest rates for non-OPEC producers. The choice of the results reported are based on the availability of data and the quality of the results.

Except for real interest rates, all variables are entered in log terms, making their coefficients elasticities. Real interest rates, which are already in percents and for some years are negative, are entered as levels.

A wide array of lag testing on OPEC data in Dahl and Yücel (1990) suggested that adding or substituting lagged values did not improve results. Nor did Griffin (1985) find alternative lag specifications superior. Therefore, no lagged values are contained in any of the estimation.

## Appendix B

Totally differentiating the first order condition  $MR - MC = 0$  gives

$$(\partial MR/\partial Q - \partial MC/\partial Q)dQ + \partial MR/\partial Y dY = 0.$$

Rearranging we get

$$dQ/dY = - \partial MR/\partial Y / (\partial MR/\partial Q - \partial MC/\partial Q).$$

$(\partial MR/\partial Q - \partial MC/\partial Q) < 0$  from second order conditions, while

$$\partial MR/\partial Y = \partial [P(1-1/\epsilon_p)]/\partial Y = \partial P/\partial Y(1-1/\epsilon_p) + P(\partial \epsilon_p/\partial Y)/\epsilon_p^2.$$

Then  $\partial P/\partial Y$  is positive,  $(1-1/\epsilon_p)$  is positive, and  $(P\partial \epsilon_p/\partial Y)/\epsilon_p^2$  is positive unless  $\partial \epsilon_p/\partial Y$  is negative, or equivalently, demand gets more elastic as it is shifted out. Thus, the sign on  $dQ/dY$  is indeterminate. To determine what sign on the oil price coefficient is consistent with monopoly behavior,

totally differentiate  $P$  to get

$$dP = \partial P/\partial Q dQ + \partial P/\partial Y dY \text{ or } dP/dQ = \partial P/\partial Q + \partial P/\partial Y dY/dQ.$$

Because  $\partial P/\partial Q < 0$  and  $\partial P/\partial Y > 0$ , a sufficient condition for  $dP/dQ$  to be negative is a nonpositive  $dQ/dY$ . In the more likely event that  $dQ/dY$  is positive, the sign of  $dP/dQ$  is ambiguous. Thus, a nonpositive coefficient on  $Y$  will require a negative coefficient on  $P$  for us to conclude in favor of monopoly.

## References

- Adelman, M.A. (1986). "Oil Producing Countries Discount Rates." Resources and Energy. 8:309-29.
- Adelman, M.A. and M. Shahi (1989). "Oil Development-Operating Cost Estimates, 1955-85." Energy Economics. 11(1):2-10.
- Adelman, M.A. (1989) "Problems in Modeling World Oil Supply." Cambridge, Mass: MIT Energy Lab Working Paper No. MITEL-89- 010WP.
- Crémer, J. and Djavad Salehi-Isfahani (1980). "A Competitive Theory of the Oil Market: What Does OPEC Really Do?." CARESS Working Paper no. 80-4, University of Pennsylvania.
- Crémer, Jacques and Djavad Salehi-Isfahani (1991) Models of the Oil Market, New York: Harwood Academic Publishers.
- Dahl, Carol (1990). "Louisiana Oil and Gas Model: Final Report." Baton Rouge, La, Louisiana State University, Center for Energy Studies.
- Dahl, Carol A. and Mine Yücel (1988) "OPEC Market Behavior," in Competition, Profitability, and Policy in the Energy Industries, Proceedings of the 10th Annual North American Meeting of the International Association for Energy Economics, Houston, TX, Oct. 31-Nov 2, 1988, p. 8-19.
- Dahl, Carol A. and Mine Yücel (1990). "Dynamic Modeling and Testing of OPEC Behavior." Working Paper, Oxford, England: Oxford Institute for Energy Studies.
- Engle, R. F. and W. J. Granger (1987). "Co-integration and Error Correction: Representation, Estimation, and Testing." Econometrica, 55(2):251-76.
- Engle, R. F. and B. S. Yoo (1987). "Forecasting and Testing Co-integrated Systems." Journal of Econometrics, 35(May):143-59.
- Eglinton, P. and M. Uffelman (1983). "Observed Costs of Oil and Gas Reserves in Alberta, 1957-1979." Discussion Paper No. 235, Economic Council of Canada, August.
- Hotelling, Harold (1931). "The Economics of Exhaustible Resources." Journal of Political Economy, 39 (2):137-75.
- Gately, Dermot (1984). "A Ten-Year Retrospective: OPEC and the World Oil Market." Journal of Economic Literature XXII (September):1100-14.
- Gately, Dermot (1989). "Do Oil Markets Work? Are OPEC Dead?." Annual Review of Energy, Vol. 14.

- Geroski, Paul, A. M. Ulph, and D. T. Ulph (1987). "A Model of Crude Oil Markets in Which Market Conduct Varies." Economic Journal, 97(0):77-86.
- Griffin, James M. (1985). "OPEC Behavior: A Test of Alternative Hypotheses." American Economic Review 75(5): 954-63.
- Johany, Ali D. (1980). The Myth of the OPEC Cartel, New York:John Wiley and Sons.
- Jones, Clifton (1990). "OPEC Behavior Under Falling Prices: Implications for Cartel Stability." The Energy Journal, 11(3):117-29.
- Kandel, Eugene (1990). "Competition or Collusion: the Case of OPEC." Working paper, School of Business, University of Rochester, Rochester, NY, August.
- Layton, Allen P. and Jonathan P. Stark (1990) "Co-integration as an Empirical Test of Purchasing Power Parity." Journal of Macroeconomics, 12(1):125-36.
- Libecap, Gary D. (1989). "The Political Economy of Crude Oil Cartelization in the United States, 1933-1972." The Journal of Economic History, XLIX(4), April:833-55.
- Loderer, Claudio (1985). "A Test of the OPEC Cartel Hypothesis: 1974-1983." The Journal of Finance, XL(3), July:991-1005.
- Lowinger, Thomas C., C. Wihlborg and, E. S. Willman (1986). "An Empirical Analysis of OPEC and Non-OPEC Behavior," The Journal of Energy and Development, 11(1):119-39.
- MacAvoy, Paul (1982). Crude Oil Prices as Determined by OPEC and Market Fundamentals, Cambridge: Ballinger.
- McLachlan, Michele (1989). "Finding Costs in Alberta 1970-1987." Research Report 89-1.Calgary, Canada: Canadian Energy Research Institute.
- Mead, Walter J. (1979). "An Economic Analysis of Crude Oil Price Behavior in the 1970s." The Journal of Energy and Development, (Spring): 212-28.
- Moran, Theodore (1982). "Modeling OPEC Behavior: Economic and Political Alternatives." in J.M. Griffin and D.J. Teece eds., OPEC Behavior and World Oil Prices, London: Allen & Unwin.
- Polasky, Stephen (1990). "Do Oil Producers Act as 'Oil'igopolists?." Working Paper, Boston College, November.
- Roumasset, J., D. Isaak and, F. Fesharaki (1983). "Oil Prices without OPEC." Energy Economics 5 (3): 164-70.
- Salehi-Isfahani, D. (1986). "Oil Supply and Economic Development Strategy: A Dynamic Planning Approach." Journal of Development Economics 21 (1):

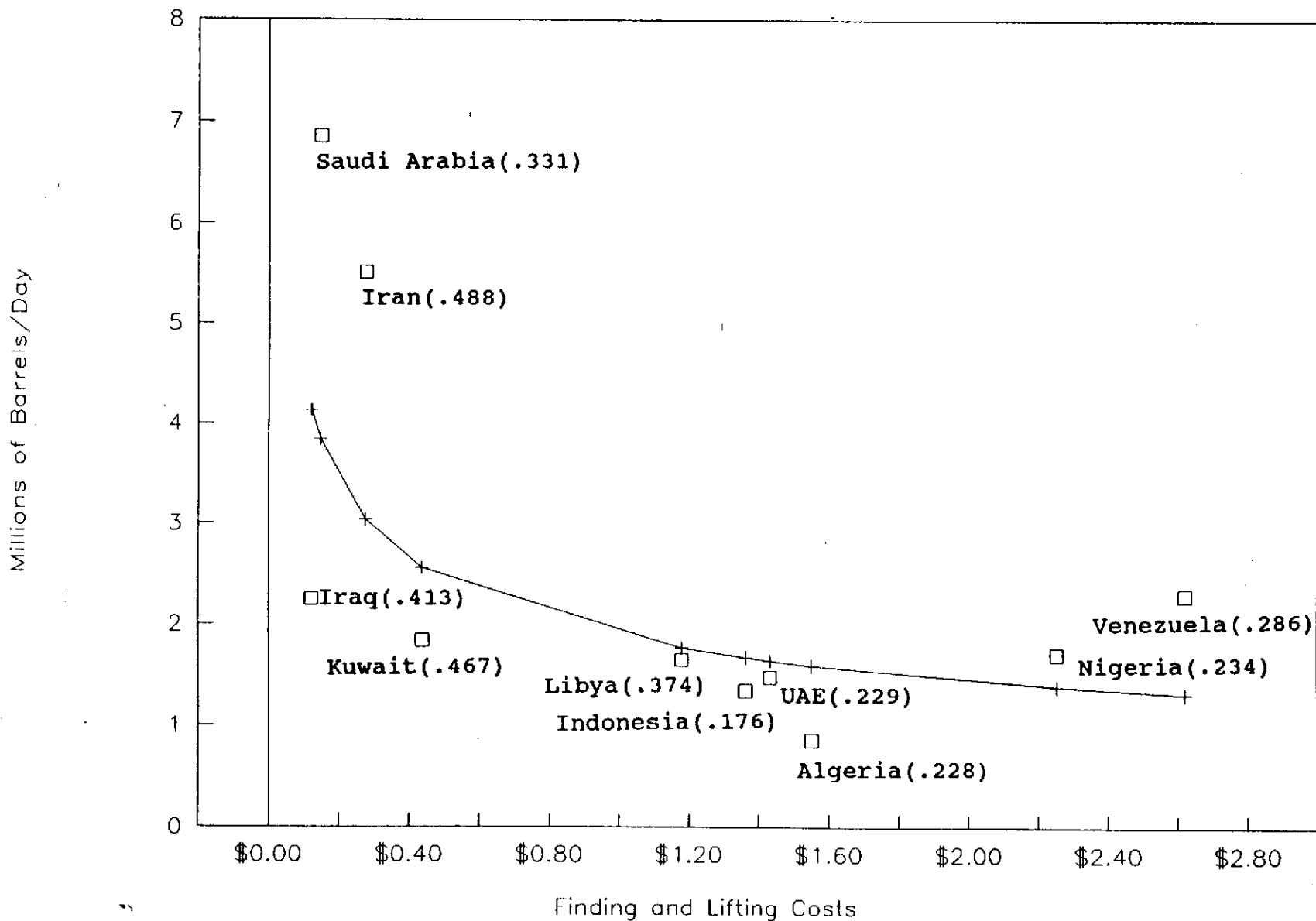


1-23.

- Salehi-Isfahani, D. (1987). "Testing OPEC Behavior: A Comment." Mimeo. Virginia Polytechnic Institute, Blacksburg, Va.
- Schwert, G. Williams (1987). "Effects of Model Specification on Tests for Unit Roots in Macroeconomic Data," Journal of Monetary Economics, (July):77-103
- Sims, C.A. (1972). "Money, Income, and Causality." American Economic Review, 62:540-52.
- Teece, David (1982). "OPEC Behavior: An Alternative View," in J.M. Griffin and D.J. Teece eds., OPEC Behavior and World Oil Prices, London: Allen & Unwin.
- Theil, Henri (1971). Principles of Econometrics, New York: John Wiley and Sons.

Figure 1

# Average OPEC Cost and Production/Day Actual vs Forecasted Production



The numbers in parenthesis are oil production  $\sigma/\mu$

Table 1: Hypothesis Tests for OPEC

		H1	H2	H3	H4	H5	H6
Reject 5%		>7.81	>5.99	>1.67	<3.84	>7.81	<-3.67
Reject 1%		>11.3	>7.38	>2.39	<5.02	>11.3	<-4.32
Test Stat*		Ch(3)	Ch(2)	t(59)	Ch(1)	Ch(3)	EYt
Algeria	1971-87	2226	226	-1.96	4.17	41.2	-3.76
Indonesia	1971-87	35202	394	-2.13	4.71	65.9	-2.97
Iran	1971-87	249	58	-0.93	0.27	108.4	9.01
Iraq	1971-87	91	46	-2.02	1.90	36.89	-2.14
Kuwait	1971-87	111	95	-0.95	1.77	21.03	-2.44
Libya	1971-82	91	53	-0.40	0.14	22.58	-3.27
Nigeria	1971-87	2494	444	-2.44	2.75	6.97	-3.27
Saudi Arabia	1971-87	616	141	-0.94	1.89	32.73	-2.08
UAE	1972-87	7451	566	-3.88	1.71	36.16	-2.41
Venezuela	1971-87	1599	459	-1.79	1.96	78.96	-2.36

\*The test statistics are  $Ch(i) = \chi^2$  with  $i$  degrees of freedom, the  $t$  statistics all have 59 degrees of freedom except for Libya with 39 degrees of freedom and the UAE with 55 degrees of freedom, the critical values are for a  $t$  statistic with 60 degrees of freedom. EYt is the  $t$ -statistic from the regression with the critical values taken from Engle and Yoo (1987), p. 157 for the closest sample size in all cases of 60.

Table 2: Estimated Model for OPEC

		$\alpha$	$\alpha_p$	$\alpha_w$	$\alpha_y$	$\alpha_I$	$\alpha_c$	$\alpha_{qw}$	$R^2$	DW	$\rho$
Algeria	71-87	5.83 (4.71)	-0.12 (-2.18)	0.21 (5.67)	-1.80 (-3.31)	0.38 (6.18)	-0.10 (-0.45)	0.08 (0.22)	0.44	2.02 (4.82)	0.57
Indonesia	71-87	8.12 (6.85)	0.19 (3.44)	0.12 (2.98)	0.42 (0.94)	0.07 (0.72)	-0.27 (-5.84)	-0.73 (-2.41)	0.53	2.10 (2.23)	0.29
Iran	71-87	11.71 (3.81)	-0.19 (-2.25)	0.07 (1.27)	-3.27 (-2.80)	0.72 (10.51)	-0.44 (-0.77)	-0.41 (-0.61)	0.74	1.71 (4.77)	0.54
Iraq	71-87	-1.51 (-2.62)	-0.72 (-7.11)	-0.05 (-1.22)	0.26 (0.12)	0.83 (24.41)	-1.13 (-3.21)	3.06 (5.45)	0.87	1.58 (24.03)	0.95
Kuwait	71-87	1.07 (1.72)	-0.57 (-6.22)	-0.03 (-1.78)	-4.82 (-3.77)	0.65 (9.65)	0.01 (0.10)	1.63 (3.53)	0.47	1.92 (13.26)	0.90
Libya	71-82	-0.91 (-0.97)	-0.62 (-7.03)	-0.01 (-0.13)	-1.87 (-2.14)	0.76 (11.43)	-0.62 (-2.11)	1.63 (4.22)	0.69	1.70 (6.23)	0.78
Nigeria	71-87	-2.09 (-1.22)	-0.06 (-0.61)	0.07 (1.25)	0.32 (0.42)	0.38 (7.34)	-0.38 (-2.20)	0.94 (1.70)	0.24	2.38 (6.29)	0.66
Saudi Arabia	71-87	3.16 (5.00)	-0.33 (-4.34)	-0.04 (-0.71)	-6.34 (-5.60)	0.63 (10.89)	0.32 (1.48)	1.13 (2.88)	0.51	2.03 (11.00)	0.89
UAE	72-87	1.90 (1.39)	-0.17 (-2.94)	-0.07 (-1.92)	0.13 (0.19)	0.24 (6.46)	-0.47 (-3.21)	0.23 (0.66)	0.39	2.34 (5.85)	0.63
Venezuela	71-87	7.18 (6.39)	-0.12 (-2.32)	0.06 (1.67)	-2.23 (-5.47)	0.16 (3.08)	0.34 (1.40)	0.38 (1.09)	0.64	1.90 (3.68)	0.13

The numbers in parentheses under the coefficients are t statistics.

Table 3: Hypothesis Tests for Non-OPEC Countries

Reject 5% <-3.67  
 Reject 1% <-4.32

	H1	H2	H3	H5	H6
	<u>F(d1,d2)</u>	<u>F(d1,d2)</u>	<u>t(df)</u>	<u>F(d1,d2)</u>	<u>EYt</u>
Egypt	2368(3,14)*	24(2,14)*	0.26(5)	3.80(3,11)*	-2.17
Argentina	24080(3,5)*	831(2,5)*	-0.28(4)	6.11(3,11)*	-2.03
PR China	...	...	...	46.20(2,13)*	4.85
USSR	...	...	...	31.30(2,13)*	-1.91
Norway	635(3,14)*	34(2,14)*	-1.51(11)	13.44(2,12)*	-1.57
India	7207(3,11)*	105(2,11)*	0.21(8)	48.77(3,11)*	-2.33
Brunei/Malaysia#	3776(3,14)*	100(2,14)*	2.06(5)	20.61(3,10)*	-2.57
US	308894(3,14)*	815(3,14)*	-3.17(10)	6.29(3,11)*	-2.63
UK	108(3,14)*	13(2,14)*	0.80(11)	12.29(2,12)*	-2.20
Canada	57948(3,14)*	268(2,14)*	-4.17(10)	0.73(3,11)	-3.06
Mexico	780(3,11)*	17(2,11)*	-1.01(3)	48.30(3,11)*	-2.24

F(d1,d2) denotes an F statistic with d1 degrees of freedom in the numerator and d2 degrees of freedom in the denominator. t(df) denotes an t statistic with df degrees of freedom. Since critical values vary for hypothesis 1 to 5 \* values are significant at the 5% level or less. EYt is the t-statistic from the regression with the critical values taken from Engle and Yoo (1987), p 157 for the smallest sample size in the table of 60.

Table 4: Estimated Supply for Non-OPEC Countries

		Const	P	C	Wt	Y	Qw	Inv	R2	DW
<b>Egypt</b>										
1971	1987	31.91 (2.06)	-0.37 (-2.17)	1.09 (3.16)	0.65 (1.44)	1.46 (1.06)	-3.28 (-2.21)	...	0.857	0.998
<b>Argentina</b>										
1971	1987	6.45 (3.33)	-0.08 (-2.52)	-0.54 (-3.59)	0.20 (3.09)	0.06 (0.63)	-0.05 (-0.3)	...	0.79	1.62
<b>China</b>										
1971	1987	-23.08 (-4.63)	0.30 (4.61)	...	...	2.70 (9.61)	1.62 (3.96)	...	0.94	1.40
<b>USSR</b>										
1971	1987	2.43 (1.39)	0.12 (5.23)	...	...	0.77 (7.78)	0.28 (1.93)	...	0.93	1.18
<b>Norway</b>										
1971	1987	-72.42 (-3.07)	0.88 (2.58)	...	-0.19 (-0.53)	9.51 (5.18)	3.05 (1.64)	...	0.87	2.18
<b>India</b>										
1971	1987	8.24 (1.56)	-0.13 (-1.64)	-0.02 (-0.14)	0.04 (0.70)	3.41 (6.92)	-1.69 (-4.08)	...	0.95	2.29
<b>Brunei/Malaysia</b>										
1971	1987	-16.02 (-4.80)	-0.18 (-1.68)	0.10 (0.83)	-0.21 (-2.01)	1.18 (1.74)	1.40 (4.83)	0.61 (2.68)	0.96	2.22
<b>United States</b>										
1971	1987	11.85 (8.17)	-0.08 (-1.29)	-0.06 (-0.86)	0.10 (1.11)	-0.11 (-0.76)	-0.28 (-3.54)	...	0.59	1.78
<b>United Kingdom</b>										
1971	1987	-137.92 (-2.83)	2.84 (2.97)	...	-3.47 (-1.69)	24.22 (4.94)	3.96 (1.06)	...	0.85	0.92
<b>Canada</b>										
1971	1987	-1.12 (-0.13)	-0.28 (-1.94)	0.35 (0.97)	0.05 (0.29)	-0.01 (-0.02)	0.76 (0.84)	...	0.01	1.43
<b>Mexico</b>										
1971	1987	-6.37 (-1.04)	0.32 (4.04)	0.05 (0.17)	0.38 (1.65)	4.71 (4.15)	-1.07 (-1.55)	...	0.97	0.91

The numbers in parentheses under the coefficients are t statistics.

## ENDNOTES

1. For more complete surveys of the literature see Gately (1984), Gately (1989), Dahl and Yücel (1988), and Crémer and Salehi-Isfahani (1991).
2. At the aggregate level, see Loderer (1985), Lowinger (1986), and Geroski et.al. (1987).
3. We use seemingly unrelated regressions for OPEC, with a correction for first order serial correlation where appropriate, except for the co-integration tests. Given the difficulty in programming with differing sample sizes, we estimate on 3 sample sizes 71:I-87:IV, 72:I-87:IV, and 71:I-82:IV. In the seemingly unrelated regression procedure each country's equations were represented as  $Y_{it} = X_{it} \beta_i + u_{it}$  where  $i=1, \dots, N$  and  $t=1, \dots, T$ .  $E(u_t, u_t') = \Sigma$ , with  $u_t = (u_{1t}, \dots, u_{Nt})$ . When the Durbin Watson statistic suggested positive serial correlation in the residuals it was assumed that  $u_{it} = \rho_i u_{it-1}$ . Using a maximum likelihood procedure  $\rho$  and  $\beta_i$  were estimated for each equation. The estimated  $\rho$  were used to transform the variables for each equation in the following way  $Y_{it}^* = Y_{it} - \rho_i Y_{it-1}$  and  $X_{it}^* = X_{it} - \rho_i X_{it-1}$ . The system of equations was then reestimated using seemingly unrelated regressions where  $\beta = (X^{*'} (\Sigma^{-1} \otimes I) X^*)^{-1} X^{*'} (\Sigma^{-1} \otimes I) Y^*$ . Where the  $\beta$  and  $y$  are the stacked coefficients and independent variables for each equation, the  $X^*$  is formed by stacking augmented  $X_i^*$  matrices with columns of zeros for all explanatory variables in other equations, and  $\otimes$  is the Kronecker product. A test of the linear restrictions  $R\beta = r$  in the systems estimation is a standard  $\chi^2(Q) = (r - R\beta)' (R\Sigma_x R')^{-1} (r - R\beta)$  with  $\Sigma_x$  the estimated variance covariance matrix of the coefficients and  $Q$  the number of restrictions being tested. A test of a linear restrictions done in a single equation format is standard  $F(Q, N-K) = (r - R\beta)' (R\Sigma_x R')^{-1} (r - R\beta) / Qs^2$  where  $s^2$  is the estimate of the error variance of the equation. See Theil (1971), pp. 308, 312-314.
4. A Sims' (1972) exogeneity test on each equation did not reject the hypothesis that the price of oil was exogenous for all countries. This test was conducted by including a future lag on price in equation 7. The null hypothesis is rejected for each country where the coefficient on the future lag is significantly negative implying that a positive error in current output causes a decrease in price next period. In an earlier version of the paper on data through 1986 and using a common oil price for each country the hypothesis was rejected for Iran, Kuwait, the UAE, and Venezuela. The test for exogeneity for investment was conducted by including a future lag for investment in equation 7. A significant positive sign on future investment would imply that increasing output this period causes increases in investment next period rather than exogenous investment being a target that is causing revenue. For no country was exogeneity of investment rejected.
5. These results supersede preliminary results in Dahl and Yücel (1989). With data revisions, updating, and a more complete model there is no longer any evidence of dynamic optimization. Two interesting recent studies

at a disaggregate level, Polasky (1990) and Kandel (1990), develop models explicitly assuming dynamic behavior and a constant discount rate over the sample. Kandel develops a closed form solution for a dynamic competitive model assuming a quadratic cost function and a specific form of price expectations. His equation allows him to compare consistency of the data for 24 countries from 1958 to 1987 with the competitive hypothesis and to compare behavior of oil producers within OPEC to those outside. Polasky (1990) develops his hypothesis from a dynamic multi-country Cournot model. His equations allow him to test oligopoly theory for 73 countries from 1970-1989 and 400 U.S. oil companies in 1983 and 1984. Future researchers might pursue the hypothesis of dynamic optimization further by developing tests in the context of either of these models.

6. These estimates all have investment in them. In all cases except Indonesia, investment is the most significant variable. Although including investment in the equation negates the nice theoretical base of profit maximization, it does add significant information and the results of the hypothesis tests are somewhat more consistent. However, since the investment results are somewhat sensitive to how they are quarterized, we would urge further work investigating the role of investment in OPEC decision making as longer periods of annual data are available.

7. The null hypothesis that all coefficients in equation 7 are equal could not be rejected for these pairs of countries at the 5% level.

8. The tests for co-integration are developed using an augmented Dickey Fuller test in Engle and Granger (1987) and extended in Engle and Yoo (1987). A nice description of how to perform the test is given in Layton and Stark (1990). The procedure is as follows. Since co-integration is a test for equilibrium between non-stationary variables, each variable is first tested for stationarity, by running the following regression

$$DQ(t) = \Phi Q(t-1) + \sum_1^p \tau DQ(t-i)$$

where D represents a first difference and p is chosen to be 4 using a rule of thumb in Schwert (1987). We reject non-stationarity in favor of stationarity if  $\Phi$  is found to be significantly negative by comparing the t statistic on  $\Phi$  to the critical values in Engle and Yoo (1987), p. 157. As would be expected no country's output nor total OPEC output was found to be stationary. Next we test for co-integration of each country's output with total OPEC output. This test is conducted by regressing each country's output on a constant and total OPEC output and testing the residuals to determine if they are stationary using the above test. The tests were also conducted to see if each country's output was co-integrated with the rest of OPEC production rather than total OPEC production. The results of these tests found no evidence of co-integration. Co-integration was also tested and rejected in all cases for a linear specification of the model.

9. Since rejection of competition is inconsistent with the earlier exogeneity tests, further work might be undertaken to develop, estimate, and test these hypotheses in a simultaneous systems framework.



10. All tests were also done using exports instead of production. The results were very similar but there was more consistency of results for production than for exports.

11. Using the US interest rate and testing for the market economies did not find dynamic behavior either. For China and the USSR given the nonconvertibility of their currencies and their isolation from the world economy such a test does not seem relevant.

12. Our result is at odds with Griffin (1985) and Jones (1990). When they regressed output on price, they found upward sloping supply as evidence of competition for all but the U.S. and Canada. Repeating their test on our data, we found their conclusions were sensitive to whether the data was corrected for serial correlation or not. Kandel (1990) in his dynamic model also found non-OPEC countries more compatible with a competitive model than OPEC countries. Our result supports recent results by Polasky (1990). His dynamic duopoly model implies that producers with larger reserves extract a smaller share of their reserves. He finds this pattern to hold for 73 countries for 1970-1989 and for 400 U.S. oil companies in 1983 and 1984 and concludes against a competitive fringe. These interesting differences across modeling approaches would be a fruitful area for further work.

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