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An Update on OPEC Behavior: Cartel Stability Under Falling Prices

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I. Introduction

Griffin's (1985) widely cited study of OPEC behavior first tested the empirical validity of several alternative hypotheses that have been put forth to explain the motivations and market power of the OPEC member nations. Although the sample period considered by Griffin (primarily 1971:I-1983:III) contains both upward and downward price fluctuations, the overall trend and dominant expectation among oil produces and consumers over that period was one of steadily rising real oil prices both in the near and far term.[1] Thus, the observed production behavior by both OPEC and non-OPEC producers over this period should have reflected this relatively optimistic (from the producers' point of view) scenario of ever higher real oil prices.

Since the end of Griffin's sample period (1983:III) much has changed in the world oil markets. What was thought to be only a marginal and perhaps necessary downward revision in the official OPEC price level for its marker crude Saudi Light (34° API) from $34 per barrel to $29 per barrel on March 14, 1983 turned out instead to be only the beginning of a prolonged price slide.[2] The nominal spot price for Saudi Light finally bottomed out at $7.91 per barrel in May 1986 before rebounding to its current (Fall 1988) range of $15-$18 per barrel, nearly half of its earlier value during 1983. As a result, oil producers' price expectations have been sharply revised downward, at least for the foreseeable future, and have probably only been slightly affected by the ebb and flow of Middle East political tension and the Persian Gulf war between Iran and Iraq. While some doomsayers still warn that sharply higher oil prices could be just around the corner, most observers see little

hope for real oil prices to rebound to pre-1983 levels before the end of the century or beyond.[3]

Thus one could reasonably expect the largely unanticipated need to make significant downward revisions in future expected oil prices to have in some way affected the more recent production behavior of OPEC and non-OPEC countries alike. For the members of the OPEC cartel, the prospects of steadily dwindling oil revenues and shrinking residual demand for OPEC oil has come to mean that internal cartel discipline and adherence to at least cartel-wide production limits is more important than ever before, but also more difficult to enforce. Cheating and over- or under-production by members of a cartel is always much easier to live with if the revenue pie available to all is growing year by year. In a similar fashion, firms may find it easier, and perhaps more efficient, to suffer some cost overruns or permit lax monitoring of resource usage if their market share is on the rise and normal profits are not being threatened. However, as the industry in which the firm operates matures, or as oil prices began to flatten out or trend downward, such inefficiencies or cheating by cartel members cannot be so easily ignored. A shrinking pie is much harder to divide than a growing one.

The empirical question addressed by the present study is to what extent the softening of world oil markets since 1983 has changed the behavior of the oil producing nations, in particular the OPEC members. Do the conclusions reached by Griffin regarding the validity of the various OPEC hypotheses still hold over this latter period of much lower expected future prices? Furthermore, does the data suggest problems for OPEC in maintaining cartel stability through the 1990s? Finally, what is the evidence regarding the

success of OPEC in enlisting the help of major non-OPEC producers such as Mexico and Norway in supporting a supra-competitive price of oil?

The next section briefly summarizes the competing hypotheses regarding OPEC behavior that were analyzed in Griffin's study. This theoretical section is then followed by an econometric analysis of OPEC and non-OPEC behavior which closely follows Griffin's original methodology to allow for direct comparison with his results. Implications for cartel stability and the cooperation of non-OPEC producers are assessed in the final section.

II. Alternative OPEC Hypotheses

Griffin's study assessed the empirical validity of four general types of OPEC production models: (1) cartel models (e.g., Pindyck (1978), Gately and Kyle (1977), Adelman (1982); (2) competitive models (e.g., MacAvoy (1982)); (3) the target revenue model (see Teece (1982), Ezzati (1976), or Cremer and Salehi-Isfahani (1980)); and (4) the property rights model (see Mead (1979) or Johany (1978)).

Testing of the cartel models followed from the econometric estimation of a very simple reduced form production equation derived from the assumption that OPEC is the residual supplier of crude oil:

$$(1) \qquad Q_{it} = f(P_t, Q^{oo}_{it}) \qquad i = 1,\ldots,n \qquad t = 1,\ldots,T$$

where Q_{it} is the i^{th} OPEC country's oil production, P_t is the real oil price and Q^{oo}_{it} is the aggregate oil production coming from the other (n-1) OPEC countries, all for period t. Assuming a log-linear functional form, Griffin's hypothesis tests considered three different variants on the general cartel model of equation (1): (a) a "constant market sharing" (CMS) model (where the elasticity of oil production with respect to price (ε_p) equals zero and the

elasticity of oil production with respect to the other OPEC countries' aggregate oil production (ε_o) equals one); (b) a "market sharing" (MS) model (where $\varepsilon_p \neq 0$ and $\varepsilon_o = 1$); and (c) a "partial market sharing" (PMS) model (where $\varepsilon_p \neq 0$ and $\varepsilon_o > 0$). The CMS model implies that all OPEC members share equiproportionately in production cutbacks or increases, regardless of the price, while the MS model allows the price to affect the individual members' market shares. The PMS model further allows individual cartel members to respond less than proportionately to changes in their fellow members' aggregate production.

Testing of the competitive model involved estimating a competitive oil supply curve for each OPEC country that posits current oil production to be a function of real price, "perceived user costs ((U_{it}), and current extraction costs (M_{it})" (Griffin, pp. 955-6). Lacking direct observations on U_{it} and M_{it}, Griffin could only estimate a "simple log-linear specification in which production is a positive function of the real oil price," and test the hypothesis that $\varepsilon_p > 0$.

The target revenue model states that the largely underdeveloped OPEC countries will deliberately limit their oil production to keep from earning more oil revenues than their economies can "absorb" at any one time, particularly since they are distrustful of foreign investments and would prefer having "oil in the ground" to "money in the bank." As a result, the country's investment needs (I^*_{it}, as limited by its absorptive capacity) dictate their desired or "target" level of oil revenues in each period:

$$(2) \qquad I^*_{it} = P_t \cdot Q_{it}$$

Rearranging (2) and taking natural logarithms provides yet another simple log-linear specification directly amenable to hypothesis testing. The "strict"

version of the target revenue model would require that $\varepsilon_p = -1$ while the elasticity of oil production with respect to investment needs (ε_I) should be equal to one. A milder "partial" version allows for $\varepsilon_p < 0$ and $\varepsilon_I > 0$ only.

The property rights model was tested by estimating the coefficient on the percentage of total country oil production directly produced by the host country or its national oil company (g_i), using a semi-log specification (since the percentage is zero in some periods) with no other explanatory variables. The property rights hypothesis is based on the theory of exhaustible resources, whereby transfer of oil production property rights from foreign oil companies to the host government (which is assumed to have a significantly lower discount rate on future revenues) would cause a one-time jump upward in the real price path as domestic extraction was decelerated after expropriation. Accordingly, the sign of g_i should be negative if the property rights hypothesis is to be validated.

Finally, to test the proposition that the observed production behavior of almost any oil producing country, OPEC or non-OPEC, would be at least as consistent with some variant of the cartel model as with the competitive model, Griffin also analyzed the behavior of 11 prominent non-OPEC oil producing countries. For those countries, Q_{it}^{00} in equation (1) was replaced with total OPEC production, Q_{it}^{0}, in effect treating each non-OPEC producer as the $(n+1)^{th}$ member of the cartel.

III. The Econometric Analysis

A. The Data

The revised and updated data set for testing the various hypotheses about OPEC members contains quarterly and annual observations over the period

1971:I - 1987:IV on OPEC members' oil production in thousand barrels per day (mbpd) and the real oil price per barrel as measured by the "free on board" (FOB) cost of Saudi crude, deflated by the fixed-weight price index for the fixed investment component of U.S. GNP (1982 = 100). For the target revenue models, quarterly observations were also gathered on OPEC members' market exchange rates and, where available, annual observations on gross fixed capital formation (the proxy variable used for "desired" target revenues).[4] As in Griffin's original paper, the annual investment series were converted to quarterly series by way of linear interpolation, using end of year figures as fourth quarter observations, and the resulting quarterly investment series were converted to real terms (1982 $) using the contemporaneous quarterly exchange rate and the same fixed weight price index used to deflate the oil price series. Annual observations on the percentage of government equity oil needed for the property rights model were updated through 1986, adding five years to Griffin's sample period of 1971 - 1981.

For the non-OPEC countries, annual observations on oil production (in mbpd) and real oil price per barrel were updated through 1987, as Griffin's non-OPEC sample only went from 1971 - 1982.

B. Regression Results - OPEC Countries

Tables 1A - 1D present the OLS regression results for the four basic model types for 11 of the 13 OPEC countries, broken down by sample period.[5] Notice that the sample periods used for Iran and Iraq reflect Griffin's earlier truncations on the basis of the Iranian revolution and the beginning of the Persian Gulf war. Under these four econometric specifications, estimates of the relevant production elasticities over the sample periods used by Griffin differ from his results only because of the slight differences in the deflated

price series and minor revisions in the data mentioned above. Table 2 summarizes the conclusions reached for the various hypothesis tests performed in each sample period for the OPEC countries.

1. Cartel Models

As can be seen in Table 1A, for the cartel hypotheses my conclusions over the same sample period used by Griffin are largely the same as his were.[6] The strict CMS variant is not supported, except in the case of Qatar; the weaker MS variant is not rejected in the cases of Iran, Libya, Nigeria and the United Arab Emirates (U.A.E.); the PMS-I variant ($\varepsilon_0 > 0$ and $\varepsilon_p \neq 0$) can only be rejected for Iraq, Algeria and Qatar; and the PMS-II variant ($\varepsilon_0 > 0$ only) can only be rejected for Iraq, the only OPEC member whose estimate of ε_0 was negative, although not statistically significant.

Over the updated latter half of the data set (the post-Griffin periods), the various cartel hypotheses performed in much the same way as in the earlier sample; however there were some notable differences. While the PMS variants still had the most support, many of the individual countries' elasticity estimates changed considerably. This was particularly true for the only three countries to reject the PMS-II hypothesis: post-revolutionary Iran, wartime Iraq, and Nigeria, which experienced a major political upheaval and military coup on December 31, 1983 after widespread evidence of political and financial corruption. Iran's pre-revolutionary oil production averaged approximately 6 million bpd; after the Shah's fall, it fluctuated widely from 1 to 3 million bpd at first before flattening out at about 2.5 million bpd since mid-1982 due to Iran's war-hampered export capability. Thus, the econometric analysis over this constrained period of production was unable to identify either elasticity with any precision at all--both ε_0 and ε_p were

not statistically significant and the $\bar{R}^2$ was negative. Iraq's wartime revenue needs have led it to seek output maximization over this later sample period in spite of falling oil prices and calls for production restraint by the cartel. This can be clearly seen by the fact that both of Iraq's elasticity estimates over this period are large and negative, although only its price elasticity estimate is statistically significant. For Nigeria, which underwent a second military coup on August 27, 1985, this second sample period has, like Iran's, been one of relatively flat production, as they have sought to maintain maximal production levels whatever the price of oil or desires of its fellow cartel members, much like Iraq. (Both Iraq and Nigeria have traditionally favored output maximization over cartel stability, and Iraq has never displayed a strong interest in following the cartel's directives, despite being a charter member.) Thus, neither of Nigeria's recent elasticity estimates are statistically different from 0 and its $\bar{R}^2$ is now also negative.

For the other OPEC countries, only two exhibited production behavior over this later sample period that was consistent with the earlier period: Indonesia (although it experienced a substantial decline in its estimate of ε_p from .203 to .086) and Kuwait (whose price elasticity estimate also fell, but only by one-third); both countries' estimates of ε_0 remained essentially unchanged. In contrast, Algeria's average responsiveness to variations in the rest of the cartel's output fell by two-thirds (.787 to .262), while its estimated price elasticity remained small; neither result is surprising given Algeria's declining proven reserve base and relatively flat oil production profile over this later period, producing only between 600 to 685 mbpd. Clearly Algeria is finding itself less and less able to do much to match or counteract the actions of its fellow cartel members or wide swings in prices.

Libya, Qatar and Venezuela all showed a curious reversal from negative to positive price elasticity estimates, indicating their new willingness to curb their own output in the face of lower prices and help to support the cartel. In addition, Qatar's estimate of ε_0 rose by over 50 percent from the earlier period to 1.449, indicating an even greater willingness to support the cartel-wide production declines that have occurred since 1983:III. (OPEC's total oil production averaged 26.6 million bpd from 1971:I - 1983:III but only 17.3 million bpd from 1983:IV - 1987:IV.) Thus these three OPEC members have apparently become somewhat better cartel members as prices have declined, recognizing the importance of coordinated output restriction and cooperation for cartel stability.

The remaining two members in our analysis, Saudi Arabia and the U.A.E., both exhibited negative estimated price elasticities in the second sample period (although Saudi Arabia's is not statistically significant), after showing positive price elasticities for Griffin's sample. In the case of the U.A.E., with little change in their positive estimate of ε_0, this probably reflects their widely publicized rejection of their production quotas since they were assigned for the first time in March 1983. The U.A.E. have regularly exceeded their quota limits of approximately one million bpd and recently have produced as much as 1.78 million bpd (1987:III - IV). For Saudi Arabia, its now insignificant negative price elasticity is less interesting than the strong increase in its estimate of ε_0 from .607 to 1.447. (Notice that Saudi Arabia is now the only OPEC member whose behavior is consistent with the strict CMS cartel hypothesis over this later period although this is overshadowed by the poor fit of the model.) These results are consistent with the actions the Saudis took to "discipline" their fellow cartel members by more than

matching their self-serving production increases as prices began to slip in 1985 and early 1986.[7] Finally, one can clearly see the coordinated actions by three of the Gulf states often said to comprise the cartel's "core" -- Saudi Arabia, Kuwait and Qatar--in the fact that all three countries' estimates of ε_0 were roughly equal to 1.500, although their price elasticities differ.

2. Competitive Models

Table 1B presents the results for the competitive specification across the two sample periods. As Griffin found, the evidence in favor of the simple competitive hypothesis ($\varepsilon_p > 0$) was split in the earlier sample period, although the values of $\bar{R}^2$ were substantially higher for the cartel model compared to the competitive model. This is not too surprising, since the competitive model is a nested restricted version of the cartel model and it is well known (e.g. Maddala, p. 126) that dropping an explanatory variable whose coefficient's t-ratio is less than (greater than) one will increase (decrease) $\bar{R}^2$, and the t-ratios for ε_0 are greater than one for all but the maverick Iraq. In general, Griffin concluded that the OPEC members' observed production behavior was more consistent with the cartel specification than with the competitive one.

The same basic conclusion holds for the later sample period considered here, albeit much more strongly, as the competitive hypothesis can now be rejected for all but Algeria, the only OPEC member to exhibit a positive and significant price elasticity in this specification. Adding ultimate recoverable oil reserves or some other resource base proxy to the competitive specification to measure possible user cost phenomena would certainly make for a more satisfying analysis of the validity of the competitive theory than the simple functional form tested here. However, the proven oil reserve series that are publicly available reflect widely varying assumptions about the amount

of the resource that can eventually be extracted and have been known to exhibit significant revisions at any time with no apparent link to changes in recovery technology or price. Witness the recent massive increases in estimated recoverable oil reserves for the U.A.E. from 33.1 billion barrels as of 1-1-87 to 98.1 billion barrels as of 1-1-88 (Oil and Gas Journal); for Iraq from 47.1 billion barrels to 100.0 billion barrels; and for Iran from 48.8 billion barrels to 92.9 billion barrels. Changes of these magnitudes in the face of flat or declining oil prices seem incongruous and demonstrate vividly the difficulties in using published recoverable reserve series as proxies for resource base scarcity or to provide indirect information on user costs.

3. Target Revenue Models

It was only possible to obtain updated investment series for 8 of the 10 OPEC countries used to test the target revenue hypotheses in Griffin's original paper. The IMF investment series ended in 1975 for Iraq and 1981 for Libya, and was not available at all for Qatar. For Algeria and Nigeria the investment series ended in 1985; for the remaining six countries the series ended in 1986. Nevertheless, the results of estimating the target revenue specification across both sample periods for these eight OPEC countries as seen in Table 1C give a clear picture of the validity of the target revenue hypothesis.

First, while the strict target revenue variant could be rejected for all OPEC countries in the earlier sample, it could not be rejected for Saudi Arabia in the later sample. Does this imply that, in recent years, Saudi Arabia has been so constrained by its limited ability to absorb new oil revenues that it has deliberately cut back on its oil production as oil prices

rebounded slightly? Or that it followed rather than led the 1986 oil price decline and increased its own production to maintain a desired level of target revenues? Neither explanation seems to fit, especially since Saudi Arabia has not shown much reluctance to use foreign capital markets to invest any idle or excess oil revenues or obtain short-term funding when necessary.[8] A more plausible explanation is that a shrinking residual demand for Saudi production and OPEC crude in general put downward pressure on oil prices, and in an effort to maintain or dampen the price decline, Saudi cut back its planned investment expenditures as well as its own oil output.[9] The implications for the estimated elasticities in the target revenue specification would be the same under either explanation, but the implied direction of causation is much different.

The weaker partial variant of the target revenue hypothesis has no more validity over either sample period than did the strict variant: it is rejected for all 10 countries in the earlier sample and 7 out of 8 countries in the later sample.[10] Interestingly, another cartel "core" member, Kuwait, was the only OPEC country for which the partial target revenue hypothesis could not be rejected in the later sample. Not only was Kuwait's estimate of ε_I (1.058) statistically significant, it was also not statistically different from one, while their estimated price elasticity in the target revenue specification was -.484 and also statistically significant. This suggests that Kuwait was again following Saudi Arabia's lead in its production decisions by scaling back its own domestic investment "needs" to help support the cartel price. Overall, the explanatory power of the target revenue specification is lower than that of the cartel specification.[11]

4. Property Rights Models

Table 1D shows the OLS results of estimating the semi-log property rights specification over both Griffin's original sample period (1971-1981) and an extended sample period (1971-1986). Since this specification could only be estimated from annual data, the updated latter half of the extended sample (1982-1986) contains only 5 observations, and, for 3 countries, the explanatory variable (percent of government equity oil) was constant at 100% over those 5 years. Accordingly, I chose to re-estimate the property rights model over the entire sample period rather than only over the updated portion as I did for the other three model types.

As I have interpreted the property rights hypothesis, a country's behavior only supports it by exhibiting a statistically significant and negative coefficient on the percent of government equity oil (g_i). Thus, as Table 2 concludes, the property rights hypothesis can be rejected for all but Kuwait, Libya and Venezuela during the earlier sample. Over the entire sample, the property rights hypothesis has marginally more support, with only 6 rather than 8 OPEC members' behavior being inconsistent with it, as Algeria and Qatar join the other 3 countries just mentioned above.

However, as Griffin noted, this simple analysis provides little real support for the property rights hypothesis, since a negative estimate for g_i may reflect nothing more than the downward trend in a country's oil production over the sample period as its reserves are depleted or as its residual market share falls in an increasingly competitive world oil market. In fact, all of the countries whose behavior is not inconsistent with the property rights hypothesis have seen their average oil production rates drop by 30-40% over the sample while, for all but Kuwait and Venezuela, their

proven reserves (however measured) have fallen considerably. Kuwait's reserves have surprisingly leapt from 63.9 billion barrels to 90 billion barrels in 1984 while Venezuela's reserves have steadily grown from 13.9 billion barrels in 1971 to over 30.0 billion barrels in 1987, reflecting the latter's aggressive exploration program after full nationalization in 19786. Also, the near constancy of the explanatory variable for many of these countries over large portions of the sample periods makes it act much like a dummy variable and explains the low explanatory power of this specification.

In conclusion, my updating of Griffin's data set for the purpose of re-assessing the empirical validity of four basic hypotheses about OPEC behavior during a period of much lower current and expected future prices has shown that the partial market sharing cartel variant is still more consistent with recent observed OPEC production behavior than any of the alternatives. This is not too surprising, especially since the econometric analysis so closely followed Griffin's original methodology, using OLS to estimate the same log-linear and semi-log specifications.

Among the results from the OLS estimation of the preferred cartel specification shown in Table 1A are some rather low values for the Durbin-Watson (D.W.) test statistic, especially over the earlier sample period. Nigeria and Qatar are the only two OPEC countries in the earlier sample for which the D.W. statistics were not significant at the 5 percent level. For five of the other nine countries with significant D.W. statistics (Indonesia, Kuwait, Libya, Saudi Arabia and Venezuela), the D.W. statistic was even below the value of $\bar{R}^2$. In his original paper, Griffin did recognize the possibility of autocorrelated errors and re-estimated each model assuming a first-order autoregressive error term, only to find that doing so provided no significant

improvement in the models' explanatory power while his basic conclusions were unchanged.

In contrast, over the more recent sample period the D.W. statistics were not significant for eight of the eleven OPEC countries and never fell below $\bar{R}^2$, only indicating rejection of the null hypothesis of no first order autocorrelation for Iraq, Saudi Arabia and the U.A.E. For the record, re-estimation of the cartel specification for these three countries over this later sample period using an AR(1) model made virtually no difference at all in the estimated elasticities or their standard errors.

However, the very low D.W. statistics seen for many of these countries in these OLS results in one or both sample periods could be signalling the presence of something other than just first-order autocorrelation. Significant D.W. statistics might also indicate a higher order autoregressive process, a moving average process or even some kind of specification error, such as incorrect functional form or omitted variables. Griffin implicitly realized this and experimented with alternative specifications by adding lagged oil reserves to the cartel and competitive models, trying a Koyck infinite lag structure in the competitive model, and substituting a trended investment series for lagged actual investment in the target revenue model. None of these variations were seen as being superior to the simple OLS log-linear specifications of Section II.

In a separate paper (1988), I examine in some detail the choice of proper functional form and autocorrelation in modelling the production of crude oil by OPEC countries, following the generalized Box-Cox approach of Savin and White (1978). This approach allows the researcher to simultaneously test for both first-order autocorrelation and functional form, since as Savin and

White show, testing and correcting for these two phenomena separately is often inappropriate. Surprisingly, the OLS log-linear results presented here are found to be fairly robust to more general specifications, particularly over the 1983:IV - 1987:IV period. The only substantial differences are found in the price elasticity extimates over the earlier sample: six more OPEC countries' estimates of ε_p become small and satistically insignificant in the generalized Box-Cox specification, leaving only Iran and Iraq with positive and significant estimates of ε_p and only Kuwait with a negative and significant estimate of ε_p. In this case, using OLS to estimate simple log-linear functional forms appears to adequately uncover the primary characteristics of OPEC production behavior while allowing for relatively easy assessment of the validity of alternative hypotheses about OPEC's true nature.

C. Regression Results - Non-OPEC Countries

As a point of interest, Griffin also estimated the log-linear cartel and competitive specifications using annual data for 11 major non-OPEC oil producing countries over the period 1971-1982. Table 3 provides OLS estimates of these 2 specifications for the non-OPEC countries over the more recent period 1983-1987 as well as over Griffin's earlier sample for purposes of comparison.

By again using a somewhat stricter interpretation of the cartel and competitive hypotheses than Griffin did, we see in Table 4 that we can reject the CMS cartel hypothesis for all 11 non-OPEC countries over the 1971-82 period, as none of them displayed estimates of ε_0 that were not statistically different from one while also having an estimate of ε_p that was not statistically significant. However, over this earlier period the MS cartel

variant could not be rejected for China or Norway, since both had statistically significant (and positive) estimates of ε_p and estimates of ε_0 that were not statistically different from one. This suggests that China and Norway, whether intentionally or not, did tend to vary their production in concert with the OPEC cartel although they were both willing to increase their oil output as prices rose over this period.[12] China is also the only country that supports either of the two weaker PMS cartel variants prior to 1983, so that fully 10 of the non-OPEC countries exhibited production behavior that was inconsistent with either of those cartel hypotheses.

Strengthening the case against non-OPEC cooperation with OPEC in favor of competitive fringe behavior by these 11 non-OPEC countries during Griffin's sample period is the conclusion that the competitive hypothesis cannot be rejected for all but, strangely enough, Canada and the United States. Both Canada and the U.S. were found to have negative price elasticities, although only the U.S. estimate was statistically significant. Rather than implying non-competitiveness, these results probably reflect the tight federal regulations on oil prices in the U.S. and oil production in Canada over this period.

Since oil prices began to seriously decline in the mid-1980s, there have been repeated calls by OPEC for cooperation from the major non-OPEC producers in helping to share the production cutbacks needed to maintain a monopoly price of oil.[13] If these attempts at expanding the OPEC cartel have had any real success, it should be reflected in the non-OPEC countries production behavior over the updated sample period from 1983-1987.[14] We should, therefore, see sympathetic non-OPEC countries' behavior beginning to more

closely emulate that of the OPEC members, with the cartel hypotheses finding more support over this later period than it did from 1971 to 1982.

Returning to Table 3, we find that over the more recent sample period of 1983-1987 only two of the 11 non-OPEC oil producers have positive elasticities with respect to OPEC oil output (ε_0), namely Argentina and the U.S.S.R., both of which had negative estimates of ε_0 over the earlier period. In contrast, the estimates of ε_0 were positive as implied by the cartel hypothesis for 4 of these 11 producers in the earlier period.[15] Thus 9 out of 11 non-OPEC major oil producers have, since 1983, demonstrated a clear willingness to counteract or take advantage of OPEC production decreases to increase their own market shares, rather than to assist the cartel.

Particularly interesting are the results for three non-OPEC countries in this group who have openly participated in recent joint OPEC meetings and agreed in principle to accepting some share in production cutbacks--China, Mexico and Egypt. China's estimates of ε_0 and ε_p have both changed from positive to negative from the earlier period as she has pushed her annual average oil output up by nearly one-third since 1982 to almost 2.7 million bpd in 1987 in spite of lower prices and OPEC's calls for restraint. Mexico experienced a significant decline in its estimate of ε_0 from -1.379 to -.388, yet it is still negative and significantly different from zero; their estimated price elasticity also fell (.598 to .102) but remains positive and significant, too. This is hardly the behavior of a sympathetic non-OPEC producer; only wartime-pressed Iraq had a worse record for cartel cooperation over this period, with a statistically significant estimate for ε_0 of -.638, and Iraq made it quite clear during those years that it would ignore any production restraints suggested for it by its fellow OPEC members. Arab Egypt's estimate of ε_0

was essentially unchanged at -1.008, while its estimated price elasticity became negative, as China's did, as it also acted to maximize its own oil revenues while publicly calling for greater non-OPEC cooperation to maintain stable prices.

Norway is often mentioned as a promising candidate for greater cooperation with OPEC, and has even hinted that it is sympathetic to such joint efforts. Comparing its behavior from the earlier period to more recent times, we see that Norway has followed China's lead and begun to take advantage of OPEC cutbacks to increase its market share (ε_0 is now negative), counteracting recent oil price declines with higher production levels (up by 87% since 1982, so that ε_p is also now negative). The combined output of Brunei and Malaysia (formerly operated as one unit) has similarly changed under falling prices, with both estimates of ε_0 and ε_p becoming negative, while India and the United Kingdom now exhibit negative price elasticities to complement their still negative OPEC output elasticities. Fully 7 out of these 11 non-OPEC oil producers now have negative production elasticities with respect to price and OPEC output; only the U.S. did in the earlier sample.

In sum, Table 4 shows that we can reject all but the weakest PMS-II cartel variant for all 11 non-OPEC countries in this later sample, failing to reject the PMS-II variant only for the Soviet Union, with its statistically significant OPEC output elasticity of .381. The competitive hypothesis can also be rejected for 9 of the 11 non-OPEC producers, since they do not exhibit the traditional positive price elasticity assumed in that model. However, this only demonstrates the limited applicability of the simple competitive specification, since they have been very aggressive in expanding their individual market shares. As oil prices have fallen, these non-OPEC producers

have stolen market share from OPEC, leaving most OPEC members with no choice but to cut their own prices to regain their market shares. This is unquestionably competitive behavior on both parts, indicating the difficulties OPEC has had controlling its own members who see their market shares and oil revenues being eroded away.

IV. Implications for Cartel Stability

The preceding econometric analysis of OPEC members' production behavior suggests that cartel discipline will continue to be more difficult to achieve as long as oil prices remain depressed. The development of new non-OPEC sources of supply and the greater price responsiveness of Western consumers have reduced OPEC's residual market share so that cartel wide cuts in oil production would be needed to reverse the oil price decline; no longer can any one member or "core" afford to bear the brunt of reductions in the demand for OPEC oil. Of course, such coordinated cutbacks are precisely what OPEC seems least able to enforce at present.

Since the end of Griffin's sample period, we have seen Algeria and Nigeria become significantly less cooperative with the cartel, in large part due to declining reserve bases and political turmoil. Iraq has become even more independent than before the Iran-Iraq war, and even with the signing of the recent cease-fire accord, appears intent on developing and producing its oil reserves to the limit.[16] Iran also seeks to rebuild after its long and debilitating war with Iraq, and once its export capabilities are fully restored can be expected to seek to maximize its own oil revenues while at least publicly calling for higher prices. Iran's recent adherence to its assigned quota was undoubtedly more the result of its limited productive capabilities than its willingness to cooperate with the cartel. The U.A.E. have yet to show

that they will abide by any quota limits, and Saudi Arabia has publicly declared that it is unwilling to play any kind of "swing" producer role.[17] This leaves Indonesia, Kuwait, Libya, Qatar and Venezuela to absorb a more than proportional share of much needed cartel production cutbacks, yet these five members accounted for only 31.3 percent of OPEC's total output in 1987.

Understandably then, OPEC has begun a campaign to enlist the aid of the non-OPEC oil producing countries in supporting a supra-competitive price of oil. Based upon the results presented here, the actual recent production behavior of the major non-OPEC oil producing countries is driven more by competitive self-interest than a motivation to help out the struggling OPEC cartel. Regardless of appearances at joint non-OPEC/OPEC strategy sessions, non-OPEC producers seem unwilling to do much to maintain world oil prices other than to urge <u>others</u> to cutback. Unless their behavior changes drastically, the non-OPEC producers should not be counted on by OPEC to make the difference in stabilizing the world oil market.[18] If anything, under falling prices OPEC may be more on their own than ever before.

Notes

1. As an example, the DOE's base case oil price forecast published in February 1983 in its Annual Energy Outlook 1982 projected a nominal oil price of $29 per barrel in 1985, rising to $42 by 1987 and then $59 by 1990. Even after inflation, their forecast assumed an average annual real growth rate in oil prices of over 8% from 1985 to 1990.

2. As late as May 1984, by which time the $5 price cut by OPEC in March 1983 had been incorporated into their projections, the DOE's Annual Energy Outlook 1983 base case forecast still called for nominal world oil prices to reach $29 by 1985 as before, but only $53 by 1990. However, by 1995 nominal oil prices were projected to double to $102 per barrel, reflecting an assumed real growth rate from 1990 to 1995 of 14.0% per year! Clearly, long-term future oil price expectations were still very high at the end of Griffin's sample period.

3. The latest DOE forecasts (March 1988) project real world oil prices (1987 dollars per barrel) reaching $30.76 by the year 2000 in their base case scenario, $24.93 in their low world oil price/high growth scenario and $40.19 in their high world oil price/low growth scenario. All three scenarios project negative annual average percent growth in real oil prices through 1990, but approximately 5.5 - 7.0 percent real growth each year from 1990 - 2000. Less optimistic forecasts for the year 2000 have recently been made by Data Resources, Inc.--$29.00 per barrel in 1986 dollars--and Wharton Econometric Forecasting Associates--$22.00 per barrel in 1986 dollars. See the Annual Energy Outlook 1987, Table 7, p. 28.

4. OPEC and non-OPEC production data were updated from various issues of the DOE's Monthly Energy Review, as were nominal price data. Market exchange rates and investment data for the OPEC countries came from the appropriate monthly and annual issues of the IMF's International Financial Statistics. The 1982 fixed weight price index was taken from monthly issues of the Survey of Current Business published by the Commerce Department, and its use instead of the implicit GNP fixed investment deflator (1972 = 100) chosen by Griffin represents the most significant departure from the original data set, although the impact on the deflated series is minimal. A few isolated observations on price or OPEC production prior to 1983:IV were corrected to reflect revisions in published sources; however, there were substantial corrections made to the OPEC investment series, particularly for Kuwait, Iran, Nigeria and Venezuela. As noted in the text, the investment series was not complete, ending in 1985 and 1986 for most countries and earlier for Libya (1981) and Iraq (1975). The percent of government equity oil produced each year in the OPEC countries was found in the OPEC Annual Statistical Bulletin.

5. Gabon and Ecuador are again excluded from the analysis due to data limitations and their relatively insignificant contributions to cartel output. Pooling the two sample periods was considered but rejected. The obligatory pretests for the equality of error variances indicated that Chow tests could only be performed for Nigeria, Qatar and the U.A.E., and for all three countries the null hypothesis of stable coefficients

and for all three countries the null hypothesis of stable coefficients could be rejected at the 1 percent error level.

6. My conclusions regarding the validity of the various hypotheses about OPEC behavior differ from those reached by Griffin over the same sample period for several reasons. For example, Griffin (Table 2, p. 958) does not reject the CMS model ($\varepsilon_0 = 1$, $\varepsilon_p = 0$) for Qatar, since its estimate of ε_0 is not statistically different from 1 while its estimate of ε_p is not statistically different from 0. However, Griffin then concludes that the alternative MS model ($\varepsilon_0 = 1$, $\varepsilon_p \neq 0$) also cannot be rejected for Qatar (p. 957), as well as the PMS model ($\varepsilon_0 > 0$, $\varepsilon_p \neq 0$), although both of these cartel hypotheses require a statistically significant price elasticity. As presented in the text (p. 955) the only difference between the CMS and MS cartel hypotheses is in their opposing assumption about the price elasticity--the former requires that $\varepsilon_p = 0$ while the latter requires that $\varepsilon_p \neq 0$; one cannot fail to reject <u>both</u> hypotheses in a classical two-sided test. With estimates of ε_p in the cartel specification that varied from being statistically significant and positive (Saudi Arabia, U.A.E., Iraq, Iran, Nigeria and Indonesia) to statistically significant and negative ((Kuwait, Libya and Venezuela) to statistically insignificant (Qatar and Algeria), Griffin's conclusion to fail to reject the PMS hypothesis for all eleven OPEC countries must have implicitly required <u>only</u> that ε_0 not be negative and statistically significant, with no restrictions on ε_p. In what follows, such a weaker variation ($\varepsilon_0 > 0$ only) on the originally stated PMS hypothesis (hereinafter PMS-I) will be referred to as PMS-II and considered along with the other cartel hypotheses listed in section II.

It further appears that Griffin's conclusions about the estimated values of ε_0 for the PMS-II cartel hypothesis were based on a one-sided test of $\varepsilon_0 \geq 0$ vs. $\varepsilon_0 < 0$, rather than testing $\varepsilon_0 > 0$ vs. $\varepsilon_0 \leq 0$. This can also be seen in his testing of the other hypotheses of section II, where the maintained hypotheses he used always included the value of 0 in the set of acceptable values for the relevant parameter. The difference here is in what one concludes when a parameter estimate is not statistically different from 0; should such a result support the maintained hypothesis? Griffin's rule was to conclude that it supports it; mine is to conclude that it does not.

7. At the time of this writing (October 1988), the Saudis appear to be repeating this painful lesson as they have significantly boosted their output in recent weeks with the stated goal of restoring cartel discipline. (See "OPEC Output Jumps to Highest Since '86, Spurred by Saudi Increase; Oil Prices Fall," <u>The Wall Street Journal</u>, September 30, 1988, p.3.)

8. The significant involvement by OPEC member nations in the international financial system, which contradicts the crucial assumption of the target revenue hypothesis of preferring to hold "oil in the ground," has been analyzed in some detail by Richard Mattione (1985). Mattione found that across all the OPEC countries, current account surpluses of nearly $400 billion were invested abroad over the period 1974-83.

9. By drawing on its capital reserves, Saudi Arabia cut its planned domestic expenditures by only one-third from 1981-1985 in the face of a 75%

growth rate for the non-oil sectors of its economy from 7 to 3 percent. Further, total planned expenditures over the period 1985-1990 were reduced by 30 percent. For a complete discussion, see OPEC, Its Member States and the World Energy Market (1986), pp. 285-6.

10. Notice once again that I test ($\varepsilon_I > 0$ and $\varepsilon_p < 0$) vs. ($\varepsilon_I \leq 0$ and $\varepsilon_p \geq 0$) for the partial target revenue variant while Griffin tested ($\varepsilon_I \geq 0$ and $\varepsilon_p \leq 0$) vs. ($\varepsilon_I < 0$ and $\varepsilon_p > 0$) in his study.

11. The relative inability of the target revenue specification to yield statistically significant elasticity estimates may be in large part due to the high collinearity between the explanatory variables. Sample correlation coefficients between the lagged investment and price series varied from +0.61 for Indonesia to +0.89 for Libya over the sample periods.

12. One should realize that both of these countries went from being rather insignificant oil producers to major contributors to non-OPEC oil output over this earlier time period as oil prices rose to make such new sources profitable to operate. China's average annual oil production rose from 532 mbpd in 1971 to 2,045 mbpd by 1982 while Norway's rocketed from a mere 5 mbpd in 1971 to 520 mbpd in 1982 as its North Sea reserves came into play. Thus, their unusually rapid rises in oil production over this period are more likely to reflect self-interested wealth-maximizing behavior over this period than intentional cooperation with the OPEC members, in spite of what the regression results imply. The results for the next 5 years, discussed below, agree with this interpretation.

13. These calls culminated in an unprecedented joint meeting in April 1988 between the 13 OPEC countries and seven non-OPEC oil producing countries in an attempt to agree to shared production cutbacks to prop up world oil prices. The seven non-OPEC attendees included China, Mexico, Egypt, Malaysia, Oman, Angola and Colombia. Some OPEC representatives also made it clear that they would welcome the additional presence of other major non-OPEC producers such as the U.S.S.R., Norway and Brunei at such joint meetings. ("Oil Producers Near Coordinated Output But Cuts May Be Less Than Anticipated," The Wall Street Journal, April 28, 1988, p.8.)

14. For example, Mexico was praised by OPEC's president for voluntarily holding its oil exports to 1.5 million bpd from mid-1983 through mid-1984. ("OPEC to Ask Nigeria to Ease Pressure for Larger Share of Production Quota," The Wall Street Journal, July 11, 1984, p.4.)

15. The estimates of ε_0 in the later sample period are generally less precise than in the earlier period, reflecting the small number of degrees of freedom with only 5 annual observations. I doubt that re-estimation with quarterly or monthly data, where available, would affect these results very much.

16. This prospect is mentioned in a recent front-page article in The Wall Street Journal on August 26, 1988 entitled "Iraq Moves Up Fast as a Petroleum Power With Huge Reserves."

17. "Saudi Arabia Rules Out Role as Guardian of OPEC Policy, Cartel 'Swing Producer'," The Wall Street Journal, September 14, 1987, p.3.

18. This is clearly demonstrated by the recent dispute between OPEC and non-OPEC producers on who should cut their oil exports first ("OPEC, Non-Cartel Producers Do a Dance Over Who Should Begin Oil Output Cuts," The Wall Street Journal, September 19, 1988, p.43). The non-OPEC nations are insisting that OPEC return to its own quotas before they help out with a 5% cut that many see as "too little, too late."

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Table 1A - Comparison of OLS Log-Linear Results for OPEC Countries Across Sample Periods: Cartel Model[a]

	1971:I - 1983:III				1983:IV - 1987:IV			
Country	ε_0	ε_p	$\bar{R}^2$	D.W.	ε_0	ε_p	$\bar{R}^2$	D.W.
Algeria	.787	.013	.703	.978	.262	.094	.441	1.551
	(.07)	(.02)			(.12)	(.03)		
Indonesia	.420	.203	.805	.439	.418	.086	.365	1.289
	(.06)	(.01)			(.14)	(.03)		
Iran[b]	.868	.043	.700	.918	-.061	-.036	-.052	1.183
	(.15)	(.01)			(.25)	(.15)		
Iraq[c]	-.170	.258	.592	.969	-.638	-.641	.575	.946
	(.43)	(.03)			(.39)	(.14)		
Kuwait	1.472	-.297	.833	.812	1.491	-.187	.769	2.673
	(.14)	(.03)			(.28)	(.06)		
Libya	.863	-.201	.535	.522	.629	.126	.313	1.537
	(.19)	(.04)			(.24)	(.05)		
Nigeria	1.125	.089	.700	1.517	.011	-.031	-.129	1.824
	(.10)	(.02)			(.36)	(.08)		
Qatar	.920	-.019	.718	1.397	1.449	.286	.462	1.670
	(.09)	(.02)			(.42)	(.09)		
Saudi Arabia	.607	.230	.516	.450	1.447	-.003	.036	.731
	(.12)	(.03)			(1.01)	(.16)		
U.A.E.	.911	.158	.771	.857	.825	-.207	.524	.689
	(.08)	(.02)			(.35)	(.07)		
Venezuela	.273	-.198	.724	.624	.282	.021	.311	1.463
	(.09)	(.02)			(.09)	(.02)		

[a] Standard errors appear in parentheses.

[b] Sample periods are 1971:I - 1978:III and 1978:IV - 1987:IV (pre- and post-revolution).

[c] Sample periods are 1971:I - 1980:III and 1980:IV - 1987:IV (pre- and during Persian Gulf War).

Table 1B - Comparison of OLS Log-Linear Results for OPEC Countries Across Sample Periods: Competitive Model[a]

	1971:I - 1983:III			1983:IV - 1987:IV		
Country	ε_p	$\bar{R}^2$	D.W.	ε_p	$\bar{R}^2$	D.W.
Algeria	-.031 (.03)	.005	.343	.072 (.03)	.285	1.732
Indonesia	.175 (.02)	.639	.276	.049 (.04)	.048	.935
Iran[b]	.077 (.02)	.365	.694	-.053 (.13)	-.024	1.188
Iraq[c]	.255 (.03)	.601	.941	-.745 (.13)	.548	.806
Kuwait	-.339 (.05)	.470	.295	-.278 (.09)	.347	1.241
Libya	-.235 (.05)	.338	.439	.072 (.06)	.036	1.877
Nigeria	.022 (.04)	-.014	.520	-.032 (.07)	-.053	1.833
Qatar	-.068 (.03)	.067	.465	.168 (.11)	.079	1.215
Saudi Arabia	.147 (.03)	.268	.277	-.105 (.15)	-.031	.761
U.A.E.	.100 (.03)	.157	.240	-.258 (.08)	.376	.741
Venezuela	-.208 (.02)	.672	.573	-.003 (.02)	-.066	.980

[a] Standard errors appear in parentheses.

[b] Sample periods are 1971:I - 1978:III and 1978:IV - 1987:IV (pre- and post-revolution).

[c] Sample periods are 1971:I - 1980:III and 1980:IV - 1987:IV (pre- and during Persian Gulf War).

Table 1C - Comparison of OLS Log-Linear Results for OPEC Countries Across Sample Periods: Target Revenue Model[a]

	1971:II - 1983:III				1983:IV - End of Data			
Country	ε_I	ε_p	$\bar{R}^2$	D.W.	ε_I	ε_p	$\bar{R}^2$	D.W.
Algeria[d]	.128	-.113	.010	.344	-.320	-.034	-.286	2.541
	(.11)	(.08)			(.72)	(.16)		
Indonesia[e]	-.009	.174	.602	.288	.947	.021	.226	1.191
	(.05)	(.04)			(.44)	(.03)		
Iran[b]	-.009	.079	.294	.729	.931	.248	.083	1.400
	(.04)	(.04)			(.47)	(.37)		
Iraq[c]	.226	.022	.293	1.184		N.A.		
	(.17)	(.12)						
Kuwait[e]	-.325	-.093	.523	.284	1.058	-.484	.745	1.063
	(.11)	(.10)			(.29)	(.08)		
Libya[f]	-.374	.061	.310	.408		N.A.		
	(.20)	(.13)						
Nigeria[d]	-.149	.085	-.004	.554	.051	-.441	-.140	2.270
	(.11)	(.07)			(.56)	(1.01)		
Qatar		N.A.				N.A.		
Saudi Arabia[e]	-.071	.234	.240	.313	1.279	-.573	.048	.902
	(.06)	(.09)			(.91)	(.36)		
U.A.E.[e]	.072	.006	.132	.243	.391	-.338	.810	1.813
	(.06)	(.07)			(.24)	(.08)		
Venezuela[e]	-.228	-.092	.716	.614	.082	-.012	.132	1.142
	(.07)	(.04)			(.042)	(.03)		

[a] Standard errors appear in parentheses.

[b] Sample periods are 1971:II - 1978:III and 1978:IV - 1985:IV (pre- and post-revolution).

[c] The only sample period available is 1971:II - 1975:IV due to data limitations.

[d] Sample period ends in 1985:IV due to data limitations.

[e] Sample period ends in 1986:IV due to data limitations.

[f] Sample period ends in 1981:IV due to data limitations.

Table 1D - Comparison of OLS Semi-Log Results for OPEC Countries Across Sample Periods: Property Rights Model[a]

Country	1971 - 1981			1971 - 1986		
	g_i	$\bar{R}^2$	D.W.	g_i	$\bar{R}^2$	D.W.
Algeria	.398	-.048	1.028	-1.322	.147	.374
	(.54)			(.70)		
Indonesia	1.497	.873	1.354	.807	.401	.632
	(.18)			(.24)		
Iran[b]	.205	.747	2.691	-.524	.036	.372
	(.05)			(.42)		
Iraq[c]	.552	.463	1.535	.018	-.071	.596
	(.20)			(.38)		
Kuwait	-.612	.509	1.077	-.917	.447	.559
	(.18)			(.25)		
Libya	-.569	.293	1.438	-.953	.408	.748
	(.25)			(.28)		
Nigeria	.181	-.003	1.449	-.166	-.031	.629
	(.18)			(.23)		
Qatar	-.038	-.084	1.596	-.246	.142	.788
	(.08)			(.13)		
Saudi Arabia	.614	.739	1.788	-.077	-.064	.474
	(.11)			(.25)		
U.A.E.	.658	.726	.822	.316	.060	.275
	(.13)			(.23)		
Venezuela	-.328	.681	1.676	-.428	.689	1.139
	(.07)			(.07)		

[a] Standard errors appear in parentheses.

[b] Sample periods are 1971 - 1977 and 1971 - 1986.

[c] Sample periods are 1971 - 1979 and 1971 - 1986.

Table 2 - Summary of Hypothesis Tests for OPEC Countries Across Sample Periods

Models	Griffin's Sample		Current Sample	
	DO NOT REJECT	REJECT	DO NOT REJECT	REJECT
1. Cartel				
CMS ($\varepsilon_0=1$, $\varepsilon_p=0$)	1	10	1	10
MS ($\varepsilon_0=1$, $\varepsilon_p\neq0$)	4	7	4	7
PMS-I ($\varepsilon_0>0$, $\varepsilon_p\neq0$)	8	3	6	5
PMS-II ($\varepsilon_0>0$)	10	1	8	3
2. Competitive ($\varepsilon_p>0$)	5	6	1	10
3. Target Revenue				
Strict ($\varepsilon_I=1$, $\varepsilon_p=-1$)	0	10	1	7
Partial ($\varepsilon_I>0$, $\varepsilon_p<0$)	0	10	1	7
4. Property Rights ($g_i<0$)	3	8	5	6

Table 3 - Comparison of OLS Log-Linear Results for Non-OPEC Countries Across Sample Periods: Cartel and Competitive Models[a]

	1971-82							1983-87						
	Cartel				Competitive			Cartel				Competitive		
Country	ε_o	ε_p	$\bar{R}^2$	D.W.	ε_p	$\bar{R}^2$	D.W.	ε_o	ε_p	$\bar{R}^2$	D.W.	ε_p	$\bar{R}^2$	D.W.
Argentina	-.190	.040	.264	.873	.049	.208	.570	.019	.152	.610	2.132	.151	.740	2.154
	(.14)	(.03)			(.03)			(.49)	(.06)			(.04)		
Brunei/ Malaysia	.322	.288	.648	1.363	.272	.653	1.438	-.262	-.186	.373	2.699	-.167	.577	2.230
	(.35)	(.06)			(.06)			(.76)	(.10)			(.07)		
Canada	.261	-.038	.212	1.166	-.513	.125	1.208	-.289	-.090	.077	2.215	-.069	.263	2.154
	(.18)	(.03)			(.03)			(.46)	(.06)			(.04)		
China	.694	.543	.907	2.400	.508	.865	1.546	-.619	-.249	.558	2.151	-.204	.606	2.268
	(.30)	(.05)			(.06)			(.75)	(.10)			(.08)		
Egypt	-1.193	.324	.378	.849	.383	.323	.805	-1.008	-.154	-.178	2.178	-.080	-.138	2.205
	(.87)	(.15)			(.15)			(1.06)	(.14)			(.11)		
India	-1.044	.210	.689	1.078	.261	.464	1.206	-1.464	-.354	.859	2.187	-.246	.547	2.192
	(.36)	(.06)			(.08)			(.53)	(.07)			(.10)		
Mexico	-1.329	.598	.867	.922	.663	.780	.607	-.388	.102	.911	2.582	.131	.824	1.660
	(.48)	(.08)			(.10)			(.20)	(.03)			(.03)		
Norway	.625	1.546	.746	2.152	1.515	.767	2.061	-.581	-.412	.400	2.130	-.370	.574	2.260
	(1.54)	(.27)			(.25)			(1.62)	(.21)			(.15)		
United Kingdom	-.649	3.005	.662	.932	3.037	.695	.931	-.484	-.101	.260	2.649	-.066	.183	1.673
	(3.71)	(.65)			(.59)			(.42)	(.05)			(.05)		

Table 3 - Comparison of OLS Log-Linear Results for Non-OPEC Countries Across Sample Periods: Cartel and Competitive Models[a]

	1971-82							1983-87						
	Cartel				Competitive			Cartel				Competitive		
Country	ε_o	ε_p	$\bar{R}^2$	D.W.	ε_p	$\bar{R}^2$	D.W.	ε_o	ε_p	$\bar{R}^2$	D.W.	ε_p	$\bar{R}^2$	D.W.
U.S.S.R.	-.055	.148	.843	1.035	.151	.855	1.040	.381	.019	.812	2.395	-.009	-.280	1.691
	(.11)	(.02)			(.02)			(.09)	(.01)			(.03)		
United States	-.131	-.053	.627	2.092	-.047	.525	1.959	-.394	.004	.087	2.364	.033	-.057	1.447
	(.07)	(.01)			(.01)			(.32)	(.04)			(.04)		

[a] Standard errors appear in parentheses.

Table 4 - Summary of Hypothesis Tests for Non-OPEC Countries Across Sample Periods

Models	1971-82		1983-87	
	DO NOT REJECT	REJECT	DO NOT REJECT	REJECT
1. Cartel				
CMS ($\varepsilon_0=1$, $\varepsilon_p=0$)	0	11	0	11
MS ($\varepsilon_0=1$, $\varepsilon_p\neq0$)	2	9	0	11
PMS-I ($\varepsilon_0>0$, $\varepsilon_p\neq0$)	1	10	0	11
PMS-II ($\varepsilon_0>0$)	1	10	1	10
2. Competitive ($\varepsilon_p>0$)	9	2	2	9