OPEC and World Oil Prices: Is the Genie Back in the Bottle?

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After reviewing and analyzing OPEC's behaviour in the past two decades, this paper employs a simulation model to explore plausible paths for oil prices. OPEC's members are subdivided into analytically convenient maximizing groups. All price paths eventually reach the backstop level. An important insight from the model simulations is that the price development preferred by the "cartel core," the countries with the most abundant oil reserves, is akin to that which would ensue in a competitive market setting.

Après avoir passé en revue et expliqué le comportement de l'OPEP au cours des deux dernières décennies, l'auteur utilise un modèle de simulation pour tracer les courbes plausibles des prix du pétrole. Selon ce modèle, dans lequel les membres de l'OPEP sont divisés en groupes de maximisation aux fins d'analyse, toutes les courbes de prix finissent par atteindre le niveau du prix filet. L'une des importantes constatations qui se dégage des simulations est que l'évolution des prix préférée par les pays clés du cartel, c'est-à-dire ceux dont les réserves pétrolières sont les plus abondantes, est semblable à celle qui se produirait dans une situation de marché concurrentiel.

I. Introduction

In describing OPEC in 1971, Morris Adelman observed that the genie was out of the bottle (Adelman, 1971). The sharp decline in world crude oil prices in the 1980s led many observers to conclude that the OPEC genie is back in the bottle. Prompted by reports of widespread cheating on production quotas, a popular view today is that while OPEC, the organization, still exists, it is ineffectual, and merely ratifies prices arrived at by an essentially competitive market.[1] An alternative view is that OPEC remains a relatively cohesive cartel, but finds itself constrained by external market conditions which limit its monopoly power in ways not experienced in the 1970s.[2] Our objective here is to determine which viewpoint most accurately reflects reality. If OPEC's principal problems are external to the cartel, resumed demand growth and reduced non-OPEC production in the 1990s could lead to sharply higher prices in the future. Alternatively, if OPEC's problems are internal cohesion, reconstitution of the cartel would be

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1/ See *The Economist*, October 15, 1988. Also, see former Energy Secretary John Herrington's statement in *Wall Street Journal*, January 17, 1989.

2/ For example, see Gately (1989) and Jones (1990).

much more difficult.[3] Accordingly, OPEC producers would be expected to simply expand production to satisfy demand along a much lower, competitive price path.

To test these competing hypotheses, a variety of methodological approaches exist. Options include examining the production decisions for individual OPEC countries to test for market sharing or competitive behavior (Griffin, 1985). Recently, Jones (1990) applied this approach to more recent data and found that partial market sharing behavior still persists among OPEC producers. Yet another approach is to follow Pindyck (1978) using optimal control analysis to estimate competitive and monopoly price paths, which could in turn be compared with existing prices. In this paper two alternative methodologies are employed. First, a simple extension of Lerner index analysis is utilized to compute Lerner indexes (1934) of observed and potential market power. Internal cartel problems are important to the extent that the observed Lerner index of market power is less than the Lerner index of potential market power. Second, we utilize OPEC Genie, a simulation model, to solve for future price paths and net present value of oil reserves corresponding to the following three behavioral patterns: a monolithic wealth maximizing cartel, collusion among the cartel core members of OPEC, and competition.

Section II provides a brief description of historical developments regarding oil prices, observance of cartel quotas, and the potential for output expansion. Section III describes the Lerner index analysis approach and its empirical implications. Section IV utilizes OPEC Genie to solve for price paths and payoffs corresponding to different market structures. Section V briefly recapitulates the major findings.

II. Background Information

Seemingly, all the usual indicators of OPEC performance such as oil prices, OPEC's market share, and its lack of adherence to production quotas suggest the impotence of OPEC. As shown in Figure 1, real oil prices expressed in 1990 dollars skyrocketed in the 1970s and then declined by almost 70% since 1980.[4] Indeed, real prices in recent years are below the levels reached in 1974 following the first energy crisis. The price spike linked to the Iranian Revolution in 1978-79 has been completely undone in the 1980s.

Simple economic responses to the price hikes of the 1970s have acted with a vengeance on OPEC as world oil demand contracted in response to the higher prices. Likewise, supplies from non-OPEC countries expanded systematically. With the cartel acting as a residual supplier, OPEC's share of non-communist world oil production has fallen sharply as shown in Figure 2. During the 1970s OPEC's market share fluctuated between 62.6 and 68.2%. But since 1980, OPEC's market share fell to a low of 42.2% in 1985. With a resumption of world oil demand growth, OPEC's market share recovered to 51.2% by 1990.

Internally, OPEC appears to have had its problems as well. Beginning in April 1982, OPEC instituted formal output quotas to better control production. Figures 3 and 4 show monthly quotas and actual production for the period 1983 to 1991 for total OPEC, Saudi Arabia, and other OPEC producers. Visual inspection of Figure 3 suggests that up until August 1985, OPEC produced for the most part within its assigned quotas, but thereafter exhibited systematic over-production. From this, one might conclude that OPEC disintegrated in August 1985. Instead, Saudi Arabia appears to have switched its role from the "swing producer" to a "tit-for-tat" producer. Figure 4 shows that contrary to the impression that cheating did not occur prior to August 1985, OPEC producers, other than Saudi Arabia, had been persistently producing in excess of their quotas. Under the swing producer role, the Saudis defended the official price by cutting their own production. By August 1985, Saudi production had dropped to 2.2 million barrels per day (Mb/d) and their market share

3/ See Axelrod (1984) and Klein and Leffler (1981) for a discussion of the importance of reputation.

4/ All prices in this article are in US dollars.

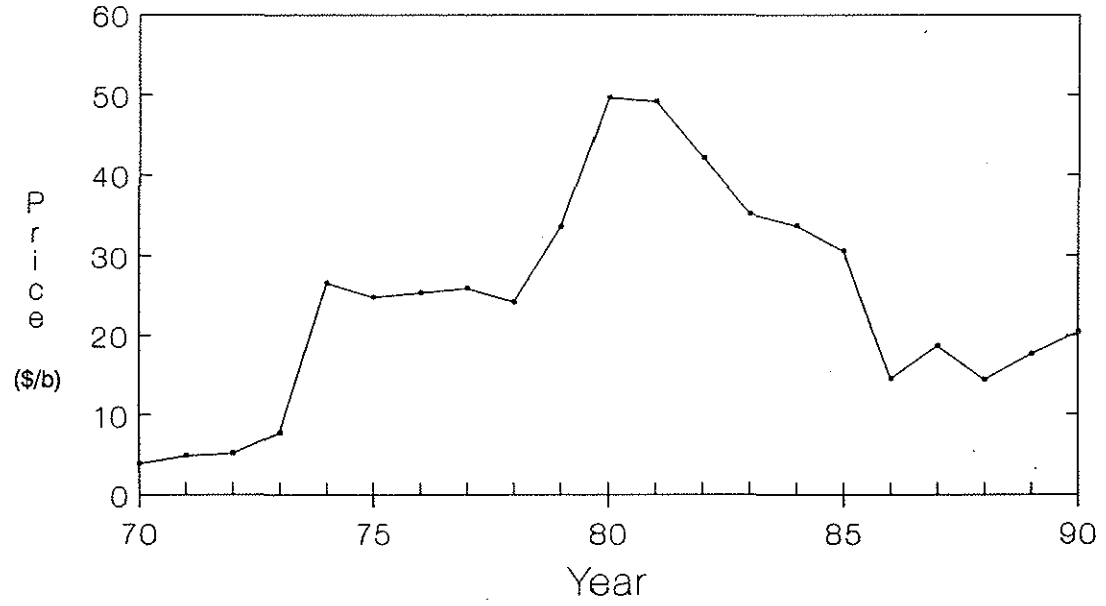


Figure 1: US Average Price for Imported Oil (1990 $)

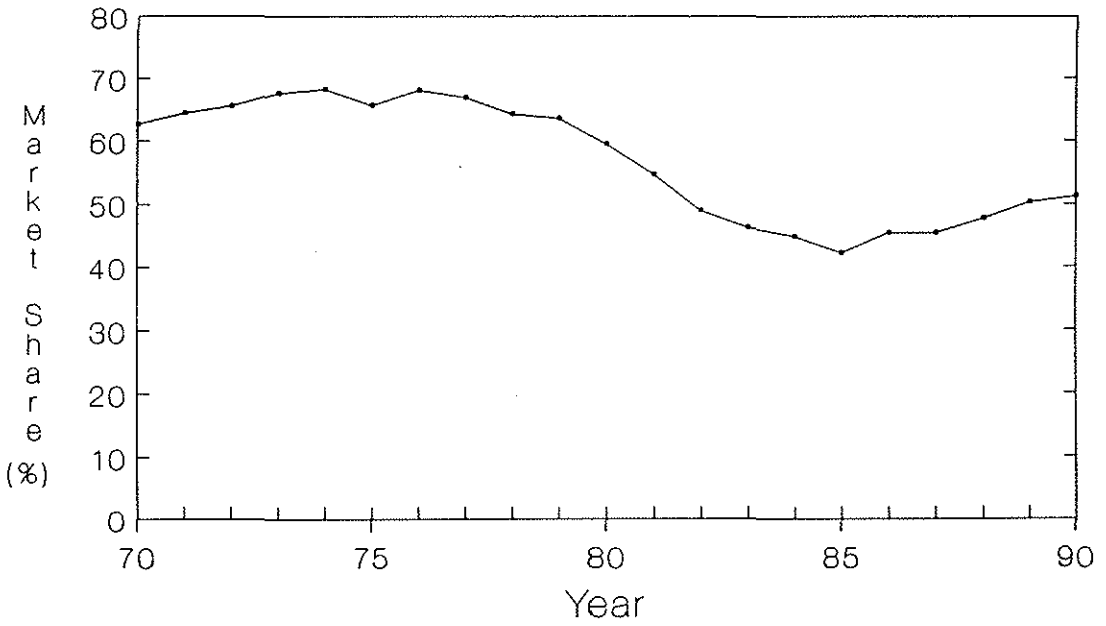


Figure 2: OPEC's Share of the Non-Communist World Market

within OPEC stood at 15.1%, despite the 27% market share implied by its official quota. They had no choice but to abandon the swing producer role.

The swing producer strategy had the serious defect that it did not penalize cheating since every barrel of over-production was, in principle, matched by an equivalent reduction by the Saudis. Indeed, Griffin and Neilson (1991) conclude that by summer 1985, Saudi Arabia would be better off outside the cartel than to continue subsidizing cheating by other producers. The

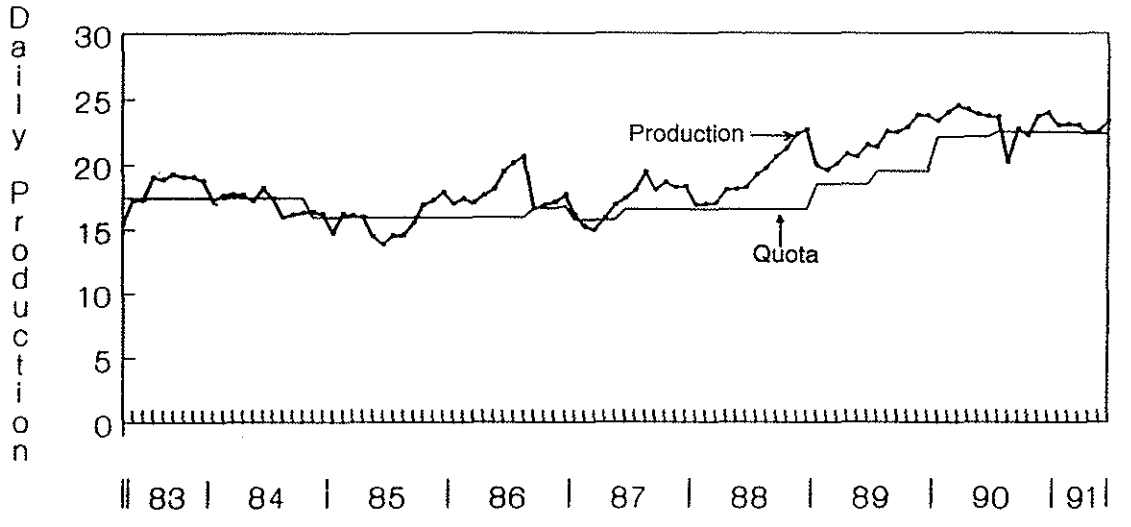


Figure 3: OPEC Production and Quotas (millions of barrels, monthly data)

Saudi experiment with "netback pricing" signalled the abandonment of the swing producer strategy and the initiation of a "tit-for-tat" strategy.

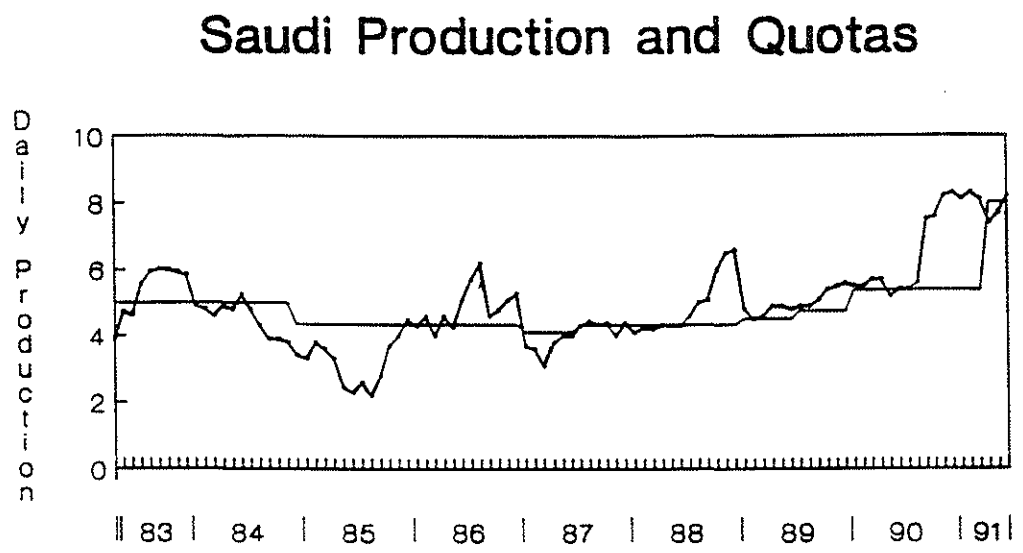
"Tit-for-tat" is a strategy designed to punish cheating by matching in some fashion the overproduction of other OPEC producers.[5] In practice, this means maintaining market share. Note in Figure 4 that for periods after August 1985, production in excess of quotas by other OPEC producers was matched by excess production by the Saudis. This strategy imposes costs on cheaters, but it tends to exacerbate price volatility. The monthly average spot prices for Saudi crude in Figure 5 show relative stability during the swing producer era versus price volatility during the ensuing "tit-for-tat" period.

The effectiveness of a "tit-for-tat" strategy hinges critically on whether other key OPEC producers join the Saudis in adopting a similar strategy and thereby increase the cost to the cheater. With only the Saudis acting as the enforcer, small OPEC producers may still find it attractive to cheat. Conversely, if all OPEC producers proportionally match cheating by any one member, the incentive to cheat is vitiated. It would seem that a policy where all OPEC producers adopt a "tit-for-tat" strategy of market share preservation would enable the cartel to deter cheating and thereby achieve the joint profit maximizing payoff for a monolithic cartel.

But pricing experience and continued cheating episodes since August 1985 indicate that the "tit-for-tat" strategy is not a very effective deterrent to cheating. The viability of "tit-for-tat" depends critically on the expectations of the responses of the various producers. Suppose a given producer announces that his quota is unjust and that he intends to henceforth exceed his official quota by 500,000 b/d, and produce his "fair" quota. If his decision is viewed as implacable, it does not pay the other members to punish him by playing "tit-for-tat" since in the process, they only punish themselves. Particularly, in a depressed market, individual members can easily concoct justifications for revising their quota market share. OPEC history since 1983 is replete with such examples. Perhaps in a strong market, "tit-for-tat" becomes a more effective deterrent because these types of justifications become less acceptable.

Examination of individual country produc-

5/ For a discussion of "tit-for-tat" in an experimental setting, see Axelrod (1984).



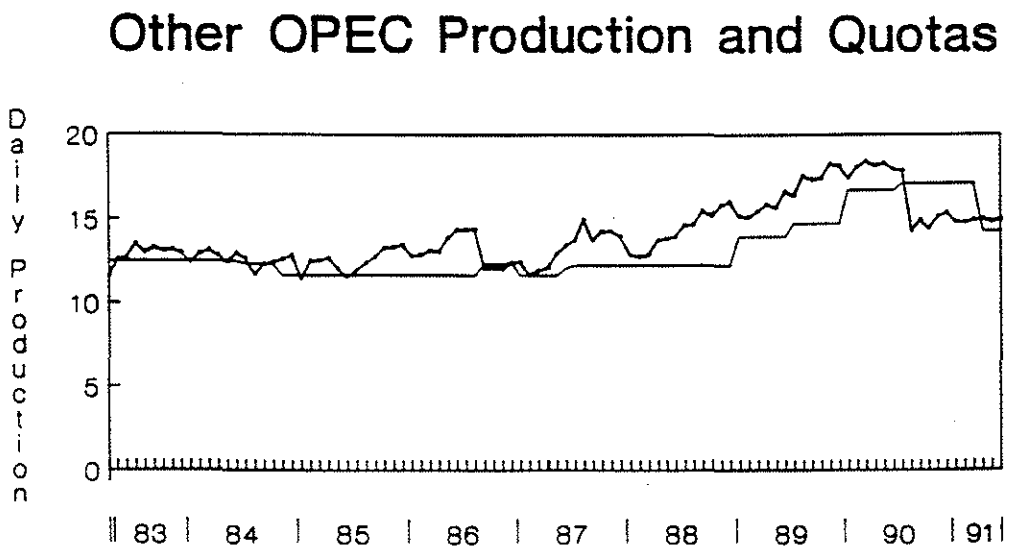


Figure 4: Saudi and Other OPEC Production and Quotas (millions of barrels)

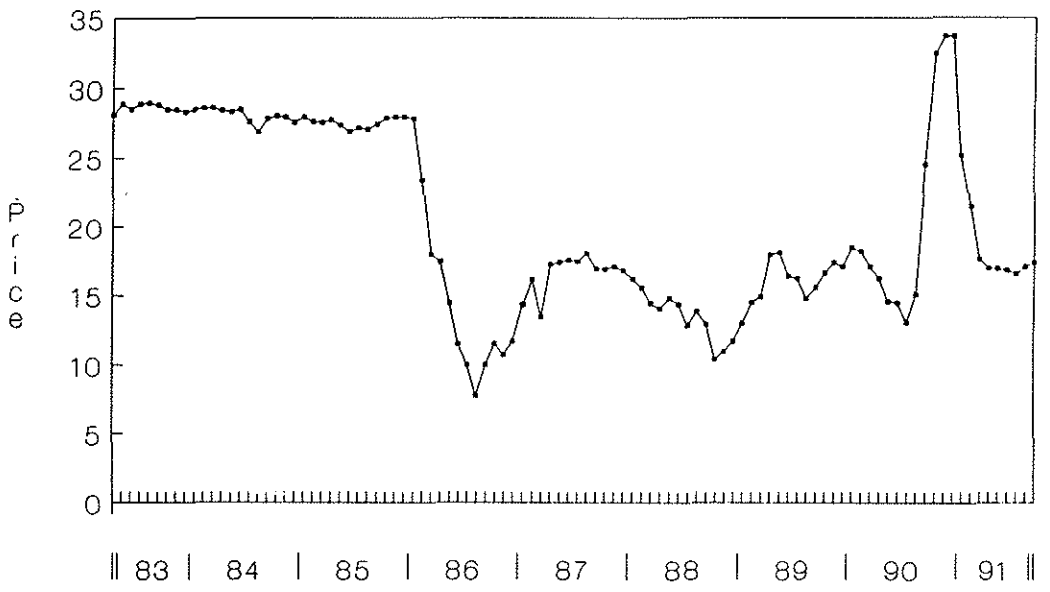


Figure 5: Saudi Light Spot Price

tion experience reveals that OPEC should not be characterized as a monolithic joint profit maximizing monopolist.[6] A popular categorization of OPEC follows Eckbo (1976) and Daly, Griffin, and Steele (1982) in assigning individual countries as either members of the cartel core, the price maximizers, or the output maximizers.[7] The output maximizers, are traditionally thought of as Iraq, Indonesia, Nigeria, Ecuador, and Gabon, because they tend to provide only minimal output restraint. The price maximizers have traditionally consisted of Iran, Venezuela, and Algeria; they exercise more output restraint and are willing to incur cutbacks to sustain higher prices. Finally, the cartel core, which usually includes Saudi Arabia, Kuwait, United Arab Emirates, possibly Qatar, and Libya, are treated as the residual suppliers. They possess huge reserves and face relatively low internal pressures for short run revenue maximization to finance internal investments. In effect, the cartel core is the key subgroup of OPEC that attempts to maximize its own wealth, given the response of the output and price maximizers. Consequently, for analytical purposes, the cartel core is the relevant maximizing entity. Their ability to cooperate in adopting a "tit-for-tat" strategy or some other cooperative strategy is critical. Given a pattern in the late 1980s of apparent disregard to their quotas by Kuwait and the United Arab Emirates, cohesion amongst the cartel core has been weak. Accordingly, there is the temptation to conclude that OPEC is ineffectual.

However, data on oil reserves compared to production rates argue against such an inference. Table 1 contrasts known reserves, production, and the number of years production could be sustained at 1989 production rates. For the cartel core, reserves are sufficient for 122 years at 1989 production rates. For the price maximizers, reserves are 75 times current production. For the output maximizers, reserves are 56 times production. Even though published estimates of OPEC "capacity" were 27.8 Mb/d in 1989, it is important to keep in mind that "capacity" is rapidly expandible in the Middle East with the drilling of additional wells. In 1990, there were only 6827 oil wells in the Middle East as com-

6/ For example, see Griffin (1985).

7/ For a discussion, see Griffin and Steele (1986), pp. 139-143. As noted in Griffin (1985) each OPEC producer has distinct behavioral characteristics so that even these three groupings represent an oversimplification.

Table 1: Selected Production, Reserves, and Capacity Data for OPEC Producers

	(1) Reserves 1/01/90 (10^9b)	(2) 1989 Production (10^9b)	(3) Reserves to Production Ratio (Years)
Cartel Core:			
Saudi Arabia	257.6	1.86	138.4
Kuwait	97.1	0.66	147.8
United Arab Emirates	98.1	0.73	134.4
Qatar	4.5	0.15	30.8
Libya	22.8	0.55	41.6
Group sub-total	480.1	3.94	121.8
Price Maximizers:			
Iran	92.9	1.06	87.8
Venezuela	59.1	0.69	85.2
Algeria	9.2	0.40	22.9
Group sub-total	161.2	2.15	74.9
Output Maximizers:			
Iraq	100.0	1.02	97.9
Indonesia	11.1	0.51	21.7
Nigeria	16.0	0.62	25.8
Ecuador	2.1	0.11	19.2
Gabon	1.8	0.07	24.7
Group sub-total	131.0	2.34	56.1
Total OPEC	772.3	8.43	91.6

pared to over 603,365 in the United States. To gain some idea of potential OPEC productive capacity we note that the US, UK, Norway, Canada, and Mexico maintained a production rate almost as great as total OPEC production on a reserve base one-sixth the size of OPEC reserves! As elaborated in Adelman's contribution to this volume (Adelman, 1992), the potential for intermediate term capacity expansion from known reserves is enormous; yet this has not occurred, indicating an impressive degree of production restraint. Consequently, notwithstanding the previous evidence of widespread cheating, the ability to resist large-scale capacity expansion is itself enough to give one pause. Perhaps this output restraint is justified on the basis of long term resource scarcity, but it may also have a simpler explanation — collusion.

III. Lerner Index Analysis

Theoretical Bases

While anecdotal evidence suggests that OPEC has been beset with both external and internal problems, the relative importance of each is unclear from the data. The focus of this section is to compute two separate Lerner indexes — one measuring **observed** market power and the other measuring **potential** monopoly power for the cartel core. By comparing the Lerner index of potential market power with the observed Lerner index, we can infer to what degree the price decline of the 1980s was a result of cartel disintegration or merely a diminution of the cartel core's monopoly power. Three possibilities exist. First, the observed Lerner index may be much less than the Lerner index of potential market power signalling the irrelevance of OPEC. Second, the observed and potential measures of market power may be approximately equal, leading one to conclude that the cartel core is successfully exercising the market power available to it. Third, to the extent that the observed Lerner index exceeds the Lerner index of potential market power, the cartel has miscalculated the long run profit maximizing price level and further price decreases are to be expected.

A traditional measure of monopoly power is the Lerner index (L), which is defined as the wedge between price (P) and marginal costs (C) relative to the market price:

$$(1) \quad L = \frac{P - C}{P}$$

The Lerner index has the nice property of varying between zero and unity with the former implying perfect competition and the latter describing a monopolist having maximum monopoly power. It can be applied to the case of a single firm monopolist or the more general situation in which a group or subgroup of producers, such as OPEC or the cartel core, exercises market power. Since the Lerner index defined in equation (1) is based on observed prices and estimates of costs, it serves as a measure of "observed"

market power.

Since cartels, like any other economic agents, can either miscalculate or fail to exercise their market power, it is useful to distinguish a separate Lerner index measure of potential market power, predicated on long run profit maximization. The Lerner index ($\hat{L}$) of potential market power, predicated on the cartel core maximizing long run profits, equals the inverse of the long run price elasticity of demand facing the cartel core (ε_{cc}):[8]

$$(2) \quad \hat{L} = \frac{1}{\varepsilon_{cc}}$$

Note that $\hat{L}$ need not equal L for several reasons. For example, cheating within the cartel core can prevent the cartel core from achieving its potential market power ($\hat{L} > L \approx 0$). Another possibility is that neither the long run price elasticity facing the cartel core nor costs (including user costs) are known precisely, so that the observed Lerner index can even exceed the potential Lerner index ($L > \hat{L}$). Also, L can differ from $\hat{L}$ if the cartel eschews long run profit maximization.

Estimates of Elasticities and Costs

In order to estimate the Lerner index of potential market power, it is necessary to measure the price elasticity of demand facing the cartel core (ε_{cc}) in equation (2). The price elasticity of demand[9] facing the cartel core (ε_{cc}) depends on the price elasticity of demand for oil (ε_w), the supply elasticity from non-OPEC countries (ε_{no}), the supply elasticity from other OPEC countries outside the cartel core (ε_{oo}), and market shares as follows:

$$(3) \quad \varepsilon_{cc} = \frac{Q_w}{Q_{cc}} \varepsilon_w + \frac{Q_{no}}{Q_{cc}} \varepsilon_{no} + \frac{Q_{oo}}{Q_{cc}} \varepsilon_{oo}$$

where the Q's reflect the relevant quantities produced by the various groups. At the outset, it should be noted that because of the substantial range of various elasticity estimates, any measure of the price elasticity of demand facing the cartel core and thus $\hat{L}$, the Lerner index of potential market power, must be viewed as only an approximation.

The price elasticity of demand for crude oil is a derived demand based on the price elasticity of demand for finished petroleum products. Therefore, it is first necessary to estimate an aggregate price elasticity of demand for petroleum products and then apply a price markup between crude oil and the finished petroleum products resulting from that barrel of oil to compute the price elasticity of crude oil demand. As described in the Appendix, a panel data set, for nine OECD countries over the period 1960 to 1984, was utilized to estimate a long run price elasticity for petroleum products of 1.04 (in absolute value). Based on the 1990 markup of crude costs to final petroleum products price of .36, this implies a price elasticity of crude oil demand of .37.[10]

Estimates of non-OPEC supply elasticities vary considerably, depending on the source. Based on estimates from the Energy Modelling Forum and the International Energy Workshop (Manne, 1988), we assume a long run price elasticity of supply for non-OPEC countries (ε_{no}) of .4. For the eight other OPEC countries, not included in the cartel core, supply elasticity estimates are very problematic, but because of their likely small magnitude, absolute errors tend to be small. The price maximizers may actually decrease production at higher prices, whereas the output maximizers (Iraq, Indonesia, Ecuador, Gabon, and Nigeria) are likely to respond

8/ As in the original Lerner paper, all demand elasticities are reported in absolute terms for expositional simplicity. This result follows from the profit maximizing condition that marginal revenue (MR) equals marginal costs (C):

$$P (1 + 1/\varepsilon_{cc}) = MR = C.$$

With algebraic manipulation, equation (2) holds.

9/ We use the long run price elasticity estimate recognizing that it overstates the exact measure outlined in Pindyck (1985) — a discounted weighted average of dynamic elasticities derived from an optimal control solution.

10/ In the Energy Modelling Forum's *World Oil Project*, a long run price elasticity of demand for primary crude oil was assumed to be .6.

more like non-OPEC, competitive fringe producers. It seems likely that for the group as a whole, the elasticity of supply is considerably more inelastic than for the non-OPEC producers. Accordingly, we have set the elasticity of supply (ε_{oo}) at .1. Combining these elasticity estimates together with market share data enables calculation of the long run price elasticity of demand facing the cartel core.

In order to compute the Lerner index of observed market power, estimates of marginal costs are necessary. The non-renewable nature of petroleum poses a problem, because marginal costs include a user cost measure in addition to the marginal extraction costs. User costs have proven difficult to measure accurately (Pindyck, 1985) because the stock of potential oil reserves recoverable at any given price is continually changing due to technological change.

For purposes here, we use the estimate derived in the next section showing that a competitive market price in 1990 would have been roughly $8.50 per barrel, escalating at a 5% real discount rate.[11] Projecting this price path backward in time at a 5% real discount rate gives a series of implied cost estimates. For 1970, the cost estimate works out at $3.13 per barrel (expressed in 1990 dollars). Given the sizeable standard error that must be attached to these estimates, it seems reasonable to conclude that it does not differ statistically from the $3.95 per barrel standard price observed in 1970.

Lerner Indexes: Observed vs. Potential Market Power

Shown in the last two columns of Table 2 are the price elasticity of demand facing the cartel core (ε_{cc}) and the Lerner index of potential market power ($\hat{L}$) for the period 1970 to 1990. The price elasticity of demand facing the cartel core ranges from 1.05 in 1970 to 4.52 in 1985. The relatively low elasticities in the early 1970s are attributable to the extremely price inelastic nature of world oil demand at the time. Crude oil constituted only 13% of the weighted average retail price of petroleum products in 1970, making the price elasticity for the crude oil only .13.

The Lerner index of potential market power in

Table 2: Calculation of Lerner Index of Potential Market Power and Lerner Price

Year	Actual Price (1990$/b)	Costs (C) (1990$/b)	Observed Lerner Index (L)	Potential Lerner Index ($\hat{L}$)	Cartel Core Elasticity (ε_{cc})
1970	3.95	3.13	.21	0.95	1.05
1971	4.92	3.29	.33	0.92	1.09
1972	5.20	3.46	.34	0.94	1.07
1973	7.73	3.63	.53	0.84	1.20
1974	26.57	3.82	.86	0.45	2.24
1975	24.79	4.02	.84	0.46	2.18
1976	25.32	4.22	.83	0.49	2.05
1977	25.87	4.44	.83	0.50	2.01
1978	24.21	4.66	.81	0.47	2.12
1979	33.58	4.90	.85	0.46	2.19
1980	49.67	5.16	.90	0.41	2.47
1981	49.17	5.42	.89	0.39	2.57
1982	42.11	5.70	.86	0.31	3.28
1983	35.20	5.99	.83	0.28	3.55
1984	33.70	6.30	.81	0.26	3.88
1985	30.56	6.62	.78	0.22	4.52
1986	14.43	6.96	.52	0.40	2.52
1987	18.65	7.32	.61	0.34	2.97
1988	14.32	7.69	.46	0.42	2.40
1989	17.59	8.09	.54	0.40	2.52
1990	20.39	8.50	.58	0.42	2.40

$$L = \frac{P-C}{P}; \hat{L} = \frac{1}{\varepsilon_{cc}}; \varepsilon_{cc} = \frac{Q_w}{Q_{cc}}\varepsilon_w + \frac{Q_{no}}{Q_{cc}}\varepsilon_{no} + \frac{Q_{oo}}{Q_{cc}}\varepsilon_{oo}$$

Table 2 tells a very revealing story. Note that in the early 1970s, the Lerner index stood at .95, signalling that the cartel core possessed immense market power. As noted above, this occurred because crude oil costs were such a minor part of the price of final petroleum products, making the price elasticity of demand (ε_w) for crude oil extremely low. As prices rose in 1974, the price elasticity of world demand increased because oil prices by 1974 constituted 55% of the value of refined products, causing the Lerner index to fall sharply to .45. In addition, from 1974 until 1985, the Lerner index continued to fall as production outside the cartel core expanded and the cartel core's production contracted. For exam-

11/ Note that this estimate is based on the following key assumptions: (1) a 5% real discount rate, (2) a $50 per barrel backstop fuel price, and (3) existing oil reserves plus E.I.A. estimates of undiscovered potential reserves.

ple, the ratio of non-OPEC to cartel core production rose from 3.05 in 1974 to 5.67 in 1985. Since 1985, the Lerner index has increased partially due to the decrease in the price elasticity of oil demand (due to oil prices constituting a smaller proportion of the price of finished products) and increased relative production by the cartel core.[12]

Also shown in Table 2 is the observed Lerner index and its key ingredients — prices and costs. Note that all prices and costs are expressed in constant 1990 dollars. The observed Lerner index indicates that until 1973-74, the extent of observed market power was small, ranging from .21 to .34. Indeed, given the sizeable standard error that must be attached to the estimate of costs, it is unclear that OPEC exercised appreciable market power until the Arab Oil Embargo in fall 1973.

The Arab Oil Embargo and subsequent price spike vividly illustrates how the observed Lerner index rose to .86 by 1974, yet the potential Lerner index falls to .45 by 1974, reflecting the fact that at higher prices, demand is much more price elastic. Throughout the remainder of the 1970s, the observed Lerner index varied from .81 to .9, while the Lerner index of potential market power ranged from only .41 to .50. This wide disparity suggests either that the cartel core had opted to maximize short run as opposed to long run profits or, more likely, that they severely underestimated the magnitude of the long run price elasticity. During this period, the cartel core probably believed it faced a much more inelastic long run demand schedule than in fact existed. Given the significant lags in adjustment to long run supply and demand functions, it is not surprising that the cartel core could make such an error, especially given the widespread view in the 1970s that demand and supply responses were very price inelastic.

Comparison of observed and potential measures of market power suggests that the post 1974 prices were not sustainable and that the downward price adjustments in the 1980s were inevitable. But rather than implying the ineptness of OPEC, the more likely explanation is miscalculation. By 1988, the observed and potential Lerner index measures equilibrated.

IV. Price Paths for the 1990s Under Alternative OPEC Configurations

The Lerner analysis suggests that the prices of the early 1980s far exceeded the prices sustainable by the cartel, so that OPEC's achievements of the 1970s were illusory. Consequently, the market adjustments of the 1980s are interpretable as a predictable reaction to the excesses of the late 1970s, rather than evidence for the disintegration of OPEC. But what implications does this have for prices in the 1990s? Does it follow that the 1990s will be a rerun of the 1970s, like an old movie?

This section utilizes OPEC Genie, a LOTUS spreadsheet simulation program designed to calculate the present values of oil revenues to OPEC and the cartel core for alternative price paths. For any price path specified by the user, the model first computes demand in the market and non-market economies, and oil production outside OPEC. Next, the model then apportions the remaining unmet oil demand among the output maximizers, and the price maximizers, leaving the cartel core to supply the residual. An important feature of OPEC Genie is that it tracks reserves for individual OPEC countries and simulates to the year 2050, and then values all remaining reserves. Genie allows the user to specify the price of the backstop fuel. In these simulations, we assume that tar sands and oil shales place an effective long-term price limit on oil of $50 per barrel in 1990 dollars. For any given price path specified by the user, the model solves for the supply and demand profiles and the net present value to total OPEC, the cartel core, and Saudi Arabia. By varying the initial price and the escalation rate, we can contrast the payoff of the various price paths.[13]

Shown in Figure 6 are three price paths

12/ From 1985 to 1990, the ratio of non-OPEC production to cartel core production fell from 5.67 to 3.75.

13/ The competitive price path is obtained by searching over the initial 1990 price, which requires that the price path rise at the real discount rate (5%) until reaching the backstop price. The $ 8.50 initial price in 1990 satisfies the condition that existing plus potential reserves are sufficient to meet demand along this price path.

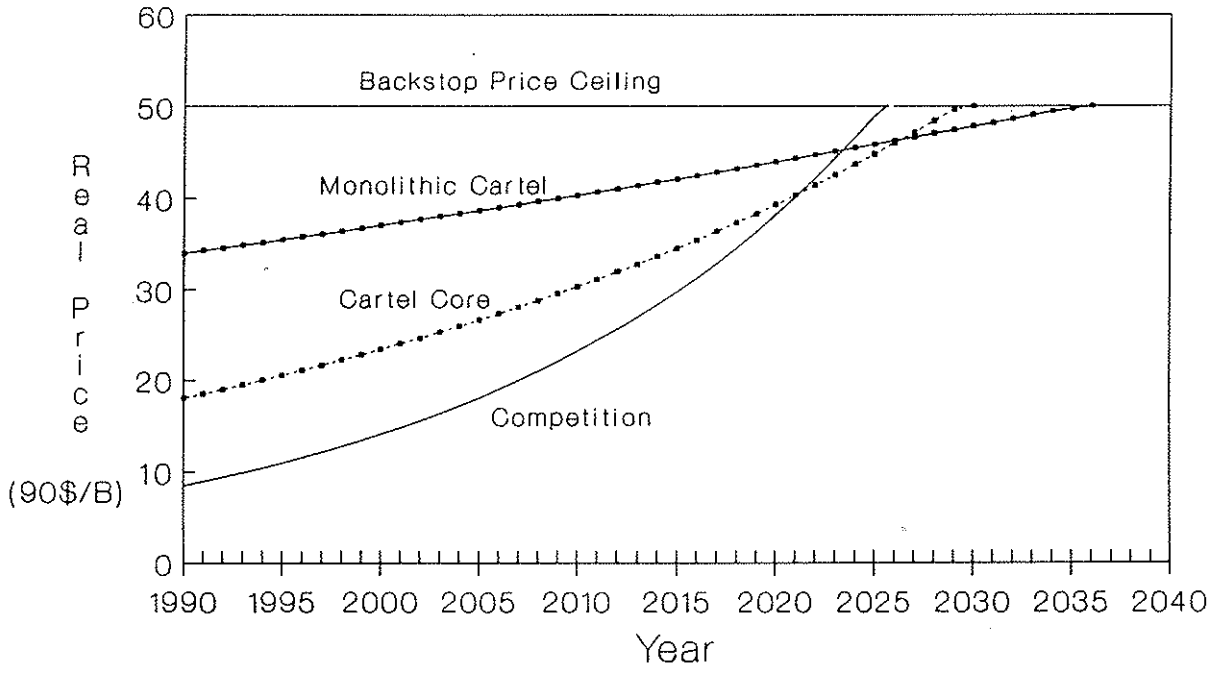


Figure 6: Comparison of Price Paths

illustrating the importance of OPEC for oil prices in the future.[14] The "monolithic OPEC" price path implies a current price of $34 per barrel with prices thereafter rising at a .85% real annual rate until the backstop fuel price is reached in 2036. The price path labeled "cartel core" shows the price path preferred by the cartel core. Its current price is $18 per barrel and increases at a 2.6% real annual rate until 2030, when the price reaches the backstop at $50 per barrel. The price path labeled competitive begins at $8.50 per barrel and escalates at a 5% rate, reaching the backstop price of $50 per barrel in the year 2026. With prices escalating at the real discount rate, we have the well known Hotelling (1931) result assuming negligible extraction costs.

The economic returns, shown in Table 3, corresponding to the three price scenarios in Figure 6 differ substantially because of the timing of oil production. Under the competitive price path, the bulk of reserves are produced sooner at relatively lower prices. This explains why the net present value to the total cartel is $7.42 trillion for the competitive price path. Conversely, the monolithic cartel price path features very high initial prices and slower production. Because of short run rigidities in oil demand and non-OPEC supply, the cartel can exploit its short run monopoly power and earn a return of $9.27 trillion. Even though this strategy means that OPEC produces the bulk of its reserves beyond the year 2010, the price is still higher than with the competitive price path.

The most interesting results in Table 3 pertain to the returns of the cartel core versus other OPEC. From the perspective of the cartel core, the cartel core's price path is preferred, yielding $4.55 trillion. But the competitive price path yields almost as much ($4.39 trillion). The monolithic cartel price path yields the cartel core considerably less ($3.87 trillion). The explanation is that because the cartel core is the residual sup-

14/ All results are predicated on a 5% real discount rate.

Table 3: Net Present Values Corresponding to Alternative Price Paths (10^{12} 1990$)

	Competitive Price Path	Cartel Core Price Path	Monolithic Cartel Price Path
Cartel Core	4.39	4.55	3.87
Other OPEC	3.03	4.09	5.41
Total OPEC	7.42	8.64	9.27

plier, it would be the prime beneficiary of the rapid demand growth at lower prices. With prices rising at 5% or less in real terms, the net present value of current oil sales is higher than deferring production into the distant future.

Whereas the cartel core has a clear preference for lower prices, the other OPEC producers strongly prefer higher initial prices. Indeed, other OPEC's return rises from $3.03 trillion with the competitive price to $5.41 trillion at the monolithic cartel price path. The rationale is straightforward, the other OPEC members, particularly the output maximizers, would not sustain any significant output reductions at the higher prices, leaving instead the bulk of the output reductions to the cartel core. With roughly equivalent production profiles, the other OPEC producers prefer the higher initial price.

The implications of these findings for oil prices in the 1990s lead to the following conclusions. First, the returns to monopolization are substantial. The existence of a $1.85 trillion reward for successful monopolization is enough to keep OPEC trying. Second, the potential for price instability is great. Even besides the type of short run price fluctuations triggered by political upheavals such as the Iraqi occupation of Kuwait, changing alliances within OPEC could produce price oscillations ranging from the monolithic OPEC outcome to the competitive outcome.[15] Third, the cartel core producers are painfully aware that their economic interests favor lower prices, while the other OPEC members favor high prices. Indeed, if the cartel core must err, it is far better for prices to be too low than too high. Corresponding to these lower prices are steadily rising production rates by the cartel core reaching 33 Mb/d by the turn of the century and 46 Mb/d by 2010. The question for the 1990s is whether these production increases will be accommodated or whether productive capacity will be frozen at say 27 Mb/d with prices rising sufficiently to stabilize production at the lower production levels. Wealth maximizing behavior suggests that the necessary capacity expansions will occur.

V. Conclusions

Yes, the Genie is still out of the bottle. The returns to monopolization are large and despite the price decline of the 1980s, OPEC is alive and performing well under the circumstances. The Lerner analysis suggests that the price levels of the late 1970s were not sustainable even with a perfectly disciplined cartel core. Long run supply and demand elasticities no doubt turned out to be much greater than OPEC anticipated.

Even though cheating contributed to OPEC's predicament in the 1980s, the primary determinant of the oil price decline of the 1980s was external market forces. It must be remembered, however, that OPEC has shown remarkable restraint if measured relative to their potential to expand productive capacity.

Looking ahead to the future, we emphasize the scope for price instability both for political and economic reasons. Even though the monolithic cartel price path seems unlikely to be sustainable in the long run given current OPEC institutions, temporary successes are possible. The more likely scenario is that prices will oscillate around the cartel core's optimal price path that features prices in today's range rising moderately in real terms.

15/ The existing institutional structure of OPEC, with production decisions resting directly with the sovereign nation states, appears to preclude the type of cooperation necessary to sustain the monolithic outcome. In principle, strategies such as "tit-for-tat" have the potential of supporting the monolithic outcome without requiring organizational control over members' production, but as discussed earlier, the approach is only an effective deterrent to cheating if it is credible that all members will follow "tit-for-tat."

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Appendix: Calculation of Long Run Price Elasticity of Non-Communist World Oil Demand

The demand model presented here differs from existing analysis in several respects. First, attempts to estimate the demand for crude oil often overlook the fact that crude oil is a derived demand based on the demand for the composite petroleum products resulting from a barrel of crude oil. Accordingly, the relevant price affecting demand is a composite of finished petroleum products consisting of gasoline, heating oil and so forth. Second, a panel data set of nine OECD countries is used for the period 1955-84 to estimate the oil demand equation. International differences in taxes on petroleum products leads to significantly more inter- and intra-country price variation — a prerequisite for more efficient estimation. Third, the demand specification follows Daly, Griffin and Steele (1982) in postulating that economic activity (measured by real Gross Domestic Product (GDP)) impacts oil demand directly, whereas interfuel and oil/non-energy substitution occurs with a distributed lag as the stock of oil consuming capital is reconfigured:

$$\text{(A.1)}\quad ln\ OIL = \alpha + \beta\ lnGDP + \frac{\gamma_0}{1-\lambda L} ln\ POIL_t + \frac{\gamma_1}{1-\lambda L} ln\ PGAS + \frac{\gamma_2}{1-\lambda L} ln\ PCOAL + \varepsilon_t$$

where the latter three variables are the prices of oil, gas, and coal respectively.

Transforming (A.1) and estimating by non-linear least squares, we obtain:

$$ln\ OIL_t = \Sigma c_i D_i + \underset{(11.4)}{.93}\ ln\ GDP_t - .744\ ln\ GDP_{t-1} - \underset{(13.3)}{.226}\ ln\ POIL_t + \underset{(1.6)}{.021}\ ln\ PGAS + \underset{(41.4)}{.042}\ ln\ PCOAL_t + \underset{(41.4)}{.783}\ ln\ OIL_{t-1}$$

$$R^2 = .998 \quad se = .047$$

This specification yields an implied elasticity with respect to GDP of .93, which accords closely with that found by the Energy Modelling Forum (1982). As expected, coal and natural gas are substitute fuels. The short run price elasticity of demand is .226, whereas the long run own price elasticity is 1.04.

The latter estimate is not directly comparable to elasticity estimates based on the price of crude oil, but adjusting for the markup in finished petroleum products over crude prices, the 1987 long run price elasticity is .37. The latter compares reasonably with the estimates surveyed by Manne (1988), which range from .35 to .6.