

*Archive*

Some Long-Term Problems in OPEC Oil Pricing<sup>\*</sup>

by

Robert S. Pindyck

December, 1978

Working Paper # MIT-EL 78-028WP

\*The research leading to this paper was conducted as part of the MIT World Oil Project, and was funded by the RANN Division of the National Science Foundation under Grant No. DAR78-19044. The support of the NSF is greatly appreciated, as is the excellent research assistance of Tom Cauchois.

## Some Long-Term Problems in OPEC Oil Pricing

### 1. Introduction.

In several recent articles [1,3,4] I have examined OPEC's oil pricing problem on the basis of economic maximization. One might argue that the pricing behavior of a cartel such as OPEC is more the result of evolving political factors, but in fact most cartels set their prices over time in ways that tend to maximize economic objectives. So far OPEC has done more or less the same thing, and to the extent that it continues to do so, economic maximization should provide a reasonable basis for explaining and forecasting the price of oil.

I have calculated optimal pricing policies for OPEC using a small model that quantitatively describes the characteristics of total world oil demand (and its response to income growth and price changes), non-OPEC oil supply (and its response to price changes as well as resource depletion over time), resource depletion within OPEC, and the different levels of reserves and different rates of time discounting among OPEC members. The model calculates a price trajectory for OPEC that maximizes its sum of present and future discounted profits. Using the model we found OPEC's best price for 1978 to be about \$12/barrel in 1975 dollars, or some \$14-15/barrel in 1978 dollars -- just slightly above the actual price. Furthermore, in real terms, this price should grow by only about 2% per year over the next ten years, and slightly faster over the following ten or fifteen years. A number of sensitivity studies indicated that these results are rather robust with respect to assumptions about the characteristics of demand and supply response, the choice of discount rates, etc.

Given these results, it would appear that OPEC's pricing problem has

a reasonably clear solution, at least for the short term. The price of oil should rise only slightly in real terms, and given the rates of inflation that have prevailed over the past year, together with the changes that have taken place in the relative values of the dollar and several other key currencies, this means a rate of nominal price increases in the vicinity of 10% per year. In fact, this will effectively be the rate of growth of price over the coming year as a result of the recent OPEC meeting in Abu Dhabi.

There are now a number of problems, however, that make OPEC's optimal price in the longer term somewhat uncertain. Two problems in particular are causing growing concern to cartel members. The first is over the allocation of production cutbacks: to what extent may Saudi Arabia and a few other producers have to carry a growing share of these cutbacks, and at what cost? The second problem is the threat raised by the possibility of large scale Mexican oil production: if Mexico becomes a major producer over the next five to ten years, to what extent would this erode OPEC's monopoly price? The answers to these questions are important determinants of OPEC's ability to maintain its monopoly price over the longer term, and are therefore of interest to oil importing countries like the United States, as well as the cartel.

Saudi Arabia, Kuwait and the Emirates have indeed endured the largest percentage of production cutbacks (they have recently been producing at about 60% of capacity), but other OPEC members have also cut back their production. So far this, Libya, Iraq and Nigeria have been producing at about 75% of their maximum sustainable capacities, Iran -- before the strikes that shut down the oil fields -- was producing at about 80% of capacity, while production of other OPEC members has ranged between 85 and 100% of capacity.

There is some question, however, as to how many OPEC members will be able (or willing) to hold production down in the future. Although OPEC as a whole has accumulated a total surplus of some \$170 billion since 1973, only five of the thirteen members -- Saudi Arabia, Kuwait, the Emirates, Qatar and Libya -- are now running annual surpluses. The other members are dipping into their reserves to finance import needs, or, as in the case of Iran, borrowing heavily from abroad.

Furthermore, the squeeze is likely to become much greater in the years ahead. Countries such as Iran, Algeria, Indonesia and Venezuela launched development plans and made import commitments on the assumption of a sustained level of oil revenues. But OPEC revenues will fall as world oil demand and non-OPEC supplies continue to adjust to the price increases that have already occurred a few years ago. As a result, OPEC's cash-hungry members may be even less willing to produce below capacity in the future.

If Saudi Arabia, Kuwait and the Emirates are left alone to maintain a cartel price, their economic interests would be best served by a reduction in that price (a reduction which would further squeeze the cash-hungry producers, making them still less willing to absorb cutbacks). At issue is the extent to which the monopoly price would fall.

Another potential problem for OPEC is the possible emergence of Mexico as a major oil producer. Although there have been conflicting estimates, it now appears that Mexico has potential recoverable oil

reserves of 150 to 300 billion barrels. (Saudi Arabia has proved reserves of 150 billion barrels, and potential reserves of about 500 billion barrels.) Mexico's production today is just over one million barrels per day, but is expected to increase to over 2 mb/d by 1980. It is conceivable that by 1987 or 1988 Mexican production could reach 7 or 8 mb/d, about equal to current Saudi production.

A major increase in Mexican production would reduce the net demand for OPEC oil, and thereby reduce the revenue-maximizing price that OPEC could set. The question is how much it might reduce the price. Can the importing countries look to Mexico to return them to an era of cheap oil?

We have used our model of optimal OPEC oil pricing to roughly measure the possible impact of a shifting burden of production cutbacks to the Saudis and a few other countries, and of increases in Mexican production. We find that the problem of allocating production cutbacks is likely to be the most serious threat to OPEC's ability to maintain a high price. A high level of Mexican production would also serve to depress the monopoly price, but not by a very large amount. However, Mexican production would significantly erode the flow of OPEC profits.

In the next section we briefly review the structure of our optimal OPEC pricing model. We also present the optimal price and production trajectories obtained previously from that model, since they will serve as a "base case" for determining the impacts of a reallocation of production cutbacks and an increase in Mexican production. Next, we use the model to examine the longer term issues that we have just raised. We conclude with some remarks about the evolution of world oil markets, and the implications for U.S. policy.

## 2. The Calculation of Optimal Prices for OPEC.

OPEC's economic interests are best served by adjusting the price of oil so that it always maximizes the flow over time of all current and discounted future revenues, i.e. so that it maximizes the equity value of OPEC's oil reserves. There are a number of important issues that affect the determination of OPEC's optimal price. First, the demand for cartel oil is a "residual" demand -- that is, the difference between total (non-Communist) world demand for oil and the supply of oil from non-cartel countries. This residual demand is particularly sensitive to price, since increases in price tend both to decrease total demand as well as increase non-cartel supply.<sup>1</sup> Of course, the impact of a price change occurs only slowly, since total demand and non-cartel supply depend on stocks of energy-consuming and energy-producing capital that cannot be converted or shifted rapidly. This would suggest that OPEC might try to make a "quick killing" by steeply increasing the price, taking advantage of the fact that the demand for its oil would fall only after a delay of several years. Such a strategy could indeed work, but only once, and at that only in moving from a period in which the world had been used to low oil prices to a period of high oil prices, i.e. it could work (and did work) in 1973-74. In fact, it explains why the price of oil has dropped in real terms from 1974 to 1978.<sup>2</sup>

---

1. For a discussion of the characteristics of world oil demand, and world energy demand in general, see R.S. Pindyck, The Structure of World Energy Demand, MIT Press, Cambridge, MA.

2. It is important to stress that such a quick killing strategy would not work now with the world in a high oil price equilibrium. Sharply increasing the price of oil again would certainly increase short term revenues, but it would diminish future revenues much more, and would therefore be undesirable to OPEC members (unless they are extremely short-sighted, and there is no evidence to indicate that this is the case).

Another important consideration is the fact that OPEC's oil resources are finite, and will eventually run out. This does not mean, however, that OPEC should sharply increase price and cut production in order to conserve its resources for the future. Over-conservation is as bad as under-conservation, since it simply reduces the net value of a resource to its owner. OPEC's problem is to find a way to exploit its resources so as to balance the revenue obtained today from current production with the (discounted) revenues that could be obtained from future production. This, in fact, is just the problem facing any producer of an exhaustible resource, and its solution usually calls for smooth and gradual changes in price.

These considerations were incorporated into a dynamic optimal pricing model for a monopolistic oil cartel. We review that model here, since it provides the basis for our analysis in this paper.

The world oil market is described by the following equations, all of which were parameterized to be consistent with the reserve, production, and elasticity estimates of the OECD, and with average elasticity estimates obtained from aggregate time series data:

$$TD_t = 1.0 - 0.13P_t + 0.87TD_{t-1} + 2.3(1.015)^t, \quad (1)$$

$$S_t = (1.1 + 0.10P_t) \cdot (1.02)^{-CS/7} + 0.75S_{t-1}, \quad (2)$$

$$CS_t = CS_{t-1} + S_t, \quad (3)$$

$$D_t = TD_t - S_t, \quad (4)$$

$$R_t = R_{t-1} - D_t, \quad (5)$$

$TD_t$  = total demand for oil (billions of barrels per year),  
 $D_t$  = demand for cartel oil (bb/yr),  
 $S_t$  = supply of competitive fringe (bb/yr),  
 $CS_t$  = cumulative supply of competitive fringe (bb),  
 $R_t$  = reserves of cartel (bb),  
 $P_t$  = price of oil (\$ per barrel), in real 1975 dollars.

The demand equation (1) is based on a total demand of 18 billion barrels per year at a price of \$6 per barrel, and at that price the short-run and long-run price elasticities are 0.04 and 0.44, respectively (with a Koyck adjustment), while at a \$12 price the elasticities are 0.09 and 0.90 respectively. The last term in the equation provides an autonomous rate of growth in demand of 1.5% per year, corresponding to a long-run income elasticity of 0.5 and a 3% real rate of growth in income. Eq. (2) determines supply for the competitive fringe, and is based on a level of 6.5 billion barrels per year at a \$6 price. The short-run and long-run price elasticities are 0.09 and 0.35, respectively, at the \$6 price, and 0.16 and 0.52, respectively, at a \$12 price. Depletion of competitive fringe reserves pushes the supply function to the left over time. After a cumulative production of 210 billion barrels (e.g. 7 bb/yr for 30 years) supply would fall (assuming a fixed price) to 55% of its original value.<sup>3</sup>

The objective of the monopolistic cartel is to maximize the sum of discounted profits,

---

3. There is no fixed upper bound on cumulative production by competitive fringe countries; there is always some price at which additional supplies would be forthcoming. For example, after 210 billion barrels have been produced, a price of \$18.50 would be needed to maintain production at 6.5 bb/yr.



$$\text{Max } W = \sum_{t=1}^N \frac{1}{(1+\delta)^t} [P_t - 250/R_t] D_t. \quad (6)$$

Here the average cost of production for the cartel rises hyperbolically as  $R_t$  goes to 0. The initial reserve level is taken to be 500 billion barrels, and initial average cost is 50¢ per barrel. The planning horizon  $N$  is chosen to be large enough to approximate the infinite-horizon problem ( $N = 40$  years usually provides a close enough approximation).

Since average costs become infinite as  $R_t$  approaches 0, a resource exhaustion constraint need not be introduced explicitly, so that eqs. (1) to (6) represent a classical, unconstrained, discrete-time optimal control problem, and numerical solutions are easily obtained. The optimal price trajectory for a discount rate of .05, OPEC production, OPEC reserves, and discounted profits are given in Table 1.

Observe that the optimal monopoly price is \$13 to \$14 in the first year (1975), declines over the next 5 years to around \$10, and then rises slowly. This price pattern is a characteristic result of incorporating adjustment lags in the model -- it was optimal for OPEC to charge a higher price initially, taking advantage of the fact that net demand can adjust only slowly. Of course, these results are dependent on the particular model and parameter values described above. However, changing the model's parameters has only a small effect on the numerical results. For example, if the elasticities (short- and long-term) of total demand are doubled, optimal prices decrease by less than 20%. Doubling the elasticity of competitive supply results in a decrease in price of about 10%. Replacing the total demand and competitive supply equations with isoelastic equations (using the \$6 elasticities from the linear equations) results in price tra-

jectories that are within 15% of those reported in Table 1. Finally, doubling or halving initial OPEC production costs, or changing the initial level of OPEC reserves from 500 billion barrels to 800 billion barrels has little effect (less than 10%) on the optimal price trajectory.

Table 1: Base Case Solution

$t$	$P^*$	TD	D	R	$\Pi_d$
1975	13.24	17.24	9.94	488.5	126.5
1976	11.19	16.88	9.23	478.6	93.8
1977	10.26	16.72	8.94	469.3	78.9
1978	9.90	16.66	8.87	460.4	71.7
1979	9.82	16.66	8.91	451.5	67.9
1980	9.88	16.69	9.00	442.6	65.7
1985	10.84	16.96	9.67	396.3	60.6
1990	11.98	17.32	10.40	346.5	56.3
1995	13.18	17.74	11.15	293.0	51.8
2000	14.46	18.22	11.91	235.7	47.1
2005	15.92	18.75	12.66	174.6	42.5
2010	20.29	18.67	12.55	110.5	41.0

\* in 1975 dollars

3. Output Allocations, Mexican Oil, and The Optimal Cartel Price.

In Table 2 we show the proved reserves, production capacity, and actual production level for each of the OPEC countries. The countries are divided into two groups, the first of which consists of "saver" countries with less immediate need for cash, and the second consists of "spender" countries with greater immediate needs for cash. Note that the "saver" countries also have much higher reserve levels; the average reserve production ratio for the first group of countries is 54.2, while it is only 26.1 for the second group. Note also that the largest production cutbacks

Table 2: OPEC Capacity and Production\*  
(in billions of barrels)

	<u>RESERVES</u>		<u>CAPACITY</u>	<u>PRODUCTION</u>		
	1975	1978	1978	1975	1977	1978
ABU DHABI	29.5	31.0	} .95	.51	.61	.53
BAHRAIN	.3	.3		.02	.02	.02
DUBAI	1.3	1.4		.09	.12	.13
IRAQ	34.3	34.5	1.17	.82	.81	.88
KUWAIT	68.0	67.0	1.10	.75	.65	.62
NEUTRAL ZONE	6.4	6.2	.26	.16	.13	.14
QATAR	5.8	5.6	.26	.16	.16	.17
SAUDI ARABIA	148.6	150.0	4.20	2.58	3.29	2.74
LIBYA	26.1	25.0	.91	.54	.75	.69
TOTAL	320.3	321.0	8.85	5.63	6.54	5.92
% INCREASE		---			16%	-9.5%
IRAN	64.5	62.0	2.55	1.95	2.07	2.05
ALGERIA	7.4	6.6	.44	.35	.34	.37
GABON	2.2	2.1	.11	.07	.08	.08
NIGERIA	20.2	18.7	.88	.65	.77	.62
INDONESIA	14.0	10.0	.66	.48	.62	.61
ECUADOR	2.4	1.6	.07	.06	.07	.07
VENEZUELA	17.7	18.2	.88	.86	.82	.76
TOTAL	128.4	119.2	5.59	4.42	4.77	4.56
% INCREASE		-7.1%			7.9%	-4.4%

\* -- Reserves as of 1/1/76 and 1/1/78, Oil and Gas Journal,

-- Capacity as of 9/78, Petroleum Industry Weekly,

-- Production in yearly amounts, 1978 annualized from 7 months, O.G.J.

have been absorbed by the first group of countries. In 1978 the average rate of capacity utilization was .67 for the first group, and .82 for the second group.

It is important to stress that although capacity utilization is higher in the second group of countries, it is still well below 1, and this has contributed to the ability of the cartel to maintain recent prices. We would now like to determine how the optimal cartel price would change if only Saudi Arabia and perhaps a few other countries had to bear the burden of all production cutbacks.

To do this, we assume first that the cartel consists only of Saudi Arabia, Kuwait, Qatar, and the Emirates (Abu Dhabi, Bahrain, and Dubai). The other OPEC countries are assumed to produce at capacity (independent of price), which is taken to decrease from its actual 1978 level at a rate of depletion equivalent to that in the competitive fringe countries. In other words, the depletion factor that was introduced in eq. (2) for the competitive fringe is also applied to the exogenous production level of these other OPEC countries. The optimal pricing decision therefore resides with Saudi Arabia and the other "core" countries just mentioned, given the exogenous production of the other OPEC countries and given the supply function for the competitive fringe.

To take this one step further, we also examine the implications of Saudi Arabia absorbing all production cutbacks by itself. Now every OPEC country except for Saudi Arabia produces at capacity, with exogenous production again declining at the same rate of depletion.

Next, we wish to determine how a significant increase in Mexican oil production over the next several years might affect OPEC's optimal price. To do this we once again include all of OPEC's members in the cartel, and

assumes that it behaves as a monopolist as in the base case. Now, however, we include an additional source of supply in computing the cartel's net demand for oil, and we replace eq. (4) with  $D_t = TD_t - S_t - SMEX_t$  where  $SMEX_t$  is an exogenous variable representing Mexican production. We assume that Mexican production rises yearly from 1 million barrels per day in 1975 to 7.0 million barrels per day (2.55 billion barrels per year) in 1985. From 1985 onwards we assume that Mexican production declines with the same rate of depletion as in the competitive fringe. Thus, Mexican production falls to 2.26 billion barrels per year in 1990, and 1.82 billion barrels per year in the year 2000.

The optimal price trajectories for these scenarios and the base case are shown in Figure 1. Observe that if Saudi Arabia alone, or Saudi Arabia together with a group of core countries are left to bear the full burden of production cutbacks, the optimal price is significantly lower than it would be otherwise, particularly during the first 15 or 20 years. In 1985, for example, the price is about 20% below that in the base case. The presence of Mexico also tends to reduce the optimal cartel price, but not by as much (less than 10%), and only after 1980. It is interesting to note that the optimal cartel price is actually higher in the first one or two years if an increase in Mexican production is anticipated. The reason for this is that the incentive to the cartel for a "quick killing" is greater since the growth in Mexican production means that there is less to lose later on from a resulting decrease in world oil demand and increase in competitive fringe production.

Figure 2 shows total OPEC production for the base case and for the cases in which Saudi Arabia alone, and Saudi Arabia, the Emirates, and Kuwait bear the burden of production cutbacks. Observe that when Saudi Arabia and the

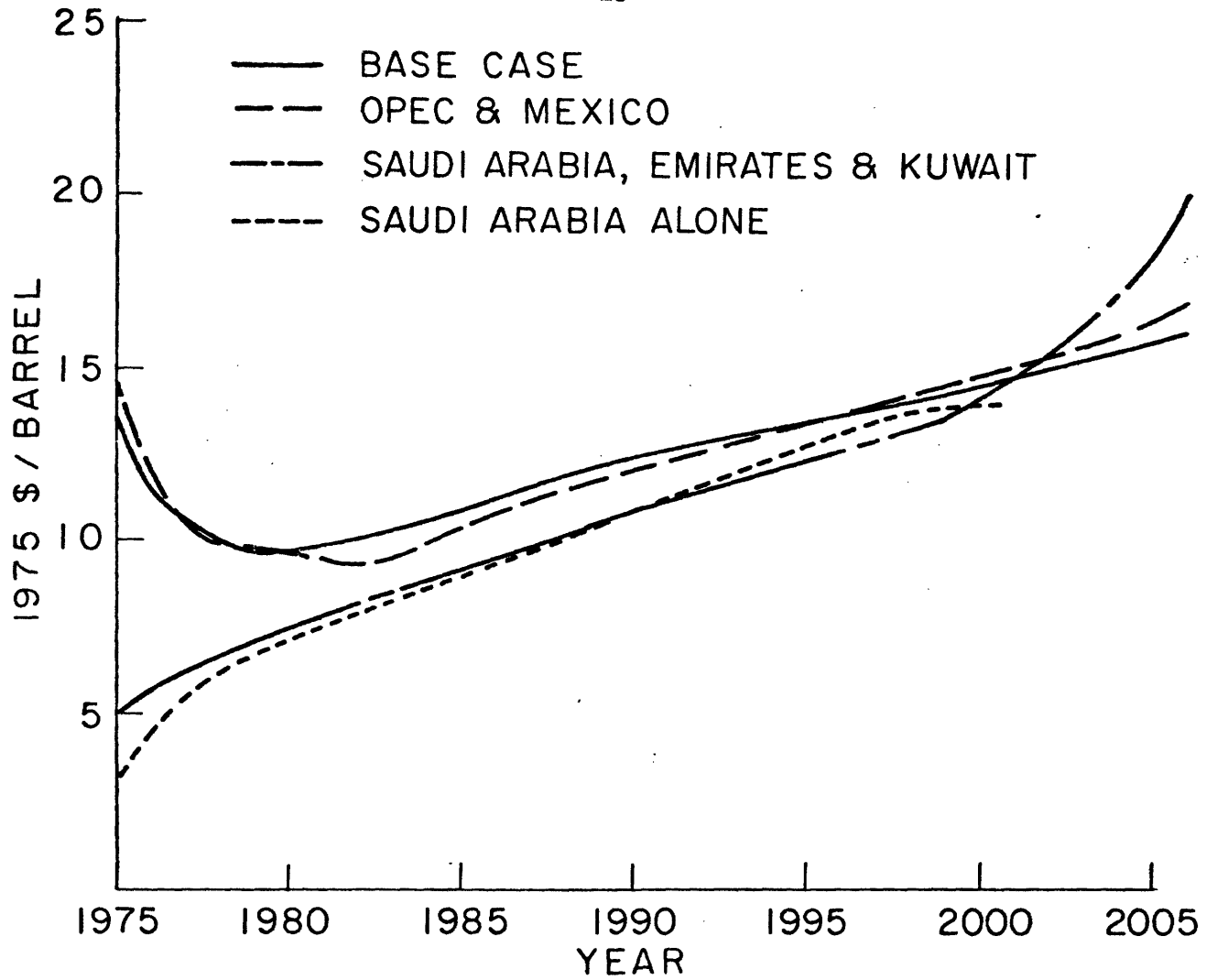


FIGURE 1: OPTIMAL PRICE TRAJECTORIES

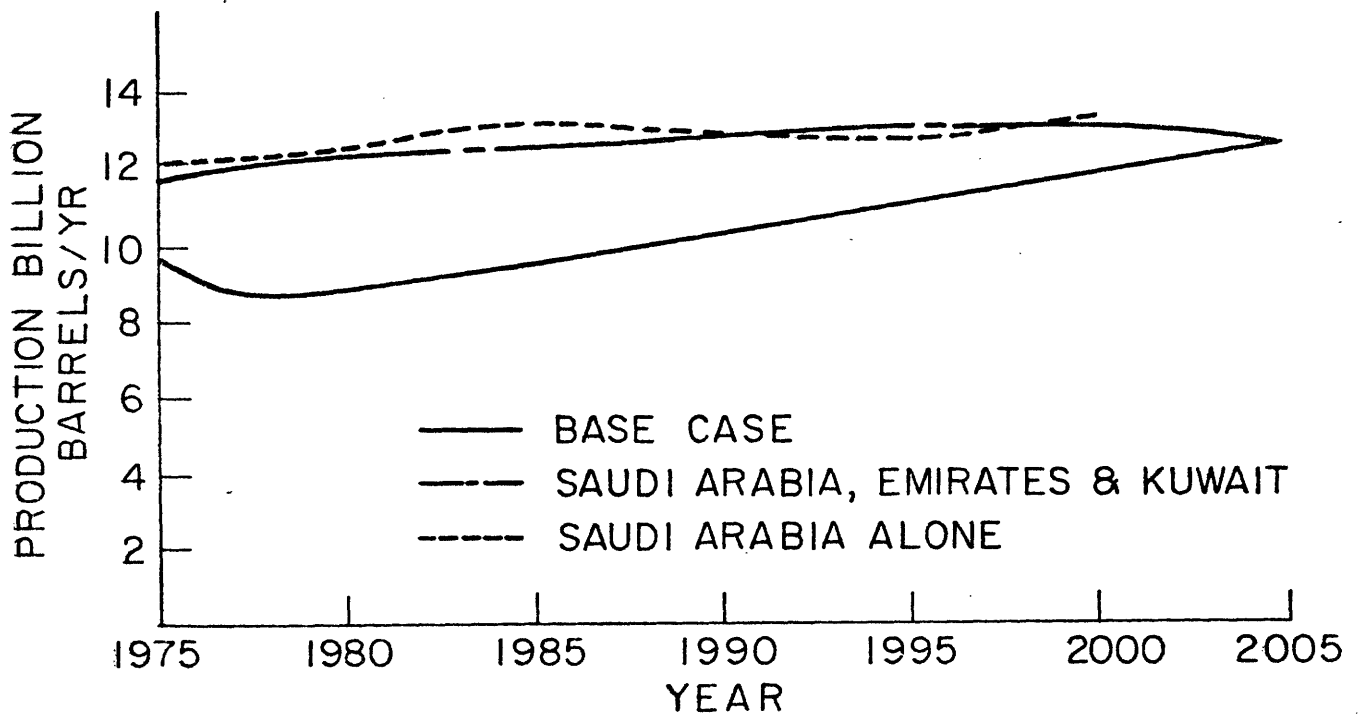


FIGURE 2: OPEC PRODUCTION

Emirates bear the burden of production cutbacks cartel production is significantly larger, which is consistent with the much lower price. However, this increase in production is not solely due to the higher production levels of the non-participating OPEC members; surprisingly, Saudi Arabia's production is also higher when it is left alone to do all of the cutting back. The reason for this is that the net demand curve for Saudi Arabia is now more elastic over a wider range of price, so that profits are maximized by an increase in production.

In Figure 3, the present discounted value of profits is shown for the base case and the case with Mexican production increasing to 7.0 million barrels per day by 1985. Note that although the price trajectories in the two cases are not very different, there is a significant difference in OPEC's profits. With Mexico on stream, the high monopoly price is maintained but OPEC has a smaller share of world oil production. In fact, by summing the present discounted value of profits in the two cases, we can determine the cost to OPEC of Mexican production. Summing to the year 2005, we find that the net present value of OPEC's profits without Mexican production is \$1843.5 billion, while with Mexico on stream, the net present value is \$1590.8 billion. In net present value terms, the cost to OPEC of Mexican production is therefore about \$253 billion.

We thus find that if OPEC cannot find a means of distributing production cutbacks, we could expect to observe a significant decline in the cartel price. The effect is large because with only Saudi Arabia and a few other core producers absorbing production cutbacks, cartel control over the market is greatly reduced. As far as Mexican oil is

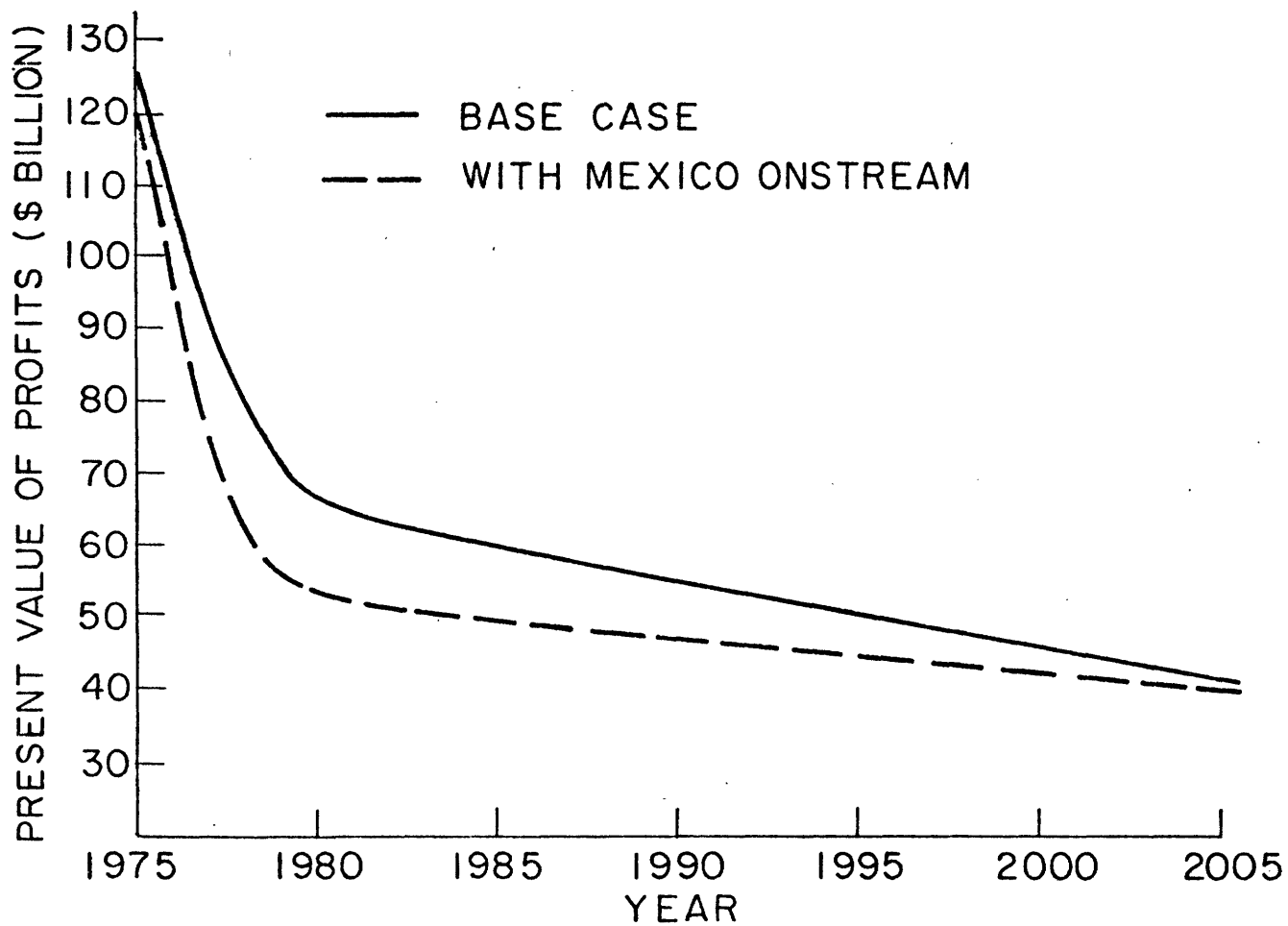


FIGURE 3: PROFITS WITH AND WITHOUT MEXICO



concerned, we find that if OPEC can successfully distribute production cutbacks among all of its members, it could limit the impact of Mexican production on the monopoly price. Even if Mexico increased its production to 7 million barrels per day as early as 1985, the monopoly price would only be reduced by some 8 to 10% at most. On the other hand, OPEC's share of the oil market would be reduced, and the PDV of its profit flow would fall by some 10 to 12%.

#### 4. World Energy Markets and Energy Policy in the Importing Countries.

Considerable attention has recently been focused on reports by the CIA and by the Workshop on Alternative Energy Strategies which predict a crisis in which energy demand will exceed supply beginning in the 1980's. According to these reports, this crisis will occur because the demand for OPEC oil will grow steadily as world oil demand increases faster than non-OPEC oil supply. OPEC production capacity, on the other hand, will remain fixed or even gradually fall, so that eventually there will be excess demand for OPEC oil. According to the reports, the crisis begins at this point; there is a shortage of oil, and what oil is available is sold at prices that increase suddenly and dramatically.

This scenario is grossly unrealistic, and ignores two important facts. First, the demand for OPEC oil and (to a lesser extent) OPEC production capacity are highly sensitive to the price of oil. Second, OPEC will gradually and steadily increase the price of oil over time, and at such a rate that capacity constraints will never become binding.

OPEC is now operating well below its production capacity, and has considerable room for capacity expansion in the future. OPEC production in 1977, for example, was about 29 or 30 million barrels per day (mb/d),

while capacity was over 35 mb/d. While the production capacity of some low-reserve countries such as Iran and Venezuela will decline during the 1980s and 1990s as reserves are depleted, the production capacities of such high-reserve countries as Saudi Arabia, Kuwait, and the Emirates can be expanded considerably. In fact, Saudi Arabia and some of her high-reserve neighbors could as much as double their capacity, particularly if there is a revenue incentive to do so. And, as long as these countries are concerned with the pursuit of their economic interests, they should increase their capacity, and exploit their oil resources at the optimal price. To do otherwise would be to waste the economic value of their resources.

We should thus expect a gradual evolution of the world oil market, so that the price of oil slowly increases at rates that will not have any serious impact on the macroeconomic output of most of the industrialized countries. At the same time, the production capacities of some OPEC countries will increase enough to more than offset possible declines in the capacities of such countries as Iran and Venezuela. In addition, gradual increases in the price of oil will serve both to dampen the growth in world oil demand, and to stimulate the production of oil from non-OPEC sources. Although oil will become gradually more expensive, there is no reason to expect the sort of price and output scenario that the CIA and WAES have predicted.

Although the CIA's scenario is extremely unrealistic, those countries that are heavily dependent on imports of OPEC oil (the United States included) must be concerned with the possibility of a sudden cutback in OPEC production and run-up in price. Unforeseen political events, such as those we have witnessed in Iran, could result in a sudden change in OPEC

production and in the price of oil. It is important to stress, however, that such a crisis could occur as easily now as in the mid or late 1980's, and it is not this kind of crisis that has been of concern to the CIA or the Carter Administration. The possibility of such a crisis should be of greater concern to the Administration, and is an important reason for pursuing a domestic energy policy directed at reducing or at least limiting oil imports. A production cutback could occur, and the United States, as well as the other industrialized importing countries, should take measures to reduce their potential vulnerability.

An important measure is the development of strategic oil reserves. The United States is now beginning to implement a program to store oil in underground salt domes near the Gulf Coast. Unfortunately, the program is now proceeding slowly, and the plan to reach the one billion barrel target in 1984 may never be reached. Furthermore, should an embargo or production cutback occur within the next few years, the United States could expect little relief from the stockpile. It would therefore be wise to speed up, and perhaps expand, the stockpile program. And comparable stockpiles should also be developed by the other import-dependent countries.

In the case of the United States, it is also important to recognize that our growing independence on imports has to a large extent been the result of our policies of price controls on natural gas and the price controls-entitlement system for crude oil. Energy prices should be deregulated in the United States, and the entitlements system should be disbanded altogether. Letting energy prices in the United States rise to world levels will considerably help to reduce our dependence on imports, and it will also permit domestic energy markets to operate efficiently, thereby reducing the

total cost of energy in the long run.

The United States should also be doing whatever it can to encourage greater Mexican energy production. As we have seen, the impact of increased Mexican production on OPEC's optimal price is not likely to be large, but it would certainly be noticeable, and a high level of Mexican output is desirable for other reasons as well. Mexico would be a much more secure source of supply for the United States, and a source of supply less likely to require political payments in addition to economic ones. The Department of Energy's recent veto of the U.S.-Mexican natural gas deal was indeed unfortunate.

The importing countries can hope that OPEC will fail to solve its long-run problems, but they had better not count on this. Mexican oil is still largely speculative, and the continuing turbulence in Iran could lead to a large and permanent drop in oil production, which could by itself solve the allocation problem for the cartel. Even if Iran's production stabilizes at its earlier levels, some of the non-core countries will lose revenues if they fail to hold back production. These countries may well have the foresight and discipline to look out for their economic interests and hold the line on production. It is therefore likely that oil will become increasingly expensive in the years ahead.

REFERENCES

1. Hnyilicza, E. and R.S. Pindyck, "Pricing Policies for a Two-Part Exhaustible Resource Cartel: The Case of OPEC," European Economic Review, 8, August 1976, pp. 139-154.
2. Organization for Economic Cooperation and Development, Energy Prospects to 1985, Paris, 1974.
3. Pindyck, R.S., "Gains to Producers from the Cartelization of Exhaustible Resources," Review of Economics and Statistics, 60, May 1978, pp. 238-251.
4. Pindyck, R.S., "OPEC's Threat to the West," Foreign Policy, No. 30, Spring 1978, pp. 36-52.
5. Pindyck, R.S., The Structure of World Energy Demand, MIT Press, to appear Spring 1979.