PRODUCERS, CONSUMERS, AND MULTINATIONALS: PROBLEMS IN ANALYZING A NON-COMPETITIVE MARKET

by

M. A. Adelman

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Producers, Consumers, and Multinationals: Problems in Analyzing a Non-Competitive Market

M. A. Adelman
Massachusetts Institute of Technology*

A paper written two years ago[1] gave a general analysis of the current world oil market, indicating why the price had nothing to do with real scarcity, but was set by a monopoly both vulnerable and very strong. The purpose is now to analyze the market more closely, with a view to making some predictions about future prices.

Non-competitive markets are notoriously hard to analyze, because we have no precise theory of small-group actions. Furthermore, the current cartel[2] is very recent, and its great successes since the 1970 Libyan negotiations have been and still are a learning process. But we can at least identify the principal factors, and eliminate irrelevant or wrong hypotheses.

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1. M. A. Adelman, "The World Oil Cartel: Scarcity, Economics, and Politics", Quarterly Review of Economics & Business, vol. 6, no. 2, Summer 1976, pp. 7-18.

2. We do not pre-judge the question of whether it is really a cartel or a dominant-firm monopoly. See below, II-B. "Cartel" is used only as a generic term.

I. CONSUMING COUNTRIES

There was active American help to the cartel in 1970-74,[1] and official policy is now more openly stated: "Huge OPEC Oil Price Rise Benefited the U.S."[2] Generally, consuming countries have been passive. "Cooperation not confrontation" has suited the word to the actions.

Policy makers in consuming countries assume a disequilibrium model: for some never-stated and hence irrefutable reason, they know price will be held below the market-clearing level. It logically follows that there will be a "gap", with more demanded than is offered. Therefore, the danger is not merely a high price, but "not enough oil for our needs". Since the market will not clear, it follows that oil will be distributed by favor and influence. Hence the ever-repeated need for "access"[3] and "assurances of supply", which are non-problems if the market clears at any price. (Experience has repeatedly proved that any agreement with a sovereign monopolist is inoperative, not enforceable by competition or by law.) Europeans and Japanese fear that the United States has somehow got Saudi Arab output preempted, so that other nations will not be able to buy as much as they wish.[4]

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1. I once gave great offense by pointing this out; subsequent events and evidence now in the public domain shows how much I understated the case. See "How OPEC Came to Power", Forbes, April 18, 1976. It is commonplace to say of the former State Department energy expert and 1973-75 ambassador to Saudi Arabia that he acted like the Saudi Ambassador to the U.S.

2. "Huge OPEC Oil Price Rise Benefited U.S.", Washington Post, July 10, 1977, is an excellent paraphrase of the official view.

3. Congressional Reference Service, "Toward Project Interdependence", 95th Cong., 1st Sess., Committee on Energy & Natural Resources, Publication 95-31 (Washington, 1977), p. 61.

4. See the joint statement in Keidanran Review No. 43, February, 1977, by Federation of Economic Organizations, Japan Atomic Industrial Forum, and Committee for Energy Policy Promotion: "However, in view of the actions of the oil producing countries in the Middle East, increasing imports of oil by the U.S.A., and other trends, it is all too uncertain whether Japan will be able to secure such a huge amount of petroleum."

The nations yearn for self-sufficiency.[1] Hence they fear to renounce nuclear reprocessing.[2]

"The gap" is a fiction, but belief in fiction is a fact. It will keep the consuming nations passive and compliant in the future as in the past. In 1972, the State Department predicted a shortage of 20 MBD by 1980;[3] indeed, their chief energy expert warned that "by 1976, our position could be nothing short of desperate".[4] Their "exaggerated talk of an energy crisis greatly strengthened the bargaining power of the Arab states".[5] The IEA predicts a world oil shortage of 14 MBD - in 1985.[6] The WAES Report has the same message.[7] The gap is like the horizon, always receding as we go toward it.

Yet consumer-country actions with a low probability of occurrence would have substantial consequences if they did occur.

A. The United States could auction import entitlements to divert revenues from the cartel to this country's treasury. The Economic Task

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1. Michel Grenon, Ce Monde Affame d'Energie (1973), passim; Guy de Carmoy, Energy for Europe (1977), Introduction, 37, 55 (West Germany's "strong" position, "progress toward energy independence"), 80, 93, 117.

2. See for example, Economist, April 16, 1977; New York Times, September 9, 1977.

3. New York Times, May 27, 1972.

4. Oil & Gas Journal, May 15, 1972.

5. Petroleum Economist, November, 1973.

6. New York Times, March 17, 1977.

7. Workshop on Alternative Energy Strategies, Energy: Global Prospects 1985-2000 (1977).

Force of the then President-elect Carter recommended such a plan.[1] It has not been heard from since. When the plan was explained to Mr. Schlesinger, his reaction was: "It would work. But do we dare let it work?"[2] The answer clearly is No, but the option is there.

B. I once argued that an excise tax in consuming countries could force the world price down as the producing governments had used it to force the price up.[3] This was too summary. More recently, Houthakker has suggested an import tariff and made estimates of its effect on cartel production.[4] I think that a flat levy would not have any such effect, but a proportional tariff or tax would, if the proportion increased with the cartel revenue. In effect, it would be a progressive income tax.

Since cost is negligible, cartel profit is maximized approximately where marginal revenue becomes zero, at the point on the demand curve where price elasticity is -1.0. In figure 1, total profit is the topmost line, a function of quantity produced. Price per unit is the slope of a line from the origin to any point on the profit line. Lower production and rising prices generate higher profits as long as demand stays in the inelastic region. If the demand for oil is now in this region, then as OPEC increases price and loses production, profits rise. OPEC would move over time to output level Q_3 where its profits would be maximized.

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1. Oil & Gas Journal, January 10, 1977.

2. Quoted in New Republic, May 21, 1977. Some other aspects of the meeting are not accurately reported, to my recollection. See also Washington Post, July 10, 1977.

3. M. A. Adelman, The World Petroleum Market (1972), pp. 261-262.

4. H. S. Houthakker, The Price of Oil (1976), pp. 29-36.

Suppose the consuming countries introduce a proportional tax equal to $\frac{a}{P}$. At today's level of output, represented by Q_1, the tax would result in a net after-tax producers' profit of P_1a_1. OPEC would increase after-tax profits by raising its prices and collecting P_2a_2. If the consuming governments responded by raising the tax rate to b/P, the OPEC governments could maximize profits by collecting P_3b_2. But a consumer outlay of P_3 would be the maximum. The producers would have exhausted their price raising power. Then consumer governments could raise the tax rate to c/P, or higher, approaching as near to 100 percent as they thought prudent-just as OPEC countries do today.

The simple proportional tax (and a fortiori the flat per-barrel tax) invites higher prices, and not merely because OPEC would cite the tax as an excuse for raising prices. There is an unlimited supply of excuses. But lower revenues would be an incentive. In the long run, of course, the cartel will move toward P_3 with or without a tax. In the short run a proportional tax might speed up the price rise.

To discourage this speed-up, the tax rate could be made proportional to the price. Then the cartel would be on notice that a higher rpice, e.g. P_2, would mean a higher tax.

Both sets of governments would have to guess at the shape of the demand and revenue curves, and they could be - probably would be - badly wrong. But the principle seems clear: the consuming governments have the power to pre-empt all the profit of the producing countries.[1]

No consuming country would today contemplate such a policy.

Yet consuming countries may inadvertently do, step by step, what they would never dream of doing deliberately. Large sudden changes in oil prices might induce action to check imports, including taxes or tariffs on

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1. See Appendix A.

crude oil products. The moral for the cartel nations: minimize risk by raising the price in small increments, and at times when the world economy is most healthy. (See also concluding Summary.)

It is doubtful that the OPEC nations have made any rigorous analysis of the problem, but they have long been aware of it. The Secretary General of OPEC recently estimated that the weighted average consumer-country tax per barrel (he probably refers to Western Europe) was about 57% of total retail sales value in 1970, declined to 39% in 1974, but rose to 45% in 1975.[1] His actual numbers seem questionable, but do not affect the main point, that there is "competition to get a larger slice of the same cake: the value generated by a barrel of crude oil." As just demonstrated, the more the consuming countries raise their taxes, the less left for producers. Therefore, aside from policy questions, a key variable in any modeling effort must be: taxes and tariffs imposed by consuming countries.

It is frequently suggested that the consuming nations can influence the rate of output of the producers by some kind of political or coonomic accommodation. But any such accommodation, once granted and irrevocable, is of no account. The succession of broken Saudi promises in 1971-74[2]

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1. Petroleum Intelligence Weekly, May 16, 1977.

2. There were at least four 1971-73 price changes, each one in violation of an agreement or assurance; and three violations of less formal assurances in 1974. There was also the promised auction in the late Summer of 1974; and the October promise not to allow any output reduction; American officials complained that this broken promise "pulled the rug from under them." See Oil & Gas Journal, March 17, 1975.

was prefigured in the 1973 comment of Sheik Yamani: "We in Saudi Arabia would have liked to honor and abide by the [1971] Tehran Agreement, but ..."[1] Circumstances, he said, had changed

The record of broken promises is not explicable by Saudi original sin or bad character but by the market structure. It merely confirms what was said above: an agreement with sovereign monopolists in unenforceable. Much more commonplace was Yamani's suggestion in 1975, of consuming countries supplying technical aid to the producers and "protection [of]... ... investments from the ill effects of inflation or currency changes", failing which "his attitude toward the industrial countries might become less friendly".[2] This is an indirect price increase, giving the producing countries something of value rather than an explicit number of dollars per barrel.

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1. Middle East Economic Survey, September 7, 1973.

2. Petroleum Economist, November, 1975.

II. PRODUCING COUNTRIES

A. We need make no assumptions about the objectives of the producing governments. Whether political or military power, or consumption, or investment, or anything, the more wealth the better. There is no sacrifice or trade-off for anything else. Saudi Arabia's current political role is based on nothing more than accumulated and expected revenues. Hence analysis of economic objectives suffices for non-economic.

To a first approximation, we have thought of the cartel countries as a single perfect monopoly, as shown in Figure I. Their heaven is unit elasticity of demand. The consensus appears to be that in the range between current prices and a large increase, say of 100 percent, the coefficient is well below unity. In terms of Figure I, we are somewhere between P_1 and P_3. The real price (adjusted for inflation) will therefore increase. To avoid provoking rebellion, the increase will come one slice at a time, and with distractions and disguises, or political occasions.

B. We now relax the assumption of a single monopoly. There is really a coalition of a dozen countries of whom Saudi Arabia is the biggest producer, and has the greatest unused potential capacity. We should avoid hard-and-fast definitions of the producing nations as <u>either</u> (a) a cartel who need the consent of most or all of the members, and some scheme for sharing output, <u>or</u> (b) a dominant firm as residual supplier. Perhaps the truth incorporates both hypotheses.

Table I is the setting for the problem of actual and potential excess capacity. In mid-1977, there was a severe worldwide glut of crude oil. "Oilmen hate short term gluts because they ... undermine their

increasingly frenzied predictions of long term scarcity."[1] Governments seem to me to be much more frenzied than companies, but it is true that most of the industry has insisted for at least the past 30 years that "rising demand will dry out the surplus." A skeptic might ask why they should be right for the first time, a super-skeptic might ask why should they not be right. The large discrepancy between the CIA projection for 1985 (column a) and one which seems more likely to me (column d), may be more apparent than real. If their estimates of supply and demand at a constant price are correct, then one must expect - as they do - a considerable price increase in the early 1980's, if not sooner. Now, the real Western European oil product price nearly doubled between 1973 and 1976.[2] To assume that from 1973 to 1985 it will have increased by a factor of 2.5 seems conservative. Assuming long run product demand elasticity of -.3, the consumption estimate in column d merely makes explicit allowance for the assumptions of column a - c.

Thus far we have merely drawn the logical consequences of the CIA calculations. But we do reject their assumption of large Communist net imports. The Soviet Government is incapable of paying for such imports, and is capable of severely compressing demand and speeding up nuclear and coal. The oil industry has pointed to large not fully developed Soviet fields, and pipelines therefrom.[3] It takes seriously the Soviet program

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1. Economist, August 27, 1977, p. 88.

2. By "real price" we mean the product price versus (a) all other prices, not the product price versus (b) the total retail price index. The difference between (a) and (b) is small but not negligible.

3. Oil & Gas Journal, May 2, 1977; May 16, 1977, Newsletter p. 4.

of nearly two million barrels daily of net exports in 1980.[1] China may already be committed to 200,000 barrels daily, to Japan alone.[2] I have arbitrarily assumed that the trend to rising Communist exports is reversed in 1980-85, but the evidence is really non-existent. The point of Table I is simply that all parties must be in considerable doubt as to the net residual demand for OPEC oil.

Other supply factors compound the uncertainty. The CIA has made no specific allowance for the increase in natural gas production, which will displace oil almost one for one. The increase in North Sea gas from 1976 to 1985 will be about 650 thousand barrels daily oil equivalent.[3] Iranian gas shipments to the Soviet Union will permit 1980 additional Soviet exports of 350 TBDOE, domestic development of an additional 614 TBDOE.[4] World trade in LNG, BP estimated last year, might reach 3 MBDOE by 1985;[5] it seems prudent to reckon on about 2 MBDOE. Thus, there is a good chance of OPEC demand being lower by nearly 4 million barrels daily. To incorporate it into our forecast would give it a mock precision. But it is an additional uncertainty with which the producing countries must live.

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1. Petroleum Economist, February, 1977.

2. Journal of Commerce (N.Y.), April 5, 1977.

3. Wood MacKenzie and Company, February 11, 1977.

4. Petroleum Economist, May, 1977; Oil & Gas Journal, June 6, 1977.

5. BP, LNG - The Next Ten Years (1976). According to a study by the Institute of Gas Technology, LNG supplied in 1976 was 1.8 bcfd. New plants "committed", "probable", and "possible" by 1980 would account for 3.6, 4.4, and 16.0 bcfd respectively. If one assigns a probability of .75 to the "probable" and .25 to the "possible", increased trade by 1980 would amount to 10.9 bcfd, or 1.8 mbdoe. E.I. Shaheen and M. K. Vora, "Worldwide LNG Survey Cites Existing, Planned Prljects", Oil & Gas Journal, June 20, 1977.

Column e embodies a projection which I would consider improbably low, and is used only to test the hypothesis that the cartel will not be disrupted or destroyed even by that large a reduction in net OPEC demand. Assuming that there is only 6.6 MBD for countries which last year produced nearly 15, can Saudi Arabia take the whole burden of excess capacity, letting the other produce as much as they wish?

Saudi Arabia could, if need be, meet their commitments with much less than current output. The most careful estimate of commitments is undoubtedly that of Theodore H. Moran.[1] But we need not reach the question of how far down is Saudi Arabia willing to go. The cartel members are sovereign nations and can suppress competition by force or the threat of force. Iran can limit out-shipments from the Persian Gulf. Saudi Arabia can invade and occupy its neighbors. Distances are short, local populations scanty, the terrain ideal for a quick grab. Today these neighbors account for six million barrels daily of capacity. They can be taken out quickly, if they do not cut back as they are told.

The cartel will not be broken by insufficient net demand. The hypothesis that Saudi Arabia <u>can be</u> the restrictor of last resort is very robust. It does not follow that they <u>will be</u>.

C. The other important lesson from Table I may be seen in Table II: tension between the interest of the cartel and of its senior member.

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1. Theodore H. Moran, "Why Oil Prices Go Up: OPEC Wants Them", <u>Foreign Policy</u>, No. 25, Winter 1976, p. 65. It would be better to subtract the amount of foreign investment income, which will be substantial by 1980, from the minimum revenue of $32 billion.

The elasticity of demand for total OPEC crude oil (column 5) approximates that for oil products (column 5). If product demand elasticity is low, a stiff increase in the price of Persian Gulf oil would serve the cartel as a whole. But if Saudi Arabia is really the restrictor of last resort, then their interests are very different from those of the cartel as a whole. On the CIA projection, a doubling of the world price of oil would increase Saudi revenues by only 18 percent. (On my own projection, there would be a substantial decrease but from a higher level, since I assumed a price increase.)

Nobody should take the actual numbers in Column 6 too seriously. But the differences, between 1970 and 1973 on the one side and 1976 and later years on the other, are so gross that they show a basic change in the relations between the largest seller and its partners.

The Saudis could be the residual supplier or restrictor of last resort if they had to, but then they would have little interest in raising the price. Others get the benefit, they bear the cost.

An accommodation is necessary and likely. The others must somehow restrain their output and let Saudi Arabia have a sufficient share of the market to let them benefit from a price increase. The Saudi maneuver of December, 1976, is one way of reaching the result. There will be many more such incidents, each one unpredictable, raising the world price of oil again.

D. But any such market sharing is difficult to maintain, not only because of the lack of formal machinery (of which more below) but because of the pervasive uncertainty. Suppose that Saudi Arabia is content to be

the residual supplier of say 8 million barrels daily, and that world consumption is lower than expected by only two MBD, a fluctuation or error of only 3 percent. For Saudi Arabia, the loss is 25 percent. As a random fluctuation, it is bearable. As a permanent loss, it seems intolerably high - not to mention the start of a downward trend. Simple prudence forbids the Saudis to run such risks.

In summary, any model of the OPEC nations as either a cartel or a dominant firm monopoly is much too simple. Both models have elements of the truth. Indeed, the knowledge that Saudi Arabia could if need be serve as restrictor of last resort ("dominant-firm monopoly") is a strong backstop to the cartel. It strengthens the willingness of the other large producers to restrain output. If they have little fear of the cartel collapsing, they have no reason to invest heavily today to expand output to make the best of an uncontrolled lower price. But the caution advisable for the cartel as a whole is reinforced by the caution which uncertainty forces upon the dominant firm. Therefore, the chances are that there will always be much un-exerted price-raising power in the system.

This caution in raising prices is of course a new departure for Saudi Arabia. Throughout 1974, while repeatedly urging the virtues of lower prices, they were repeatedly the price leaders at the Persian Gulf, the Iranian "hawks" being glad to follow.[1] Thus they increased their take from $7 per barrel at the beginning of the year[2] (the usual higher number is retroactive adjustment) to $10.12 by the end of the year. Beginning in 1975, they not only talked moderation but practicied it, and the reason is simple economic

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1. See Petroleum Intelligence Weekly, March 11, June 17, November 25, 1974.

2. Ibid., December 31, 1973.

interest. They also have earned millions of golden opinions in the United States, no bad thing from their point of view, but quite unnecessary to explain their price behavior.

E. We may now consider the optimal rate at which oil below ground should be traded for money above ground, a problem faced by any owner, public or private.

As is shown elsewhere[1], the average cost per barrel of developing a reservoir is approximated by: $C = (I/Q)(a+r)$, where Q = initial peak capacity, I = investment (including present value of future operating outlays); a = the peak depletion rate = Q/R, where R = proved reserves; r = the discount rate. A decision to accelerate or not accelerate output depends on marginal cost at the intensive margin, which is: $MC = (I/Q)(a+r)^2/r$. Thus marginal cost rises approximately as the square of the peak production: reserve ratio. An additional barrel produced today sacrifices a lower-cost barrel tomorrow. Moreover, MC increases even faster where additional wells induce interference and lower output per well, i.e., where (I/Q) is no constant but an increasing function of Q/R. And too high a rate of output may actually lose part of the producible reserves.

Where marginal cost is just equal to price, that amounts to saying that the higher cost of faster depletion is just offset by the quicker receipt of revenues. Then one looks for under-developed reservoirs where incremental cost is still below price and there is room for expansion.

One needs to reckon current and future marginal cost, which are strongly inter-related; current and future prices, which to a competitive

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1. M. A. Adelman, The World Petroleum Market (1972), P. 50-52, and M. A. Adelman and Henry D. Jacoby, "Alternative Methods of Supply Forecasting" (forthcoming).

firm are independent of each other; and the discount rate which allows current and future costs and prices to be compared with each other. Thus OPEC or non-OPEC countries, like all oil and gas producers, have complex asset-management problems. They must from time to time decide whether, given costs at the margin, they are better off producing the incremental barrel now or later.

But a little reflection will show that at current or even much higher output rates Saudi Arabia has no asset management problems. If the Saudis took their 8.5 MBD "ceiling" seriously, their end-1976 proved reserves would last 35 years, proved-plus-probable reserves nearly 60 years. In addition, there are new deposits, already found, not reflected in reserves; not to mention deposits to be found. The availability of new reservoirs makes it unnecessary to raise depletion rates in old ones, thereby easing or preventing the rise in marginal cost. These reserves also postpone the time when the barrel unproduced today is finally sold.

Thus a barrel not produced today does not lower costs, it is simply lost for decades. The present value of those far-off barrels is zero, even with inadequate allowances for risk: technological progress in production or consumption limiting the price increase; political-military action by neighbors or others; erosion of the cartel.[1]

A comparison of oil-in-ground versus money-above-ground (OGMAG) is only valid at the margin, and at the current margin oil in the ground is worth-

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1. Richard B. Mancke ("Recent World Pricing: The Saudi Enigma" Energy Policy, vol. 5, June 1977, pp. 167-168) argues that too high a short run price would bring in new competitng sources of energy, hence lower the price in the long run. On this reasoning, it pays crude-rich Saudi Arabia to be a price moderate. The Mancke thesis, in terms of our argument, it that the higher the current price, the greater the risk of lower future prices, which should then be discounted heavily relative to current prices.

less to Saudi Arabia compared with money for investment, consumption, armaments, or influence. It would be a losing game to hold back production if the Saudi decision makers could treat price as a datum outside their control. But the Saudis must and do limit production to maintain the price. For them, the OGMAG comparison is superfluous. Its popularity shows how cost functions have been neglected in the literature. It also shows the power of repeated slogans which are plausible because they are not examined, and seem clear because they are familiar.

The alleged Saudi desire to husband their oil resources for future production is an influential delusion, allied to another powerful myth: "Many observers feel the Saudis may agree ["to produce substantially more oil"] if the proper economic and political climate can be created."[2] The Saudis will boost output to the extent that they can agree with their junior partners to boost revenues. They have never done anything else, nor should they be expected to act irrationally.

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1. See Appendix B.

2. Congressional Research Service, "Project Interdependence", 95th Congress, 1st Session, Committee on Energy and Natural Resources, Publication No. 95-31 (Washington, 1977), p. 62.

III. THE MULTINATIONAL COMPANIES REPLACED BY GOVERNMENTS

A. If what we have is more a cartel than a residual-supplier monopoly, then it is time to ask by what means the cartel limits output and divides the market.

Mostly, the multi-national companies clear the market without anything resembling collusion. Each company sells what it can, and produces only what it can sell. Therefore, the amount offered is only equal to the amount demanded, and there is no pressure on prices. The margins allowed producing companies are too narrow to permit them any but trifling price reductions: perhaps 22 cents in Saudi Arabia and in Iran, which aims to reduce it.[1] Hence, no company can offer substantial discounts in order to get additional business. The cartel governments have only one simple implied agreement, that they will sell the great bulk of their output through the companies and not directly.

This is an odd kind of market sharing mechanism. Its great merit is that it avoids the difficult, divisive, and probably impossible task of prorationing. But it works haphazardly. Companies have begun to look from country to country, in search of better deals. Mostly they feel free to shop only for small incremental quantities. Even so, some countries' output has been subject to strong fluctuations.

If the governments are to keep using the companies, they confront three inter-related problems: Company margins; price differentials; and government market shares. The relative values of various crude oils keep changing incessantly because product markets and tanker rates change. Without a system of prompt corresponding adjustments in crude oil price differentials there are strong fluctuations in company margins. As companies

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1. Wall Street Journal, February 23 and May 15, 1977.

move from one supplier government to another, there are unforseen changes in governments' market shares. The differentials are very large in relation to company gross margins. Hence, a small net advantage can move a company from one source of crude oil to another, and the OPEC countries have shown themselves very sensitive to crude price differentials which are a negligible percentage of the price of crude.

The 1977 flap over a "two tier price system" was the latest but not the last squabble over differentials which influence market share. Saudi Arabia did a bold maneuver in late 1976, in obtaining a price increase, first chiselling mildly from it to increase market share, then joining it, obtaining thus the best of both worlds and great political credit to boot. They will make similar moves in the future, perhaps not always as successfully.

The hope for a "right" price structure to end these disputes over market shares is illusory. The problem can only be solved ad hoc, temporarily. There is a constant tendency toward erosion of prices, which is best remedied by raising the price of crude oil, with everyone starting out at a new higher base line. Weakness is product prices and in open market crude oil prices may be a harbinger of a cartel price increase - the contrary of ordinary competitive conditions. At the mid-year 1977, crude was in great surplus, and the price was increased.

There will from time to time be good purely economic reasons for a temporary cutback or stoppage, to clean out inventories, raise prices, and scare the daylights out of consuming nations. Temporary cutbacks cure the sickness of excess supply, without anybody being committed to any lower market share. But cutbacks can get out of hand.

C. We stated earlier that a producing government's political objectives could always be subsumed in its economic objectives. But there are significant differences between governments and private firms as oil operators and as cartelists. It is doubtful that any group of private firms could ever have dreamed of organizing so massive a transfer of wealth. We urged in another paper that in these circumstances the supply curves were often backward bending: the higher the price, the less the probability of investment.[1] The richer and more liquid are the producing governments, the less likely that one of them will be the reluctant price cutter who knows that secret rebates are dangerous, because they may spread. Yet he has bills to pay and a payroll to meet, and simply must have the additional revenues. Hence, he shades prices, hoping his fellows will tolerate it and move over to make a little more room for him. Governments with large balances can avoid this kind of misconduct. Contrariwise, the more precarious the finances of the producing governments, the greater the pressure to cut prices and the danger to the cartel.

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1. M. A. Adelman, "The World Oil Cartel: Scarcity, Economics and Politics," Quarterly Review of Economics & Business, vol. 6, no. 2, Summer, 1976, pp. 7-18.

This backward bend is at least a partial explanation why, outside the United States, there has been no great surge in drilling since the price explosion, even a mild decline from mid-1976 to mid-1977.[1] The number of offshore drilling rigs, a good index of exploration, has doubled in five years, and the increase has levelled off.[2]

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1. Oil & Gas Journal, August 22, 1977.

2. Ibid., September 12, 1977.

It is clear even from the scanty published records that exploration was badly delayed in various countries. Reserves have been gradually depleted, and capacity has shrunk while the policy makers tried to resolve their visions of how much money they could spare, and what they were likely to get from it.

Again one sees a backward-bending supply curve at work. In Venezuela, dwindling exploration in 1965-75 was due to company awareness of a short tenure. But nationalization accentuated the trend: new field wildcats drilled in Venezuela in 1973-75 were respectively ten, six and one.[1] In early 1977, not one new field wildcat was drilling.[2] The Orinoco heavy oil belt, with possibly hundreds of billions of barrels remains a geological fact, not an economic asset, awaiting a research-development effort. The surge in revenues has dulled the public awareness of declining capacity. Those in charge know the situation and are trying to turn the ship around: 1978 exploratory expenditures are budgeted at 2.5 times 1976, and may in time increase by a factor of 5.[3] In Indonesia, the inflow of funds was so great that caution was thrown to the winds and huge commitments made by a largely un-supervised oil company. This forced the government into the necessity of unilateral contract revision to obtain cash, which in turn nearly dried up exploration. Efforts are now being made to restore incentives, with perhaps some modest success. In Mexico the price explosion on the morrow of the Reforma discoveries provided ammunition both for those who would expand

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1. Petroleo y Otros Datos Estadisticos, respective years.
2. Ministry of Mines and Hydrocarbons, Monthly Bulletin, February, 1977.
3. Oil & Gas Journal, September 12, 1977.

output faster and their opponents. The expansionist party is now on top. "Our task is to develop gas and oil for export as quickly as possible to generate foreign exchange", says Jorge Diaz Serrano, the head of Petroleos Mexicanos.[1] The policy may or may not persist.

The correlation between a producing country's deficit on current account, and its willingness to expand, may not be precise, but it is highly important.

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1. Petroleum Intelligence Weekly, June 6, 1977.

IV. SUMMARY AND LONGER TERM VIEWS

One may doubt that any model can capture the subtleties of monopoly power exercised by a group like the OPEC nations. A determinate forecast of prices and production for a given year, or their path over time, with confidence limits, seems beyond our powers. One might suppose that estimates of a perfect monopoly price set the outer bounds, but as Eckbo has pointed out, the uncertainty about an imperfect monopoly inhibits investment, thus leading in time to lower production and a higher price.[1]

However, the price should gravitate slowly toward the monopoly level, which is much higher than current. It will probably never get there. Turbulence will continue as the tension between Saudi Arabia and its partners needs to be resolved each time before the price can be raised. The huge trade deficits of the importing nations have strained the world monetary system, led to protectionist steps of which GATT has recently warned, and had some part in the recession of 1974-75, and the disappointing stagnation of 1976-77. If our analysis is sound, and the cartel has great unexerted price raising power, better business conditions and a strengthening of the world financial machinery will be a signal to raise prices again. Oil producer imports will doubtless continue to grow, but so will the value of exports. Therefore, the oft-heard expectation that the oil exporters' current surpluses will trend to zero by the early 1980s seems without foundation. If the exporters continue to act rationally, their program must be to raise prices and push the world monetary system toward the brink, but not too close.

Past the mid-1980's, the picture will change, responding to forces some which are not visible today.

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1. Paul L. Eckbo, The Future of World Oil (1976), especially pp. 106-110.

Appendix A (1)

Demand function: $P = P(Q)$ (1)

Tax rate $V = V(P)$ (2)

Total revenues (profits) $TR = PQ(1-V)$ (3)

$$d(TR)/dQ = PQ\ (-dV/dQ) + (1-V)\ (P+Q\ (dP/dQ)) \quad (4)$$

Setting $d(TR)/dQ = 0$ to maximize TR,

$$PQ\ (-dV/dQ) + P + Q\ (dP/dQ) - VP - VQ\ (dP/dQ) = 0 \quad (5)$$

$$P\ (-Q\ [dV/dQ] + 1 - V) = -Q\ (dP/dQ) + VQ\ (dP/dQ) = Q\ (dP/dQ)\ (V-1) \quad (6)$$

$$P_{max} = Q_{max}\ (dP/dQ) \left[\frac{V - 1}{1-V-Q\ (dV/dQ)} \right] \quad (7)$$

The quantity in brackets must be evaluated, as follows:

$$\left[\frac{1}{-1 - \frac{Q(dV/dQ)}{V-1}} \right] = \left[\frac{1}{-1 - \frac{Q(dV/dP)\ (dP/dQ)}{V-1}} \right] \quad (8)$$

Appendix A (2)

If the tax rate $V = 0$, or if V = a constant, then $dV/dP = dV/dQ = 0$ (9)

If $V = 0$, then the quantity in brackets $= \sim 1$, and $P_{max} = -Q\ (dP/dQ) > 0$ (10)

(since $dP/dQ < 0$, $P_{max} > 0$)

If Visa positive constant and $1 > V > 0$, the quantity in brackets

$= (V-1) / (1-V) = -1$

and $P_{max} = [-Q\ (dP/dQ)\ (V-1) / (1-V)] > 0$ (11)

(since $V < 1$, $[(V-1)/(1-V)] < 0]$, $P_{max} > 0$

N.B. Q_{max} is the same for $V = 0$, or for V = a positive constant,

since $(d(PQ)/dQ) = P + Q(dP/dQ)$, and where the left-hand

term is zero for a maximum, $Q_{max} = -P(dQ/dP) > 0$

If V is a positive function of P, and $1 > V > 0$, then the expression in brackets in Equation 8 is negative because the absolute value of the fraction is positive, and it is being subtracted from -1.

Let $V_3 > V_2$, then the value of the right-hand fraction is greater. (At the limit $V \to 1$, the fraction $\to \infty$.) Then the value of the whole denominator is less, the value of the whole expression in brackets is greater, and $P_{max\ 3} < P_{max\ 2}$.

Appendix B: Present Value of Saudi Arabian Reserves Under Alternative Rates of Exploitation

The writer would be wealthy if he had $10 for every time he has been told that "oil in the ground appreciates faster than money above ground". This means that the real value of oil is growing faster than the relevant rate of discount. If that were really true, nobody should produce any oil. That would raise the price immediately to where the statement would cease to be true.

In fact, as indicated in the text, decisions to invest in oil production are governed by prices, costs, and discount rates in a complex fashion which we will not try to model. But a simple experiment will show that the usual explanation of Saudi Arabia increasing wealth by holding oil in the ground cannot be true. Of course, elimination of the false reason does not in itself give the true one.

Appendix B:

It is assumed that the price of oil is $13 /bb/ in Year 0 and increases, in real terms, by 10 percent per year for 10 years to its ultimate maximum of $34, where it stays indefinitely. Proved reserves in Year 0 are assumed 150 billion barrels.

Ultimate reserves are assumed alternatively at 150 billion barrels (i.e., zero additions in known fields, no discoveries) and at 300 billion.

Discount rates are assumed alternatively at 5 and at 10 percent.

Production Plan I sets a ceiling of 8.5 million barrels daily (3.1 billion barrels per year) until reserves are 20 times production; thereafter production declines at 5 percent per year.

Production Plan II requires only that reserves must always be at least 20 times production. In the Year 0, production is, therefore, 150 x .05 = 7.5 billion barrels, or 20 million barrels daily. If current proved reserves are also ultimate reserves, production declines indefinitely at 5 percent. If 150 billion barrels more can be added, it is assumed they are added at a rate just enough to permit the 20 MBD rate to be maintained until the Year 21, when it declines at 5 percent per year.

With three alternative assumptions, there are eight possible outcomes, as follows:

Ultimate Proved Reserves (billion barrels)	Present Value ($ billions)			
	5 Percent Discount		10 Percent Discount	
	Plan I	Plan II	Plan I	Plan II
150	1,306	1,596	684	1,109
300	1,705	3,292	803	1,764

In no case does the present value of Plan I come close to Plan II. The crucial assumption does not involve any of the three alternatives, but rather that there is an ultimate ceiling to price, assumed here to be 2.6 times the 1977 price.

Plan I looks even worse to the extent that the Plan I ceiling is held below 8.5 MBD.

Fig. I
How Consumer County Taxes Could Absorb Increasing Fractions of OPEC Revenues

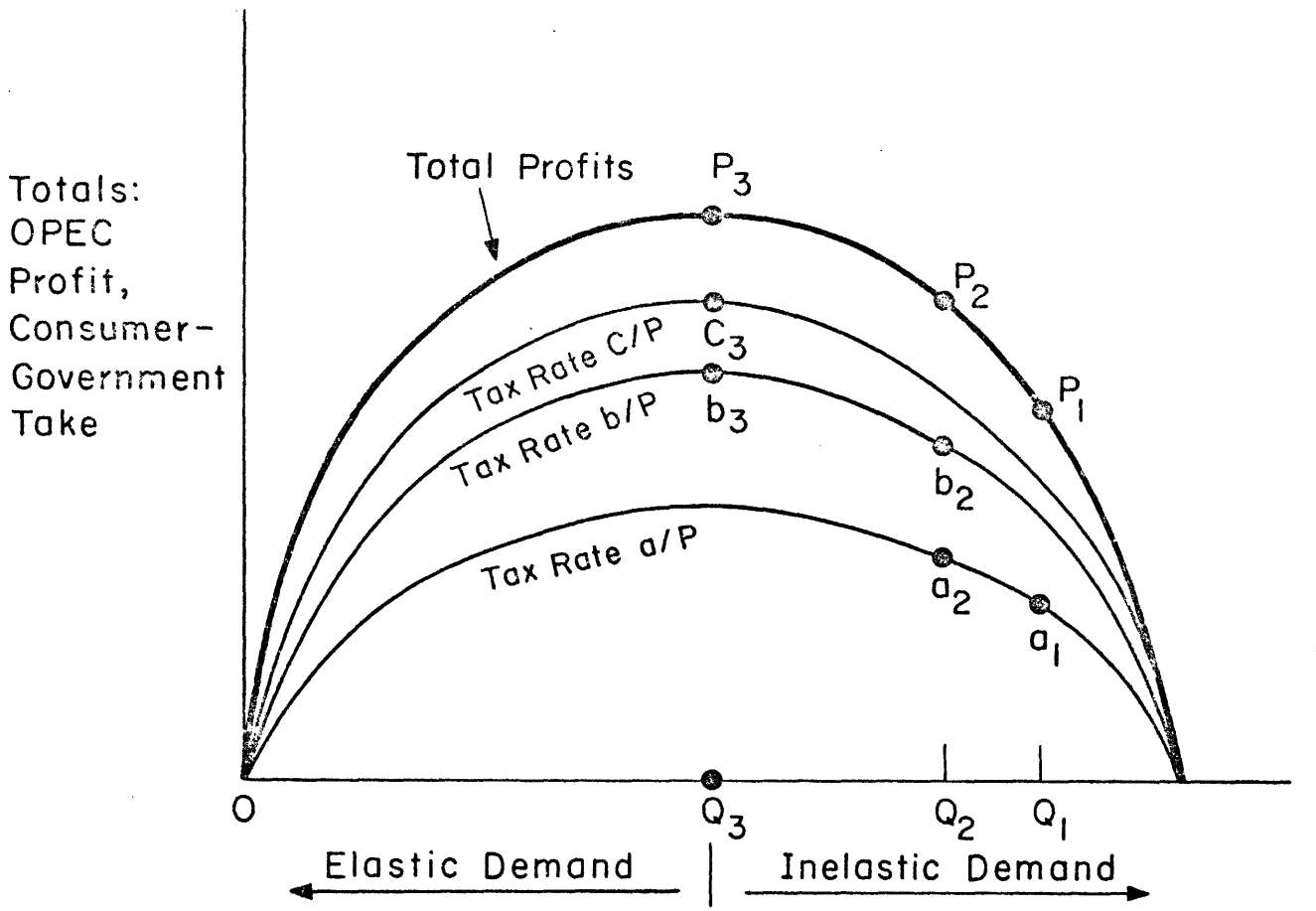

Table I. Consumption and Residual OPEC Production, 1973-85
(in millions of barrels daily)

	1973	1976	1980		1985				
			a	b	a	b	c	d	e
World (excl. Communist areas) total consumption	47.6	48.4	55.8	59.0	70.4	67.5	68.8	63.0	----
Non-OPEC Supply	16.4	17.5	22.0	23.0	21.4	27.8	27.6 ± 4.5	29.2	----
U.S.	10.9	9.7	10.0	12.5	10.5	14.5	11.2 ± 1.7	14.5	----
Canada	2.1	1.6	1.5		1.4		1.4 ± 0.3		----
W. Europe	0.4	0.9	3.7	4.0	4.5	4.8	4.7 ± 0.5	4.8	----
Other	2.2	4.2	6.1	5.5	8.9	7.5	9.4 ± 2.3	8.9	----
Communist Net Exports	0.8	1.1	0.2	1.0	-4.0	1.0	1.0	1.0	----
OPEC	31.2	30.9	33.8	35.5	49.0	40.5	41.2	33.8	28.6
Outside Southern Persian Gulf	18.2	17.5	21.6	24.5	21.8	27.0	22.6	22.0	22.0
Southern Persian Gulf excl. Saudi Arabia	5.4	4.9	6.4		6.7		7.0	11.8	0.0
Saudi Arabia	7.6	8.5	8.5	11.0	20.5	13.5	11.6		6.6

a. CIA, April, 1977, (but assuming all OPEC except Saudi Arabia at capacity).

b. Compendium of company forecasts to Survey Team, Petroleum Association of Japan, February, 1977.

c. Congressional Research Service, "Project Interdependence: U.S. & World Energy Outlook Through 1990", July, 1977.

d. Consumption: CIA estimate X (.76/.85). CIA estimates "conservation" as reducing consumption 15 percent.
Alternative: Assume real 1985 consumer price 2.5 times 1973 price, and demand elasticity -0.3. Then $(2.5)^{-0.3} = .76$.
Production: Assume companies better informed on North America, CIA on supplies elsewhere, except as to Communist block.

e. IEA, "vigorous policies" scenario.

Table II. Elasticity of Demand for OPEC Oil
and for
Saudi Oil as Residual Supply

Year	Long Run ED for Oil Products	P(Crude)/ P(Products)	World Prod./ OPEC Prod.	OPEC Prod./ Saudi Prod.	Elasticity of Demand for: OPEC Oil [(1)x(2)x(3)]	Elasticity of Demand for: Saudi Oil [(1)x(2)x(3)x(4)]
	(1)	(2)	(3)	(4)	(5)	(6)
1970	-.3	11	1.5	6.2	-.05	-.28
1973	-.3	.2	1.5	4.1	-.09	-.37
1976	-.3	.5	1.6	3.6	-.24	-.86
1980 a	-.3	.6	1.4	2.6	-.25	-.76
to b	-.3	.6	1.7	3.0	-.31	-.92
c	-.3	.6	1.7	3.6	-.31	-1.10
1985 d	-.3	.6	1.9	4.5	-.34	-1.54

Source: (1) Assumed

(2) Persian Gulf/Western Europe retail; for 1980-85 assumed $18/$30.

(3), (4) See Table I.