

World Oil: Availability and Price
The Next Ten Years

by

M.A. Adelman

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Prepared by

M. A. ADELMAN
Economics Department & Energy Laboratory
Massachusetts Institute of Technology

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WORLD OIL: AVAILABILITY AND PRICE: THE NEXT TEN YEARS

M. A. Adelman
Economics Department & Energy Laboratory
Massachusetts Institute of Technology

E40-429, M. I. T.
Cambridge, Mass., 02139, USA

Since 1970, there has been unprecedented volatility in oil prices. The peak was in November 1981, when Saudi Arabia raised the price of its marker crude to \$34, or \$41 in mid-1986 dollars. In real terms, that was about 13 times the 1970 level.

However, by November 1985, the price was down, in real terms, by over a third, to about \$26. In the next few months, the price fell precipitately, then stabilized between \$10 and \$15.

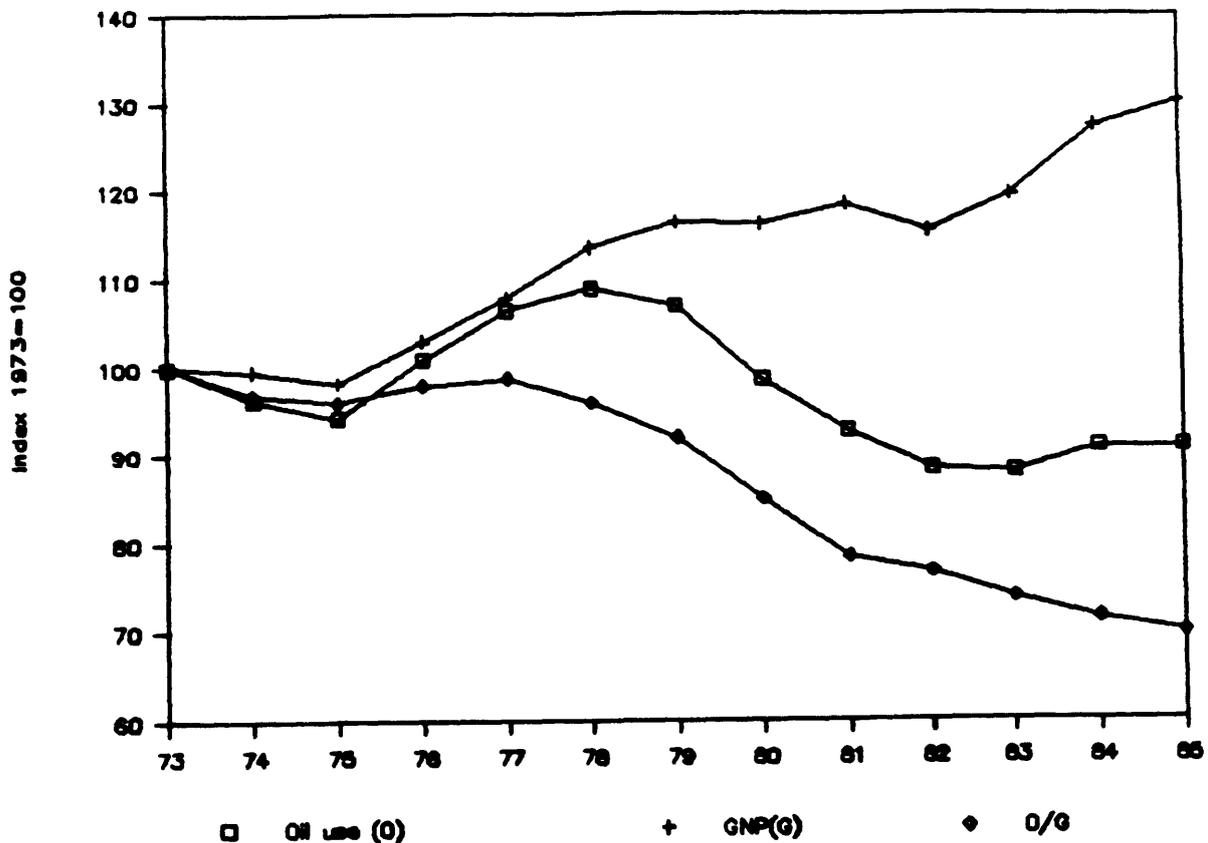
The prospect for the next ten years, as I see it, is for the price of oil to fluctuate between a competitive floor around \$5 and a monopoly ceiling around \$25.

The Developing Member Countries (DMCs) must, like everybody else, cope with \$15 oil that may often rise or fall by that much.

DEMAND

Nobody disagrees today that higher prices discourage oil consumption, lower prices encourage them. It depends on how high or low, and on the time period allowed.

FIGURE 1
Oil Use & GNP 1973-85



The United States is a good laboratory sample to study demand because world oil has always been priced in dollars. Therefore the changes in consumer prices have reflected changes in crude oil prices more promptly there than elsewhere, especially after 1979, when price controls were abolished.

Figure 1 shows how the changes in USA oil product use stayed very close to changes in the GNP from 1973 to 1977, but then swung away in delayed response to the first price explosion. They continued down, propelled by the second price explosion.

From 1981 to 1985, GNP in the USA rose by about 11 percent, and oil product prices fell by about 25 percent, real. Yet oil product use kept on declining. Not until after the big price drop, in the second quarter of 1986, when oil prices had fallen by another 25 percent, did oil consumption per unit of GNP begin to increase.

I believe it will continue to increase if the price of crude oil stays at its present levels or rises only moderately, to not more than \$20.

But increasing consumption will not get back to past growth rates, for several reasons. Energy saving technology is irreversible. The industrial countries are much more automobilesaturated. Natural gas will displace oil, and oil taxes will stay higher. Finally, the very fact that oil prices move up and down so much will discourage consumers from moving back to oil.

Chevron Oil Co. recently stated a consensus view: world gross product to grow by 3 percent through 2000 A. D., energy demand by only 2-plus percent, oil at less than 1 percent.

At such rates of increase, cumulative production will not strain existing known oil resources, let alone discoveries.

But oil resources have always been ample, and yet prices have increased. It is time to look at projections of demand and supply in the light of experience.

FIGURE 2
ACTUAL & EXPECTED PRICES
1970 - 2010 A. D.

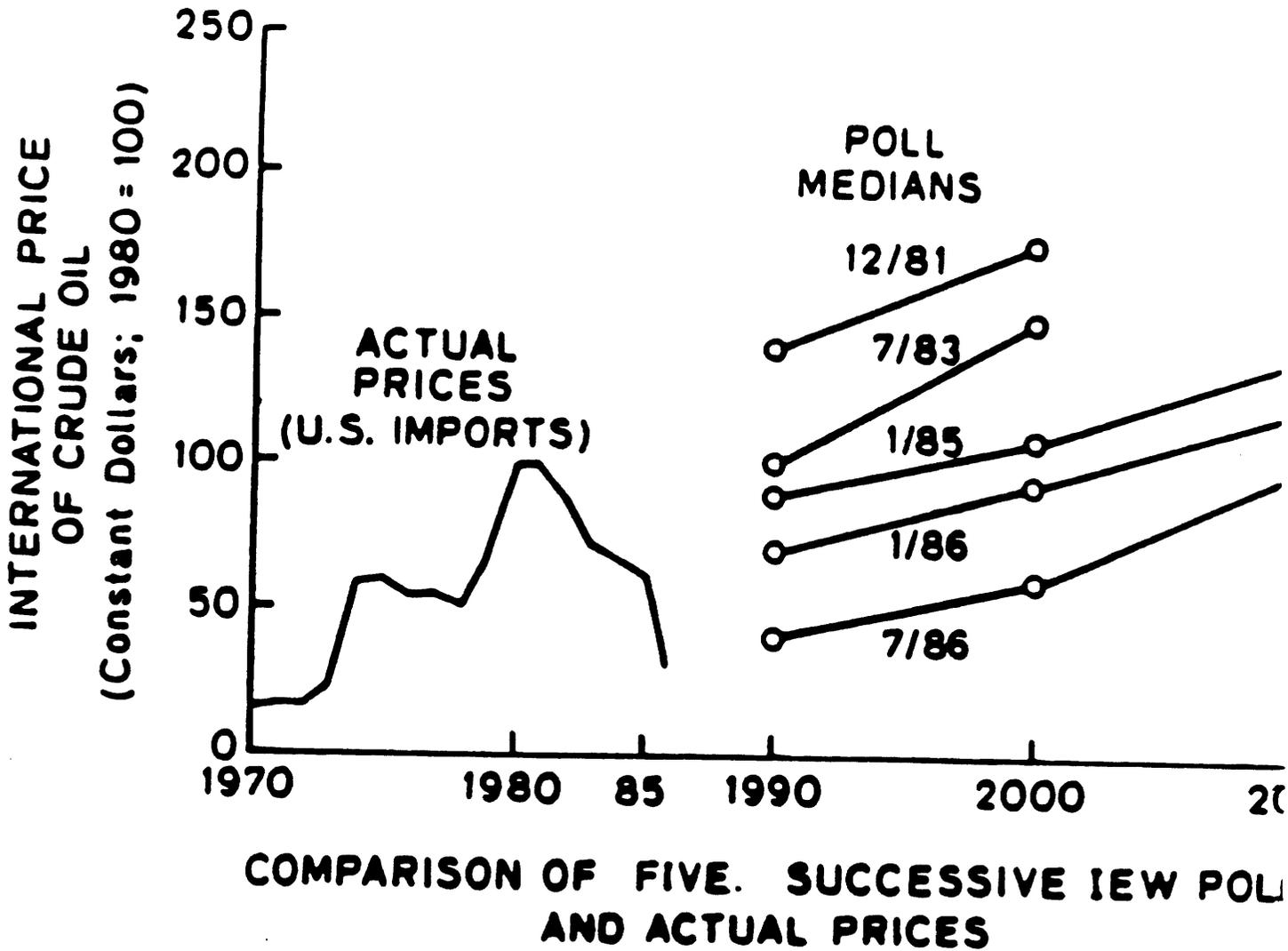


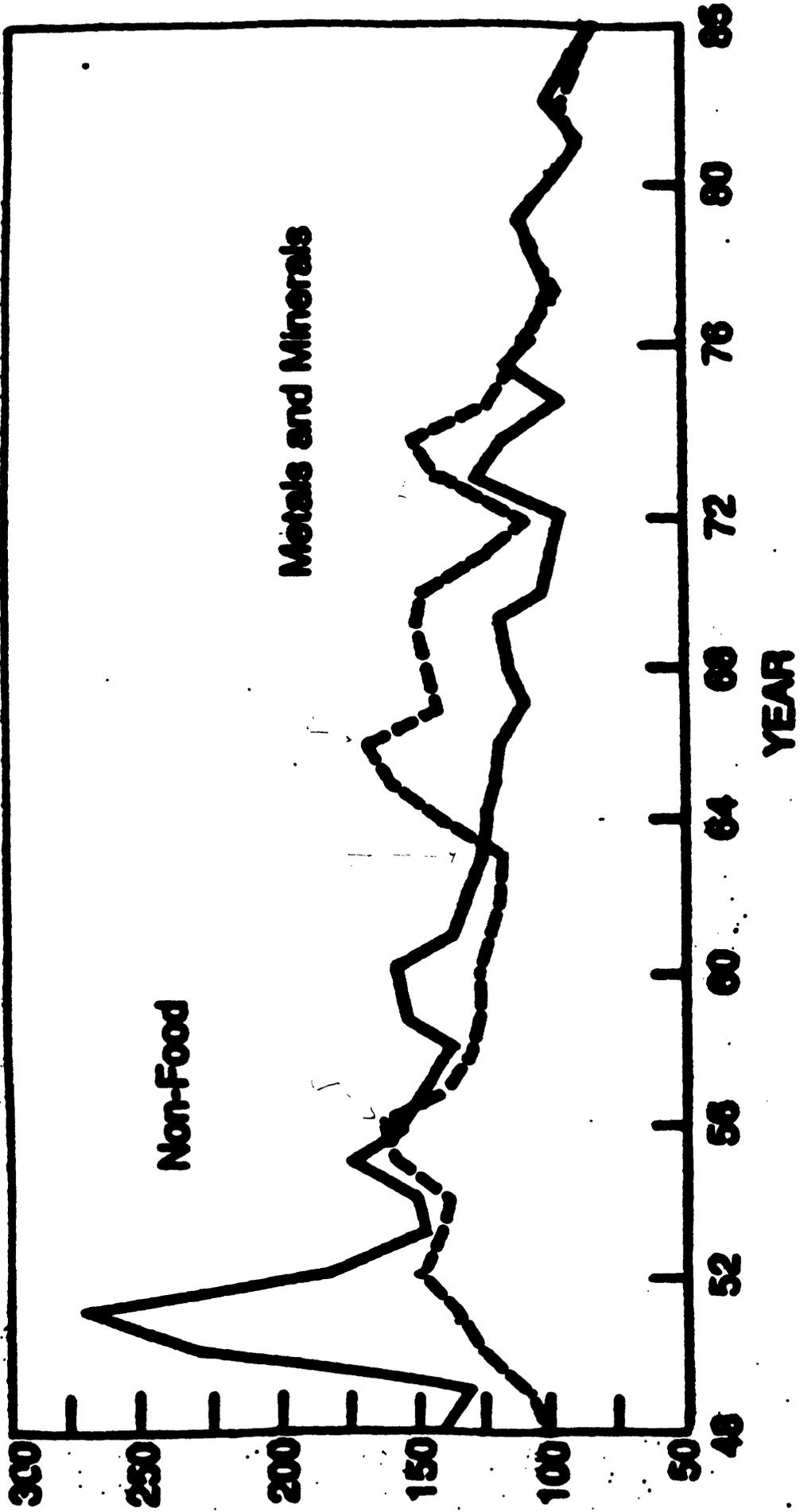
Figure 2 shows the history of prices since 1970, and shows the median forecast made by varying expert groups, compiled by the International Energy Workshop. In 1981, it started with the

then-current price, and projected it far upward. In the five years since then, the projection has not changed. The starting point is always lower, but the expectation for the future is the same.

The reason for this fixed unchangeable opinion is so widely assumed that is rarely stated: Consumption rises exponentially, much of the "finite resources" are used up, and higher prices must follow as the night the day. Therefore oil and gas reserves are low-risk appreciating assets.

This is a perfectly general theory, and holds for every mineral, including oil. It is striking contradiction to the facts. With few exceptions, minerals prices have trended downward for as long as we have any reliable statistics. This has continued at least through 1985.

FIGURE 3
REAL RAW MATERIALS PRICES 1948-1985
(Source: World Bank, Commodity Trade & Price Terms, pub. Johns Hopkins University Press, 1986)



When a theory leads to universally wrong results, it is time to amend it, or discard it. I think some reflection will show that resources--what's in the earth--are not a binding constraint.

We will never run out of oil, coal, gas, metals, non-metallic minerals, etc. We will stop digging for any one of them when and if the cost of providing new inventory--reserves-- exceeds the expected discounted price. What's then left in the earth is unknowable, and it would not matter if we did know it.

The real-world problem is not a fixed stock but the cost of providing a flow. This cost tends to rise because of diminishing returns. In any given area at any given time, the odds are we will find the biggest fields first, even by blind chance, because they are biggest. Furthermore, it is rational to exploit the best first. With no offset to diminishing returns, life would be one long slide from good to bad, and from bad to worse.

But diminishing returns are offset by increasing knowledge, both of the earth's crust and of better methods of locating and exploiting mineral deposits. The one rule we can trust is that mineral scarcity, and mineral prices, are the uncertain fluctuating resultant of opposing forces.

FIGURE 4
CRUDE OIL PRICES 1912-86
(1982 \$)

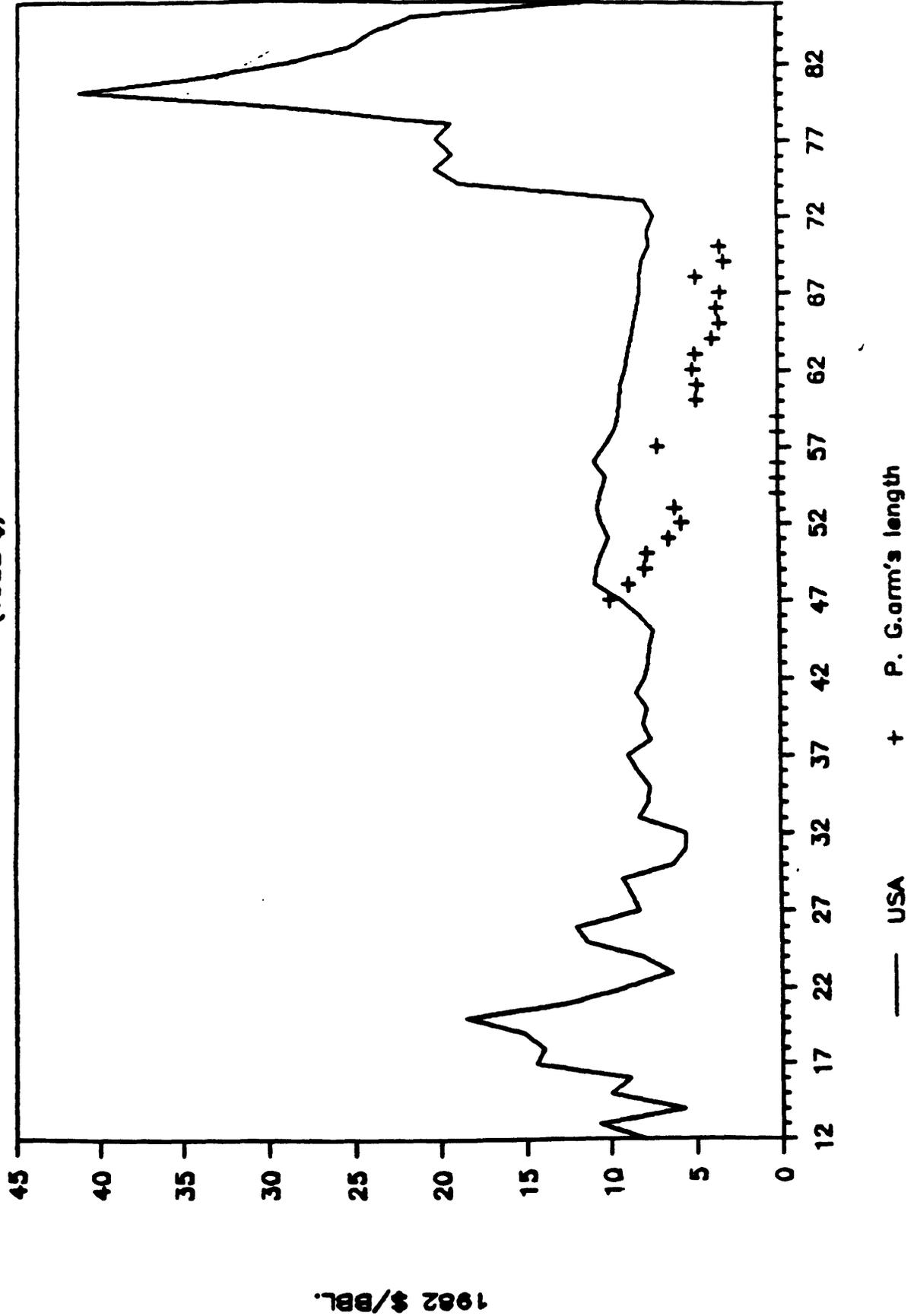


Figure 4 shows the price of oil from 1912 to 1986. The solid line is the USA, but from 1948 through about 1971, it was kept artificially high by restricting imports. The broken line shows an arm's-length price (not a posted price) at the Persian Gulf. We will shortly ask why the abrupt change in 1974.

Because minerals prices and costs fluctuate, mineral reserves are risky assets, like most other assets. Producers (and others) are constantly in the business of appraising them. They make constant comparisons of investment requirements per unit of additional oil versus expected prices.

If the cost of providing new reserves rises, then everybody is on notice that prices must also rise. The value of reserves already known, in the ground, must also rise. It will then pay to withhold high-cost oil from current production and development. This reduces the supply and raises the price of oil right now.

Thus in a regime of competitive markets future shortages and surpluses are perceived in time to allow adaptation. Mankind never has been in danger of riding blindly off the cliff of unforeseen scarcity. That is why the idea of an "energy crisis" never made any sense.

Of course the appraisals of private markets are no better than the data and analysis used. Buyers and sellers may be very wrong. But a

market in oil and oil properties, is also a market in ideas. There are strong incentives to correct mistakes, and seek out and use new data.

There was no underpricing of oil in the 1960s. Investment requirements per additional barrel of crude oil capacity were steady to declining. There was no indication of any increase in the price of reserves in the USA (the only observed market). These data refute the notion that there was any approaching scarcity.

The new force, which made the difference, was the cartel¹ of the OPEC nations (not OPEC itself, which is at most a forum for discussion).

THE UNIQUE CARTEL

This cartel is unique in being a group of sellers who are also sovereign states.

Wealth maximizing Like private firms, the cartel nations are profit- or wealth-maximizers. Their political interests and objectives do not affect their price-production behavior. The more wealth, the easier to reach the goal, whatever the goal.

¹ Some readers may find the use of "cartel" and "monopoly" offensive when applied to a nation or group of nations. It is used in the simple economic sense: a seller or group of sellers who cooperate to make the price higher, and output volume lower, than if they did nothing.

Since the oil is nearly all exported, the benefits go to the local economy, the cost is borne by foreigners. Hence there is no internal opposition to high prices, nor any dispute about whether a higher oil price helps more people than it hurts. Seller-governments, acting together, are free to raise the price to what the traffic will bear.

Governments' short horizons The OPEC nations must, as rational asset owners, use shorter time horizons and higher discount rates than equally rational private corporations. The nations' revenues fluctuate more, and they are undiversified.

1. Non-cartel producers are price takers who sell all they can produce. The cartel nations produce only what they can sell without undermining the price. Hence the fluctuations in cartel sales and revenues are greater than in total crude oil sales. They find this a burden, of course, and are trying hard to shed it--with negligible success.

2. The cartel governments are heavily committed to domestic and foreign spending. They are like heavily leveraged private firms with most income pre-committed to debt service. Fluctuations of net or disposable income are correspondingly greater.

3. Some of these governments are unstable, and unruly to each other; the Iran-Iraq war has already produced some 300,000 dead.

4. The nation-owners, as small LDCs, have no portfolio of assets, or assortment of incomes, against which to diversify oil

income. With the partial and minor exception of Kuwait, they have not built up enough assets to diversify. Their investments in domestic industries have not provided any substantial non-oil incomes. Of the thirteen OPEC nations, only Indonesia has a large enough economy to provide even a minor element of diversification.

The market discount rate or cost of capital for private oil and gas production firms appears to be about 10 percent, real. For the OPEC nations, as rational actors, it ought to be well over twice as high.²

In saying that the OPEC nations should use much higher discount rates, we do not imply that they necessarily go through any formal calculations at all. We are only trying to describe what they do as producers and price-setters. A company or government which seizes short-term gains and disregards longer-term penalties or trade-offs is, whether they know it or not, discounting at a higher rate. A company or government facing a given income stream will react according to whether the stream is (1) highly leveraged and (2) folded into a larger diversified income stream. If the stream is highly leveraged, and

² In the language of finance, these nation-operators' risk factor (Beta) is determined not by the covariance of oil revenues with their other income flows, for these latter are very small. Their risk is determined by the variance of the oil income flow itself, which is very high. The subject is covered in detail in a paper, "Oil Producing Countries' Discount Rates", in Resources & Energy, December 1986.

undiversified, the stream is very risky, and the owner will, to serve himself, discount it at a high rate.

Because of short time horizons and high discount rates, the intergovernmental cartel raised the price faster and higher than would a monopoly with a private cost of capital. They have also been slower to reduce the price for the sake of long-run maximization.

We now look at the environment in which this cartel must function in the coming decade. There is general agreement that consumption will slowly rise. It is less clear what happens to supply.

NON-CARTEL SUPPLY: THE COMPETITIVE SECTOR

Will non-cartel reserves run out?

It is widely assumed that non-cartel reserves are rather small in relation to production, which must therefore run down pretty quickly. But this derives from the basic error of treating reserves as resources. It is also disproved by experience.

No area in the world is as drilled-up today as was the United States in 1945. Over a million wells had been drilled, 30 billion barrels produced, 20 billion "remaining recoverable reserves". Discoveries of large fields had peaked during the 1920s, and could only decline. Yet during the next 40 years, not 20 but 100 billion barrels were produced (excluding Alaska), and 16 billion were left at the end of last year.

How did it happen? Many small fields were discovered, and the large ones proved very expansible--sometimes amazingly so. Kern River in California, discovered in 1899, had about 30 million barrels "remaining recoverable reserves" in 1945, and about 900 million today. Moreover, an old drilled-up oil province has a dense infrastructure of pipelines and services which mean any additional reserves can be quickly produced.

The problem, again, is cost. My calculations show a 1985 U. S. average of \$12 per barrel development-plus-operating. Of course it is a false precision, indicating only the neighborhood of cost. About a third of total U. S. development was of higher-cost reserves. Therefore a price of \$12 would not cause a quick rundown, but it would curtail investment, hence production in the long run.

Costs to the operator are much lower today, partly because factor prices are down--drilling rig rates, wage rates, materials and supplies, etc. Equally important: since 1981, when the downturn began, the efficiency of those factors is far up. The amount of feet drilled per rig-year has more than doubled. In the first half of 1986 it is up by one-fourth over first half 1985. Rigs running are down below their 1973 level; but the work they do is at the 1979 level. This growth in efficiency explains the collapse in the oil service industries, and great local distress. The cutback is not nearly as great outside the USA, of course.

Rents, and ill-conceived price controls, explain why, when oil prices in the USA were spiraling upward through 1981, gross reserve additions dropped sharply in the USA; they were also very bad in 1982. But over the next three years, as prices deteriorated, reserve-additions rose to a near-record level, exceed^{ed} only in 1949-51.

It has been alleged that the Saudis cut prices in order to destroy the US producing industry. If my own calculations are anywhere near correct, they would have to go well below current levels, and it would take far too long to make it worth their while.

At any rate, if we use the USA as an extreme example of the highest-cost non-OPEC production, it seems safe to say that if prices recover to \$20, then there will be no rundown of capacity in the United States for years. At \$5, there would be a fairly quick rundown, and at \$15, a slow one.

In October 1986, production in the United States outside of Alaska was three to four percent below October 1985. There is nothing to suggest a faster rate of decrease.

NON-CARTEL SUPPLY: OUTSIDE USA

Here the picture is dominated by the delusion mentioned earlier, that oil and natural gas are low-risk appreciating assets. Higher oil prices actually reduced supply in many countries. Lower oil prices since 1981 have promoted supply, and the process will speed up.

Before 1982, the higher prices went, the higher they were expected to go. The higher they were expected to go, the more did non-cartel governments with oil resources think they could benefit by withholding oil and gas for later development. So governments often overtaxed, regulated, or limited production or exports.

Governments with promising areas often demanded impossible terms from foreign oil companies. They felt unable to bear the accusation that they were soft on big foreign oil companies, giving away the national patrimony cheaply, or corruptly. So there was no bargain. There was comfort in the thought that eventually they would get more. But it was a cruel delusion. They would get less.

The phenomenon is best documented in Canada, the Netherlands, and Norway, and in natural gas, which is a sleeping giant slowly awakening in Europe.

In all three countries, when oil prices rose in the 1970s, the governments curtailed gas production and exports. But when oil prices began to weaken seriously in the 1980s all of them reversed course. In Canada, the government had prevented gas exports out of known reserves at \$5 per Mcf. Sold in 1981, and invested at the

riskless interest rate, that would be about \$8.34 today. But today, Canadian exports are now going at just over \$2. That was a severe capital loss on those supposedly low-risk appreciating assets.

The direct result of the 1986 collapse of oil prices was the willingness of the Norwegian government to reduce taxes, and waive its insistence on developing super-expensive unwanted Troll oil. Troll gas, for which \$7 was once demanded, will be sold at \$3.50, or less. Furthermore, as our research at M. I. T. has shown, gas from the Troll field can profitably be sold at less than \$2, once they have broken the buyers' monopoly exercised in Germany by a large transmission-distribution company. Fifteen-dollar oil, or even somewhat less, will not prevent Troll gas from backing out a million barrels of oil daily sometime in the 1990s.

The Algerians, who have painted themselves into a corner by demanding unattainable prices, will reconsider, the sooner the better for them. The Russians, despite the misguided attempts of my own Government to block them, have a great deal more gas to offer.

Oil demand will be unexpectedly weak in Europe, but the real reason will be on the supply side--the competition of natural gas because of lower prices.

As it becomes clear that current oil prices are not going back to the 1981 peak, it will become worth while to undertake a great deal of new discovery and development all over the world. I know no way to

estimate it, but the import is clear: the rate of development of non-OPEC reserves will not dwindle.

Conceivably, the competitive price could stay below \$10 for decades. It might also rise. One thing is certain: if it is a free-market price, it would take no such leaps as in the 1970s.

However, in my opinion the chances are small that the price will stay at free market levels. Having sketched out the basic nature of the cartel, and the supply-demand environment it faces, I would like to look at the way it works, and the chances of survival.

THE CARTEL IN THE NEXT DECADE

Permanent Instability

There is a never-ending cycle:

agreement, firm to rising prices; cheating, price deterioration; breakdown, then a new agreement. It is difficult to make an agreement, and even harder to abide by it, but not impossible. The basic problem is set by the same financial factors which drove cartel prices upward. The cartel nations cannot afford to wait.

This makes for a basic instability, or circle. A higher price brings higher revenues which lessen cheating and help support the price. Contrariwise, lower prices promote cheating, hence even lower prices. If lower revenues made the Iran-Iraq war sputter out, that would depress or break the price.

The threat of a price collapse may promote panic, and the price collapse itself. Or it may concentrate the minds of the cartel members, and their collaborators, and help regain solidarity.

Hence there is no simple relation between the challenge--lower or higher demand upon the cartel--and the response of a concerted orderly output change. And this is why models which deduce the price of oil from supply and demand are unreliable, and have repeatedly failed.

RECENT CARTEL AND PRICE HISTORY

Relations among the cartel nations are dominated by large versus small producers. The smaller members may cheat readily, knowing that the others will cover for them. But the largest has no such freedom. If he cheats, the agreement collapses.

But the largest seller cannot afford to become known as everybody's favorite food. Hence the endless round of threats and then action to make the threats good.

FIGURE 5
OPEC OUTPUT: SAUDI v. ALL OTHER
1980-1986

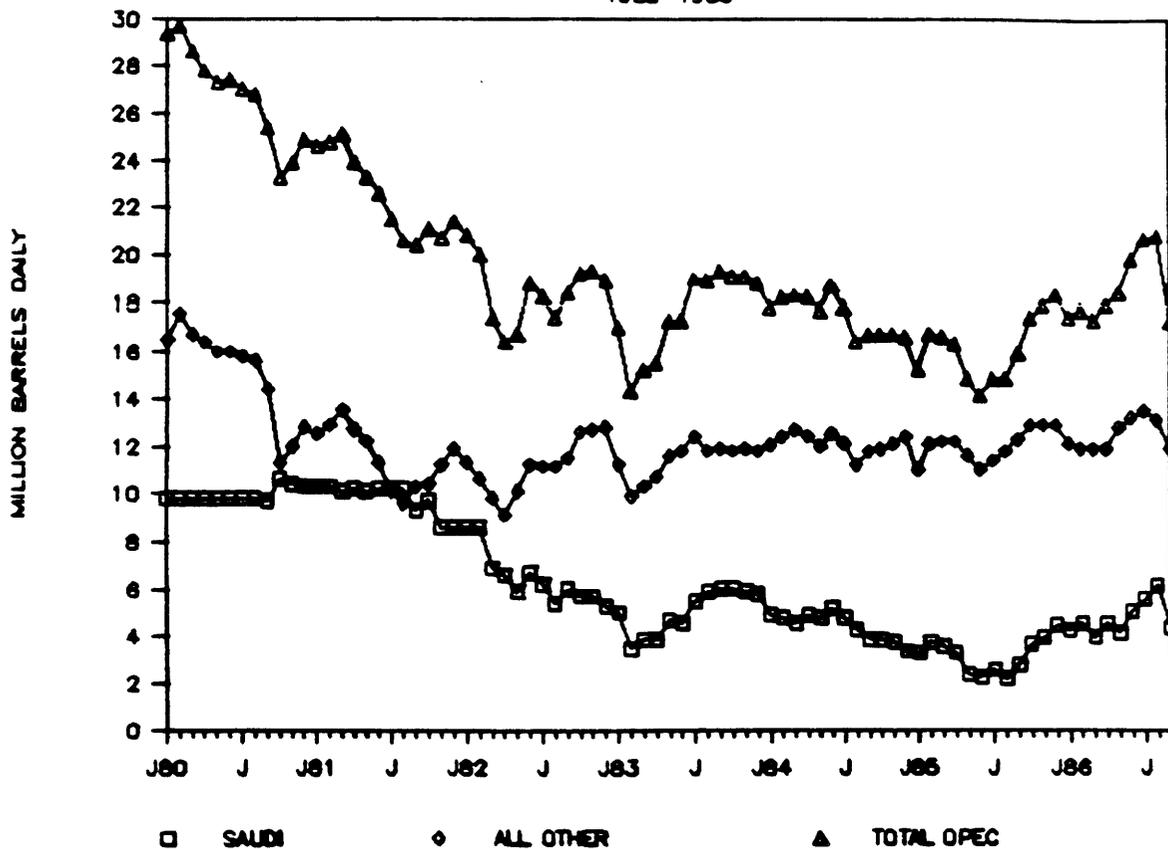


Figure 5 shows what happened after 1979. Official prices were below spot prices. But the OPEC governments exacted spot prices, except for Saudi Arabia, which charged only official prices. This

tactic was very advantageous to the Saudis. They maintained their sales volume, while the other OPEC members absorbed the whole reduction in demand, through February 1982. (Kuwait has been excluded from the "all other", but included in the OPEC total.) At this time, the others began to discount prices enough to divert business, and never afterward did they lose sales. Saudi Arabia was now absorbing the full reduction.

In January 1983, Saudi Arabia responded. They broke up an OPEC meeting and within two months the rest had agreed to quotas, which they adhered to, for about a year. Then price cheating re-commenced in the Summer of 1984.

In November 1985, after innumerable threats, and with exports down to 1.5 million barrels daily (where they had once been over 9) the Saudis acted, with great restraint. It is widely believed that they were trying to lower prices in order to knock high-cost producers (as in the USA) out of the market, or force non-OPEC producers to cooperate; or that they were trying to knock Iran out of the war, etc., etc. None of these theories will fit the facts. The Saudis could easily have cut prices far down, or increased output from 2 to 9 million barrels daily.

In fact, the Saudis did not reduce prices, or increase output beyond their quota. They offered only their full quota at netback prices; that is, product prices less some stated allowance for transport and refining costs. In effect, they matched the market price.

It was a clear message to their fellows: there is no longer any use in cheating. No matter how low you go, we will automatically match you. The Saudis did, to be sure, offer an extra inducement. The product price, which after deductions became the netback price, was set as the price at the time not of loading but of arrival, some six weeks afterward, or even somewhat later. Thus they assumed the risk of downward fluctuation, which during a period of price weakness was a substantial "sweetener".

As in 1983, they got their way, but this time it took nine months instead of two, many meetings instead of one, and a price decline of 50 percent.

One is tempted to say: another such victory for the Saudis, and they are all finished. But I believe the collapse, if it comes, will be only temporary. The OPEC nations will keep trying.

Glutted markets will be a barrier to price increases, but they overcome those barriers in the past. Cohesion, or the lack thereof, will be all-important.

The clumsy cartel Ever since they ousted the companies, the cartel has been forced to control price by changing output. They respond to perceived total demand; non-cartel supply; and inventories. Unfortunately, this guarantees price instability.

Short-run demand and supply are very inelastic. Even large price changes produce only very small changes in the amount supplied or the amount demanded. Conversely: even small output changes can yield big price changes.

By the same token, small errors in the assumed data can have big effects. But the cartel managers do not even have good current data. Production figures are often falsified. Consumption numbers lag by months in the industrial countries, and years in the LDCs. Inventories are shaky even for the oil companies, and consumers' stocks are a statistical black hole. Again and again, in recent years, inventories have looked "irreducibly low", only to turn out high. One reason, of course, is that high prices have taught everybody to economize, and the new techniques learned will not be abandoned at lower prices.

The International Energy Agency has estimated that during July-August 1986, world production exceeded consumption by 2.6 mbd, yet it could report a stock build at the rate of only 0.8 mbd. The error is twice the estimate. This ignorance is chronic and permanent.

Hence one must expect that a cartel-fixed price or production schedule will not normally clear the market.

In competitive markets, the numerous actors are free to make many immediate small corrections of demand or supply. But concerted cartel management of supply makes timely corrections slow at best, difficult to make at all. Overdue changes set off anticipations of large price movements, and often amplify them.

In success and failure alike, the cartel is clumsy and disruptive. But they would be foolish simply to stop trying. The lesson has been learned: the world oil market can be monopolized, and the rewards thereof are immense. If OPEC were formally disbanded, a new organization would replace it, with membership not much changed. The last thing to be expected is smooth convergence to any supply-demand equilibrium.

CONCLUSIONS & POLICY SUGGESTIONS

The current price, about \$12 per barrel at the Persian Gulf and \$15 at the U. S. Gulf Coast, is very high by historical standards and in relation to cost.

At this price, there is no question of supply stringency. Reserves and resources are ample to the end of the century, at least. Nobody knows how far past they will suffice.

But despite ample supply, the price will remain unstable, because it is governed by a clumsy cartel, which finds it difficult to make and enforce agreements on output division.

All of the Developing Member Countries (DMCs) must cope with these conditions as consumers. Some of them are exporters, and nearly all are potential producers of oil or gas or both.

Consumers. It is an advantage to have import contracts, since this saves both buyers and sellers the work of perpetually looking for each other, and drawing up the terms for every single cargo. But no supplier can guarantee price or delivery, because nobody knows when the next crisis will intervene, or the next price increase or decrease.

Import prices, whether negotiated directly by a DMC, or approved by it, should be related to published netback prices. Movements in these prices should be indexed to movements in netbacks at Singapore, with additional indexes to other great refining centers, e. g. Rotterdam, Houston.

The only insurance against supply disruptions is in a stockpile. Storage of crude oil is expensive, because of the need to contain the volatile components. However, storage of heavy fuel oil, and of coal, is cheap. The principal component is the investment in the fuel itself. But for dual-firing plants located on tidewater, this can be made to pay for itself, as it did in the United States and Europe before the 1970s. It permits the power plant to buy the cheapest fuel on the market at any time.

Away from tidewater, where natural gas is available, power plants should be oil-gas dual-firing, for the sake of security. The investment is much less than in oil-coal dual-firing. Natural gas will be discussed further below.

Producers Many members have good prospects of oil or gas production. Oil and gas deposits are not appreciating assets. In fact, their value has depreciated more than 60 percent in the last five years. Moreover, later revenues are not worth as much as earlier. Waiting for price increases has already cost some nations dear, as our examples of Canada and Norway showed.

DMCs should proceed as rapidly as possible to negotiate with all competent oil companies, foreign and domestic, for exploration and development. The objective should be to obtain the maximum present value of total revenues, not the maximum royalty per unit of oil or gas.

LNG Projects³ The DMCs are in an area where hydrocarbons are likely to be gas. A few years ago, gas could be sold at delivered prices in Japan and Korea of about \$5 per thousand cubic feet. No such prices are conceivable today. When the prices are re-negotiable a few years hence, they will probably be lowered drastically.

Delivered prices of LNG were set to equal or even somewhat exceed crude oil prices. But this was the result of panic about scarcity. Under more normal and competitive conditions, it is likely that gas prices will settle out somewhat below equivalent crude oil prices. Basically this is because a barrel of crude is worth the products it contains, less refining costs. But gas can not substitute for oil in its most valuable uses: motor gasoline and jet fuel. It can substitute only in stationary appliances, burning light or heavy fuel oil (or illuminating kerosine.) Furthermore, its delivery cost to the burner tip is greater. Hence with crude oil expected to stay around \$15, a competitive price for gas could hardly exceed \$2.50, and would probably be less.

We can work back from the value of LNG as delivered, to the value at the natural gas wellhead as follows, assuming a shipment distance of 4,000 miles:

³ This discussion summarizes East Asia/Pacific Natural Gas Trade, a report of the International Natural Gas Trade Project of the Energy Laboratory at M. I. T. (March 1986).

LNG price, delivered:	\$2.50
<u>less</u> Regasification	.35
<u>less</u> Shipment (tanker)	.80
<u>less</u> Liquefaction	1.00
<u>Equals</u> Wellhead value	<u>\$0.45</u>

Obviously the wellhead value is very sensitive to the delivered price. This wellhead value must be compared with production cost. We have dealt only with known fields, in order to calculate a price which would make it worthwhile to drill and otherwise develop new capacity.

Our "base case" estimate for offshore production cost in the area of the South China Sea was 26 cents per thousand cubic feet (Mcf), assuming a 12 percent real rate of return. However, costs in four offshore fields in which we had some individual information ranged from 26 cents (Thailand, "B" Structure; China, Yacheng) to 51 cents (Malaysia, Central Luconia). Obviously, with costs only mildly above our base case, there is not much left here in excess rent to be absorbed by the host government.

The only hopeful aspect I can discern here is the possible reduction in cost. Production costs have dropped sharply in the United States since 1984. Much more important is the possible decline in LNG construction costs. They increased by a factor of five from 1974 to 1983. Much of the increase was of course general inflation, which has not been reversed; but even more was inflation in this particular kind of plant, and nobody can doubt that by 1983 it was heavily padded with "rents" which can be reduced.

Thus it would be an exaggeration to say that LNG projects are dead for the next generation. But few if any will be viable.

Hence it would be more profitable for the DMCs to promote natural gas development in order to back out oil imports, or to free up oil for additional exports. Instead of the value of the gas being 45 cents, it would be \$2.50.