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THE PROSPECTS FOR OIL PRICES, REVISITED

by

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The Prospects for Oil Prices, Revisited

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1. INTRODUCTION

This article reviews recent and current opinion about the prospects for prices in the world market for crude oil. Two alternative views are examined:

> 1. The present oil glut and softness in the market is a temporary phenomenon, that will be reversed by the 1990's when the real price of oil will begin to rise again.
> 2. The changes we have witnessed in the past five years -- in oil demand, in non-OPEC supply, and in the power of OPEC -- are permanent and irreversible. Oil will be in excess supply more or less indefinitely.

In Section 2, we examine each of these basic views and the underlying arguments. In Section 3 we review the data summarizing what has happened in the world oil market over the past quarter-century, and especially since 1973-74: for demand, supply, price, and new oil discoveries. In Section 4, to provide the reader with some historical context, we review the literature of the past decade on "expert opinion". Section 5 presents a range of specific projections to the year 2000, as summarized in the 1985 poll of the International Energy Workshop (1). Section 6 presents some explicit modeling efforts, especially those of the Energy Modeling Forum's important study, World Oil (2). Section 7 presents some econometric results on one of the most important uncertainties, the long-run price-responsiveness of the demand for oil. Section 8 summarizes the outlook, with a discussion of some of the main uncertainties.

2. TWO ALTERNATIVE VIEWS: OIL GLUT TEMPORARY OR PERMANENT

2a Oil Glut a Temporary Phenomenon

In this view, both world oil demand and the demand for OPEC oil will recover and grow more rapidly by the end of the decade. By that time, the positive effect of continuing economic growth, on increasing the demand for energy and for oil, will outweigh the negative, demand-reducing effect of the continuing (but decelerating) adjustment by consumers to the price increases of the 1970's. Because only modest growth, or perhaps slow decline, is expected in non-OPEC oil production, the demand for OPEC oil will increase substantially over its current depressed level by the early to mid-1990's.

Moreover, this process will be speeded up by a likely decline in oil prices between now and 1990. Such a decline would diminish the demand-reducing effects of current price levels, would deter non-OPEC supply, and would have a positive effect on world economic growth and thus on oil demand. Some price declines are inevitable in the sluggish market now facing OPEC, as this imperfectly disciplined cartel tries unsuccessfully to restrict output.

It now seems clear that OPEC overshot the mark with its price doubling in 1979-80. OPEC, and Saudi Arabia in particular, would have been better off had they avoided such an abrupt and large price increase. It would have been better if

Saudi Arabia had expanded its production in early 1979, rather than cut it, during the Iranian disruptions. More gradual and moderate price increases would have been warranted by the underlying market conditions. Such price increases would have minimized the negative impact on world economic growth rates and avoided the sharp decline in world oil demand. Instead, what happened was that OPEC lost control of the market, and let the official contract price keep following the spot price higher and higher, misinterpreting the spot price as a good indicator of a long-term equilibrium price for its oil.[1] In its groping search for a better price-path, it raised price too much and too rapidly.

The price-overshooting and the resulting sluggish market could have the near-term effect of further depressing price. The 1979-80 price increases did not result in the anticipated increases in export revenue; any gains were only temporary. Realized ex-post export revenue was less than anticipated ex-ante revenue. Thus, producers within OPEC, especially those with relatively large populations with great need for current revenue, and perhaps some non-OPEC producers

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[1] In contrast, U. S. copper producers have historically been cautious about allowing the administered U. S. price to increase, even in response to a much higher free-market price on the London Metal Exchange, lest there be an irreversible switch away from copper to aluminum. See the paper by Fisher, Cootner, and Baily (3).

as well, can be expected to increase production above what the market is demanding. This near-term output response can be explained in terms of target-revenue behavior. To achieve the desired level of export revenue would require that output be increased.

Of course, not all the members of OPEC act as competitive, price-taking producers. But the same considerations apply to the "core" countries of Saudi Arabia and its allies within OPEC. Tending to increase their current production is the same factor: the unrealized expectations of increased export revenue from the 1979-80 price doubling. Supporting such an output increase is the realization that their longer-term interests are best served by greater output but at a lower price.

Near-term output increases might also result from a different behavioral theory for oil producers, that of intertemporal optimization behavior, but here the results are ambiguous. In that theory, an oil producer's current output depends (among other things) on both current price and expected future price. This output decision, about whether or not to produce an additional 100,000 barrels per day, is continuously revised, until the "optimal" current output is achieved. This decision depends on the comparison of the value of that oil-left-in-the-ground and its value if sold now and the proceeds invested or spent. If greater, leave that 100,000

barrels a day in the ground; if less, sell it now.

The ambiguity of results from this theory is due to the fact that the recent sluggish market has depressed both current and expected future prices. If only current price had been affected (and not expected future prices), then the value of the incremental 100,000 barrels of oil would be higher if it were left in the ground; hence current oil output would be reduced. On the other hand, if some event were to decrease only expected future prices, but not current price, then the value of that oil if left in the ground is lowered; hence current output would be increased. Since it is not clear which has been affected more in the recent sluggish market (current price or expected future prices), the predictions of this theory are ambiguous. It seems, however, that expected future prices have been depressed more than current price. This would tend to increase near-term output.

For prices not to decline would require that OPEC maintain its currently low output level, or perhaps reduce it even further. But OPEC's imperfect discipline limits its ability to reduce output . Given the capacities of its member countries, it has great difficulty reducing output below current levels. Conceivably, a member with spare capacity might be willing to abide by some quota, but the temptation to cheat is great: to sell oil now at a relatively high price, rather than to have to wait before it could sell at a still

higher price. It is far easier to get OPEC members to honor an export-quota agreement if success is expected and the reward is higher export revenue now and in the future. But if the realized result of a price increase is declining export revenue, then a rearguard-action to shore up prices is nowhere nearly as persuasive in countering the temptation to cheat. The core countries could very well now believe that the current price is too high for their own interest. The demand curve for their oil is price-responsive ("elastic"). Increasing their output, even though it will decrease price, will increase their future revenue and perhaps their current revenue as well.

What will be the effect of these near-term price declines? Certainly, these oil price declines will not affect existing changes in consumers' capital stock. For example, insulation will not be removed, nor will people abandon energy-efficiency design improvements in appliances and automobiles. But lower oil prices will affect future capital-stock decisions. Thus, we would expect a move toward somewhat larger automobiles, which would be less energy-efficient than those that would have been selected if oil prices had remained high.[2] In addition, some types of demand reduction are reversible. Thermostats can be re-set for

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[2] But they would probably still be more efficient than the 1970-75 vintage cars currently being replaced in the US.

more comfortable temperatures. Consumers can become less conscientious about energy conservation if prices decline. Also slowed down, if not reversed, will be fuel-switching decisions away from oil, for electricity generation, and residential uses such as space heating and hot water.

Similarly, such price declines could have some negative effect on non-OPEC supply, especially that which is high-cost production. Some non-OPEC producers, however, might actually increase current production for the same reasons listed above for some OPEC members: target-revenue behavior, or a downward revision in expected future prices that exceeds the decline in current price. However, any increased current production would have to come at the expense of future production; hence reduced near-term dependence on OPEC would come at the cost of increased future dependence.

However, rather than becoming a self-reinforcing "downward price spiral", this price-decline is a self-limiting process. As the market remains soft, OPEC's price will respond downward, until the demand for its oil gets to a level closer to its willingness to produce. Such price declines will cause the demand for its oil to increase, allowing the price to stabilize. After several years of such price declines, we would expect the demand for OPEC oil to recover substantially from the 1985 rate of 19 Million Barrels per day (MMBD), to the range of about 24 MMBD, perhaps by 1990. At that point, no

longer needing to worry about price declines, OPEC will have a crucial decision to make: whether to keep increasing production and hold the price constant or to maintain output and let the price rise.

2b Excess Supply of Oil a Permanent Phenomenon

The opposing view is that we have witnessed a permanent change in the oil supply-demand equation over the past five years. According to this view, the world will never again experience a period like the 1970's, so dependent on OPEC oil, and so vulnerable to major and abrupt price increases. Like Humpty Dumpty, OPEC's power is now broken, and broken forever. OPEC will never re-establish the position it had in the 1970's.

A variety of factors are said to keep oil in excess supply more or less indefinitely. On the supply side are big potential discoveries of new oil fields in lightly explored regions of the world; similarly for natural gas discoveries, especially deep natural gas. A review of the prospects for discoveries of conventional oil was provided by Nehring (4); it is discussed in the Section 3. On the demand side, the argument rests upon irreversible reductions in oil demand and the momentum for energy efficiency, especially in industry. Also important would be tax and tariff measures to reduce import dependence, now said to be more likely to be adopted for budgetary and energy-security reasons.

It could be that the demand for OPEC oil will never recover substantially. This presumes either that OPEC will keep price at or above current levels, or that a price reduction would have little effect on stimulating world oil demand or on deterring non-OPEC supply.

For the real price to stay at current levels, OPEC must be able and willing to control their production, in order to support the price. It could be that they believe the demand for their oil is not very sensitive in the short run to price reductions. And, if the market improve in a few years, it would be best to maintain current prices, in the hope of stronger demand in the 1990's. However, if the demand for OPEC oil declines, they will have to restrict output still further in order to support the price.

Some argue that a declining real price would have little effect, neither increasing the demand for oil nor deterring non-OPEC production. They assert that recent declines in oil demand are irreversible and that consuming countries would impose taxes to keep prices paid by consumers from declining. They cite the continuing improvements in conservation, both for energy in general and oil in particular. Certainly, there are numerous examples of improvements in energy efficiency: in appliances such as air conditioners, refrigerators, and boilers used for space heating; and better design and insulation of homes and factories. Similar

efficiency improvements exist for oil-using transport equipment, such as for automobiles and airplanes. In addition, there has been some fuel switching away from oil, in electricity generation (using instead natural gas, coal or nuclear), and in residential uses for space heating and hot water.

Similarly, they argue that a real price decline would have little effect on non-OPEC supply, because producers will maintain their output even at lower prices, or because their governments will imposes tariffs to protect them from cheaper OPEC oil. While it may be true that production from oil fields already developed would not be affected by a price decline, it would undoubtedly slow down the process of development of new fields and some production will be deferred.

Or it could be that, even if the demand for OPEC oil does recover, OPEC's future ability and willingness to increase price significantly or abruptly would be greatly limited. With regard to their willingness to raise price, the argument seems to be that OPEC has "learned its lesson" about the effects of raising price too high and too abruptly, and they would be unwilling to do so again. Yet, if their market does strengthen substantially, at least some OPEC members would undoubtedly respond with a call for higher prices, in order to meet their growing revenue "needs" after the sharp declines in the early 1980's.

With regard to OPEC's ability to raise price in a stronger market, denying them that would require some improvement in short-run responsiveness to oil price increases since the two major price increases of the 1970's. While it is true that there has been increased fuel-switching capability in electricity generation, there has been virtually no improvement in the transportation sector in short-run responsiveness.

As far as unintended price increases go, we have had only slight improvement in our ability to cope with another disruption. There has been only a minimal increase in the size of the Strategic Petroleum Reserve since 1981 under the Reagan Administration, despite ample opportunity to purchase oil in a very slack market. Thus, it seems that if the demand for OPEC oil does recover substantially, so that it reaches a level near their production capacity, then we are only slightly less vulnerable to another disruption than we were in 1979-80. Although the resulting price increase need not be permanent, in the meantime it would have a substantial negative effect on the world economy.

This is the key issue: can we have, indefinitely, both low prices and little need for OPEC oil? Or must there be a trade-off, that we can have either but not both?

3. HISTORICAL DATA

Data for the price of oil, for the standard quality "Arabian Light", are presented in Figure 1. This is taken from British Petroleum (5). As can be seen, between mid-1973 and early 1974, the nominal and real prices quadrupled. Again, between late 1978 and mid-1980, the nominal and real prices doubled again. Since 1981, however, the real price measured in US dollars has declined substantially, to near its level in 1974. But, in terms of European or Japanese currencies, the real price has not declined nearly so much (if at all), because of the appreciation of the dollar since 1980[3].

Figure 2 depicts total world oil consumption[4] (in million barrels per day, MMBD) and the amounts produced region-by-region. As can be seen, oil consumption grew rapidly in the 1960's and early 1970's, until the price-quadrupling of 1973-74 and the ensuing recession. Most of the increased production came from OPEC, with US production actually declining after 1970. Non-OPEC output increased substantially only after 1977, with big increases from Mexico and from the North Sea and the North Slope of Alaska.

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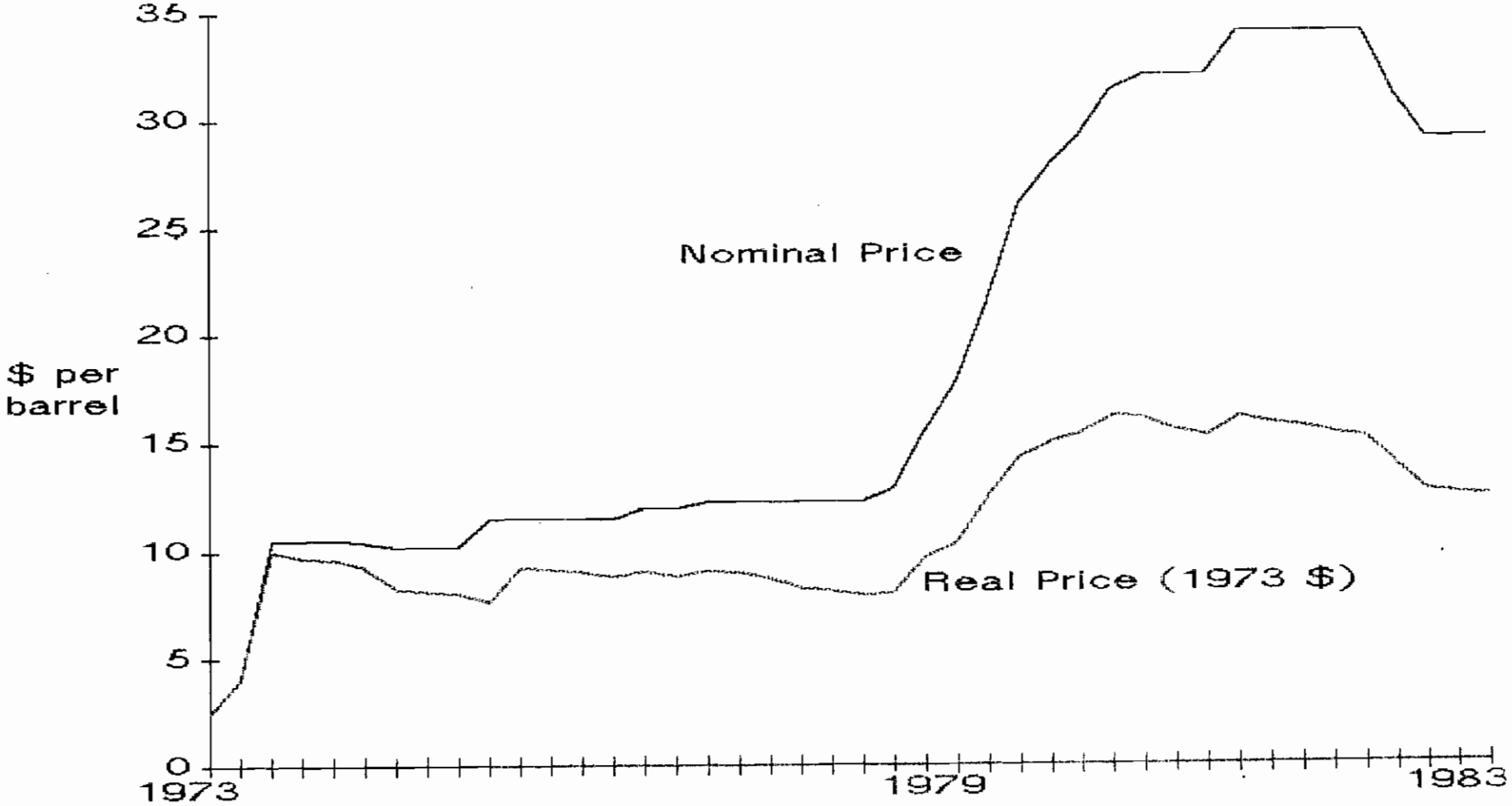
[3] For details of this, see Hogan and Leiby (6) and Huntington (7).

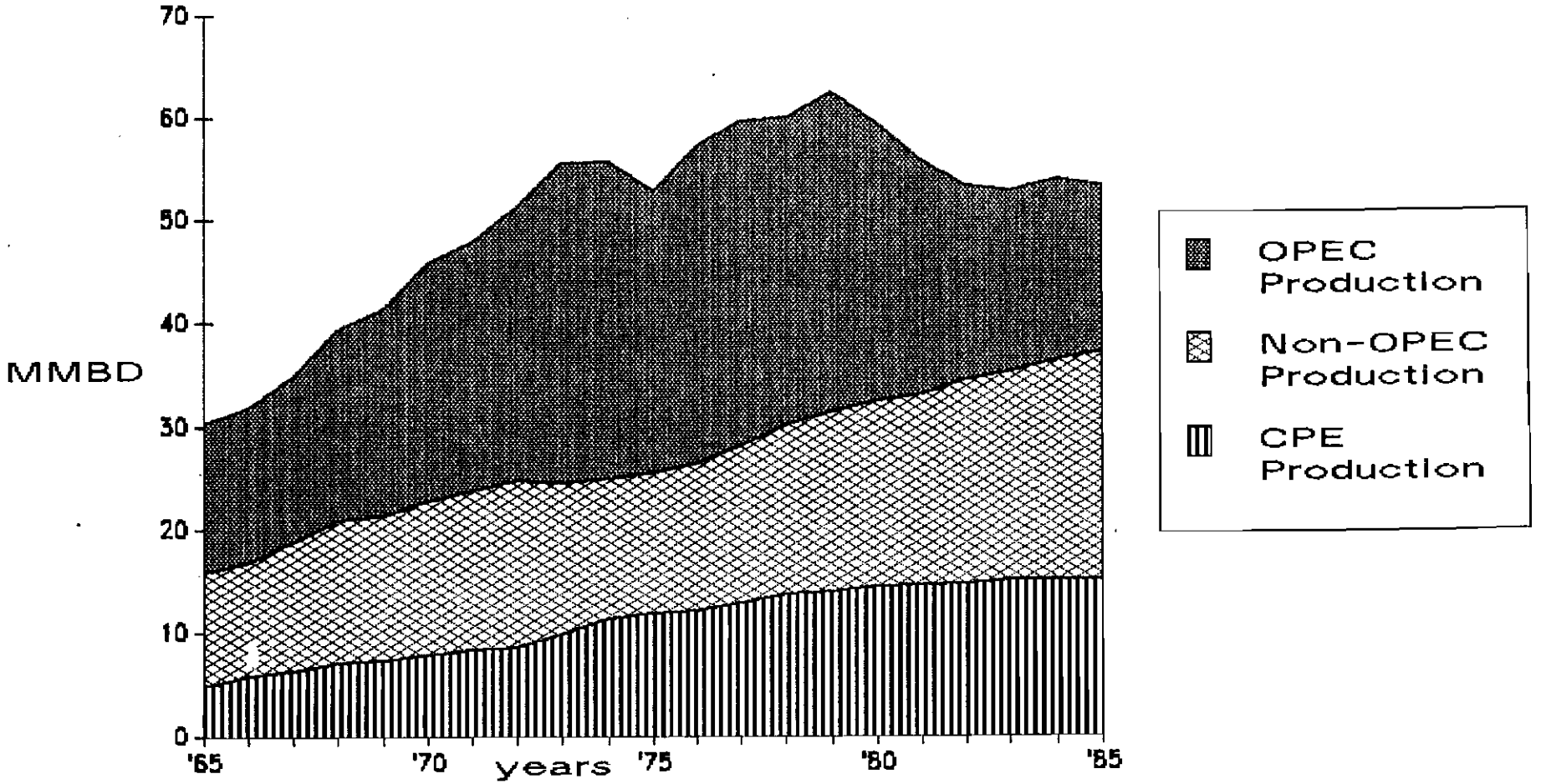
[4] This implies that total consumption equals total production, the sum of various regions' production; hence we are ignoring here any stockpile changes (which would be at most 2 MMBD per year).

Figure 1
Price of Oil (Arabian Light) since 1973
in Nominal $ and in Real 1973 $



Source: British Petroleum (1984)

Figure 2
Total World Oil Consumption
and Production by Region



Source: U.S. Department of Energy, Monthly Energy Review

Following the price doubling of 1979-80, world oil demand has declined by almost 20%. This was the combined result of a recession in the early 1980's, and the conservation response to the two major price increases of the preceding decade. The demand for OPEC oil fell even more dramatically, as non-OPEC supply continued to increase. OPEC had to reduce its output sharply, in order to keep the price from falling even more than it did.

Figure 3 depicts, for the US only, the product-by-product disaggregation of oil consumption: gasoline, jet fuel, distillates, residual fuel, and "other" oil products. Since the peak demand year of 1979, the total has declined by nearly 20%. But most of this decline has been concentrated in residual fuel, which is used for electricity generation and for industrial processes. For distillates (used for space heating and hot water), the 1985 level is slightly below its 1979 level. The demand for transportation fuels (gasoline and jet fuel) in 1985 is almost where it had been in 1979, its previous peak year; likewise for "other" oil products.

Figure 4[5] depicts the rates of discovery (and production) of world oil reserves, for the Middle East and outside the Middle East. Discovery rates for the world as a

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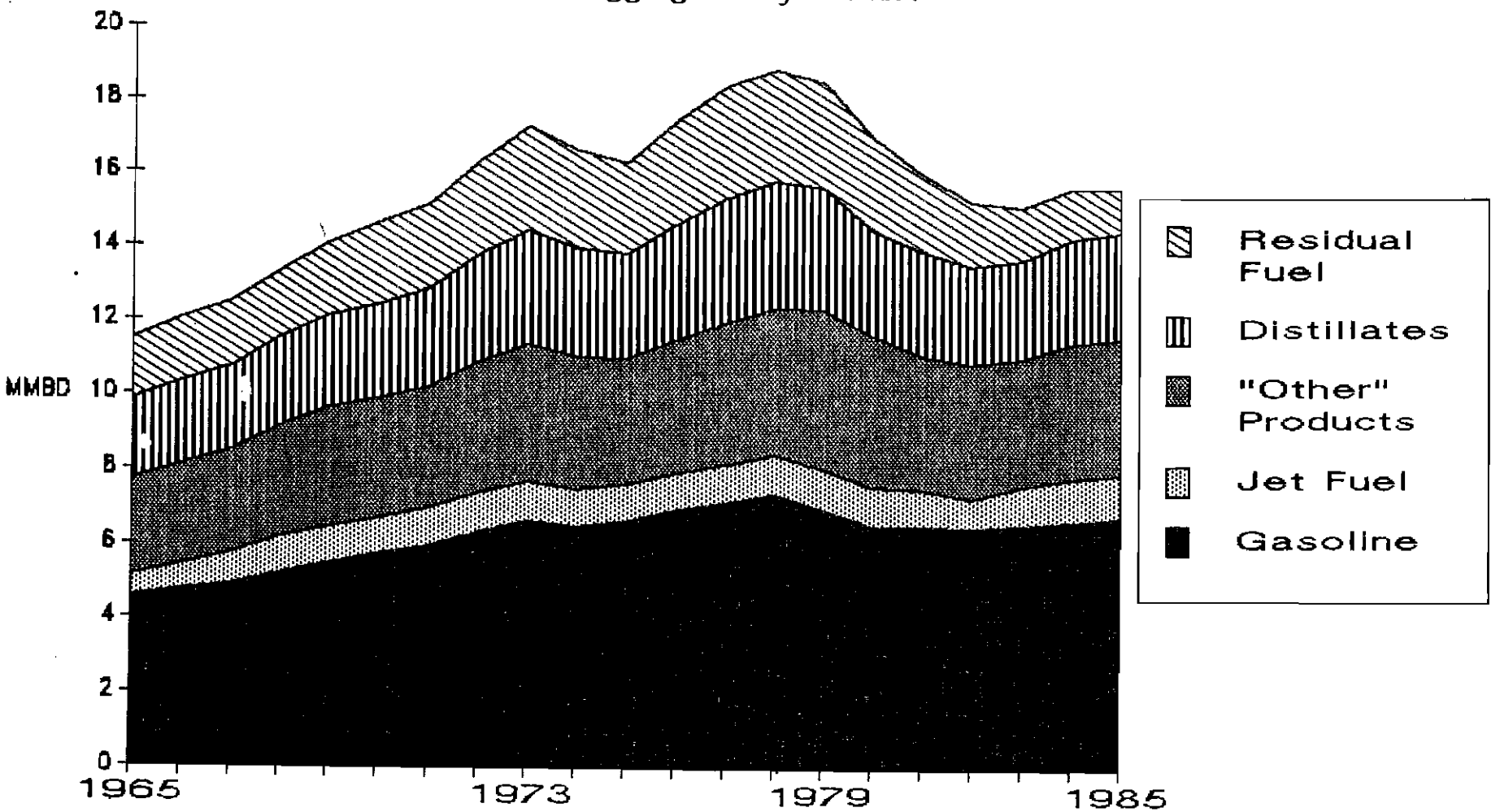
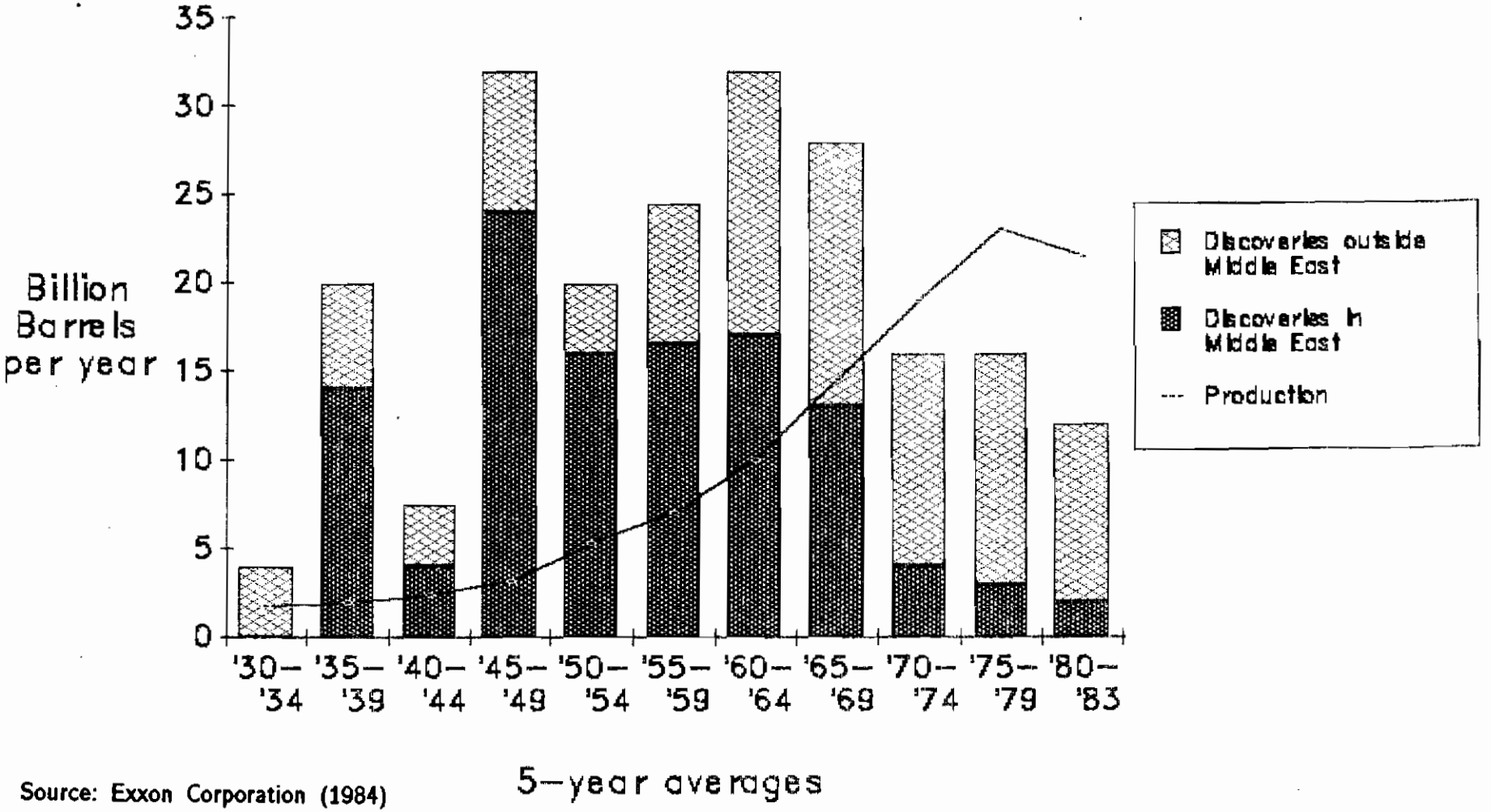
[5] This is taken from the Exxon booklet Middle East Oil and Gas (8).

Figure 3
US Oil Consumption
Disaggregated by Product



Source: U.S. Department of Energy, Monthly Energy Review

Figure 4
Rates of Discovery and Production
of Total World Oil Reserves



Source: Exxon Corporation (1984)

whole have fallen sharply since 1970, due to a sharp decline in new discoveries in the Middle East. This decline in Middle East discoveries could be attributable to the fact that so much oil was discovered in the 1945-70 period that there was little incentive to explore further. Or it could be that the largest, most obvious fields had been found first and that only smaller fields remained to be discovered. Outside the Middle East, however, there has been a great deal of exploration, given the incentive provided by higher prices; discoveries since 1970 have been comparable to the 1960's, which was the best decade of the past half-century. However, the outlook for continued high rates of discovery is not promising, according to a survey by Nehring (4).

> "After more than a century of petroleum exploration covering more than 75% of the prospective sedimentary area of the world, only seven provinces have been discovered that contained more oil than was consumed in .. [1979]. These seven super provinces ... contained more than two thirds of the known recoverable conventional petroleum liquids. ... All 25 major provinces .. contained 88.4% of the known conventional world oil resources. Thus, only 6% of the world's explored provinces and 10% of those with producible accumulations of petroleum contained nearly 90% of the world's oil."[6]

> "Maintaining a high rate of discovery worldwide has depended heavily on the continued discovery of new major provinces. ... Most of the reasons for this should be clear. The oil resources of nearly all of the major provinces are

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[6] (4, p. 180)

> highly concentrated in giant and large fields. In nearly all of these provinces the number of giant and large fields is relatively small. ... Nearly all of the known giant and large fields are in obvious traps, ..., that is, traps whose location can be determined prior to drilling either by surface geologic study or seismic techniques. Continued advances in geologic knowledge and exploration technology have improved to a high degree the ability of the petroleum industry to locate obvious traps and have made more traps obvious. ... an exploration philosophy has developed that emphasizes the early location and drilling of the largest prospects first. As a result, the period of province discovery has been gradually shortening, as indicated by the shortening periods between the discovery of the first and latest giant fields.[7]

Yet, in spite of some discoveries since 1970 outside the Middle East, mainly in Mexico, OPEC's share of the world's Proved Reserves has not changed substantially. As indicated in Figure 5, during the period 1972-82, the world's Proved Reserves of oil increased by about 6%.[8] Of this total, 92% is contained in only 15 countries, of which only 5 are outside of OPEC: the USSR, Mexico, the US, China, and the UK. Of these five, however, there have been significant increases only in Mexico and, to a lesser extent, the UK. Reserves have declined in the USSR and in the US, and remained about the same in China[9].

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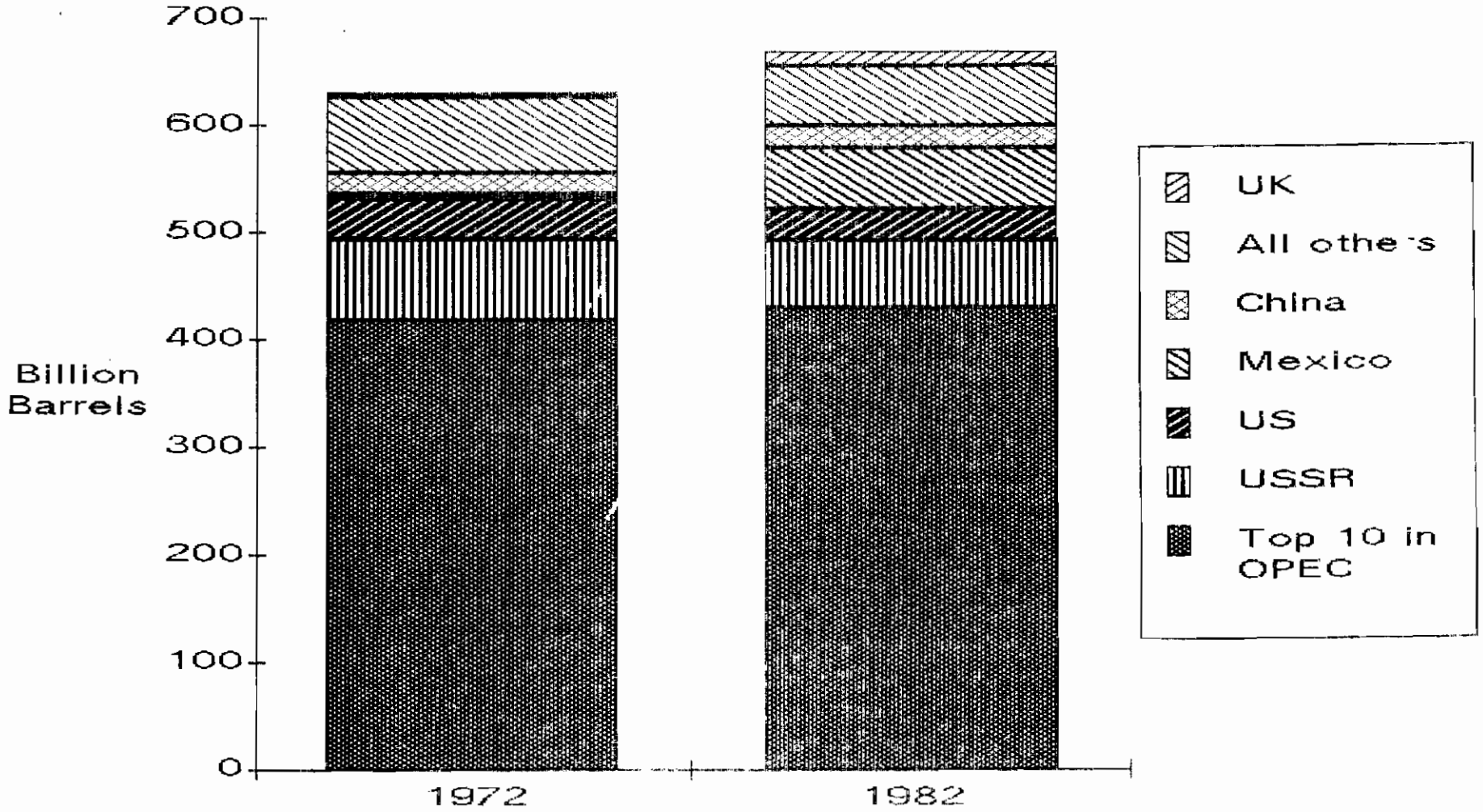
[7] (4, p. 189)

[8] Figure 4 indicates that production has exceeded new discoveries since 1970, so that one would expect Proved Reserves to have declined. However, some additions to Proved Reserves have been made in fields discovered prior to 1970, which are credited to those previous time periods.

[9] This information can be found in the Exxon booklet, How Much Oil and Gas (9).

Figure 5
Proved Reserves of Crude Oil



Source: Exxon Corporation (1982)

4. EXPERT OPINION 1973-1985

Since 1973, we have witnessed an enormous amount of analytic work on the outlook for oil prices. But we have also heard a wide range of views, some issued apparently off the top of the head. Although many of these views may have lacked prescience, they did not lack certainty. At one extreme, we had Milton Friedman, a Nobel Laureate economist writing in 1974 in Newsweek that:

> "... in order to keep prices up the Arabs would have to curtail their output by ever larger amounts. But even if they cut their output to zero, they could not for long keep the world price of oil at $10.00 per barrel."[10]

This view was typical of much of the initial response to the 1973-74 price quadrupling, that OPEC had blundered by raising its price to an unsustainably high level, and was pricing itself out of the market. More recently, and erring in the opposite direction, we had Fereidun Fesharaki's opinion that:

> "As to the extent of the price increases [in the 1980's], one can only say with certainty that real prices will not be allowed to decline again. ... On the price front, price unity seems to have permanently disappeared. OPEC feels no need for it anymore. .... Real prices are expected to rise by three to ten percent per annum during the 1980's, at irregular intervals."[11]

But it is the analytic work with which we are concerned, and which we shall now review. Because this

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[10] Newsweek, March 4, 1974.
[11] (10, pp. 304, 306, 307).

literature has been evolving in the past dozen years, it is instructive to review how the conclusions have changed over time.

In a 1975 survey, co-authored with Dietrich Fischer and John F. Kyle, we reviewed the conclusions from the seven models that were available in the 1973-75 period:

> "All papers imply that the current [1975] price of oil is higher than consideration of OPEC's long-run interests would dictate, and that prices ought to fall in the not-too-distant future."[12]

However, as the demand for OPEC oil recovered after its decline in 1974-75, many came to view the 1973-74 price increase as sustainable. But it was characterized as a one-time event, corresponding to OPEC's successful cartelization of the world oil market. In the future, price was expected to rise only gradually, but would stay below the "backstop" cost, the cost of alternatives to conventional oil, such as shale oil, tar sands or coal liquifaction.[13]

By 1977, in a paper specifying our own model of OPEC, we noted a new consensus "that oil prices are not too high and even may not be high enough."[14] We also emphasized the

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[12] (11, p. 13). The models reviewed were those of Blitzer-Meeraus-Stoutjesdijk, Bohi-Russell, US Federal Energy Administration, Kennedy, Kalymon, Levy, and Nordhaus.

[13] Unfortunately, it was rarely noted that the "backstop" cost could only be an upper limit <u>in the long run</u>, when there would be sufficient time to expand capacity. This could be three decades, or more. In the meantime, OPEC's price could well rise above the "backstop" cost.

[14] (12, p. 210)

unavoidable uncertainty involved in such projections. Looking back at that paper, although some of the numerical assumptions and the resulting price-paths are clearly wrong,[15] the conclusions still read well:

> "Price projections of all such models are sensitive to changes in the functional specification of various relationships within the model and to changes in certain parameter values. Since the `true' functional specifications and parameter values are often unknowable and/or unknown, the conclusions from such models must be carefully qualified.
>
> The analysis of OPEC's pricing decisions ... should focus not on what price-path is `best' for OPEC but upon what pricing strategy, that makes use of and responds to available market signals, ought to be adopted by OPEC.
>
> One rule-of-thumb pricing strategy [target-capacity-utilization] that is likely to serve OPEC very well for the foreseeable future ... is a strategy that is relatively cautious about further major, abrupt price increases. Such a strategy ... would increase price only gradually when market conditions warrant and would cut price aggressively if necessary to defend OPEC's market position.
>
> Notwithstanding the previous conclusion, more aggressive pricing strategies may also yield as good or better results for OPEC. Hence, consuming countries should not ignore the possibility of further abrupt price increases, perhaps a doubling or tripling of price within the next ten years.[16]

By the time of a subsequent survey, written at the end

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[15] For example, we assumed that OPEC capacity by the mid-1980's would be either 45 or 60 MMBD. We also assumed that the full adjustment of demand to price changes would be completed in either 4 or 6 years. Both of these erroneous assumptions were common at the time.

[16] (12, pp. 210-11)

of 1978, most had come to view the 1974-78 price level as sustainable by OPEC. Some, most notably the Workshop on Alternative Energy Strategies (12a), even argued that price was unsustainably low: if the real price were held constant through the 1980's, the projected demand would exceed the likely supply. We presented the following conclusions in that second survey:

> "Having reviewed nearly two dozen models and analyses of OPEC and the world oil market, what can be said about the 1980's. Briefly, the status quo through the early-to-mid 1980's with a tightening world oil market possible thereafter. In the coming five years [1979-1984] virtually all analyses project a continuation of current market conditions in the world oil market.... But we do not expect substantial changes in real prices, either down or up, given the stabilizing position of Saudi Arabia and its Arab allies on the Persian Gulf.
>
> The outlook beyond 1985, however, remains very uncertain. Many forecast a continuation of current market conditions for the entire decade. Many others project increased tightening of the world oil market. If the latter appears likely - and we ought to know by the early 1980's - we expect several gradual price increases to anticipate such a tightening, warding off another crunch like 1973-74."[17]

What happened in 1979-80 was certainly a surprise: both the abruptness and the size of the price increase. Few had anticipated the possibility that another price increase might occur or that it would be so large.

Now, with the benefit of hindsight, we can conclude

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[17] (13, p. 378)

that OPEC overshot the mark. In its groping search for an "optimal" price, OPEC misinterpreted the spot-market price as a good indicator of a long-term equilibrium price. It raised its official price too much and too rapidly. Since 1981, as we saw in Figure 1, the real price has fallen substantially and OPEC has fallen on (relatively) hard times.

Recent surveys of this literature can be found in Gately (14) and in Griffin and Teece (15).

5. CURRENT VIEWS

A starting point for surveying the range of current projections is the July 1985 poll of the International Energy Workshop, (1, 1a). This summarizes the responses from a large number of world energy analysts, regarding projections of prices and quantities over the next 25 years, for oil and other forms of energy. The poll included projections from 80 organizations, analysts, and modeling groups, located throughout the world.

There are interesting differences in projections between various analysts in the latest poll. But it is also interesting how the projections have changed in the last four years, especially the price projections. For example, median projections of crude oil prices for the year 2000 have fallen sharply in the years between 1981 and 1985. In the December 1981 poll, the real oil price in 2000 was projected to be about 70% above its 1980 value. But, by the January 1985 poll, the real oil price in 2000 was projected to be only about 10% higher than in 1980. These differences are depicted in Figure 6.[18]

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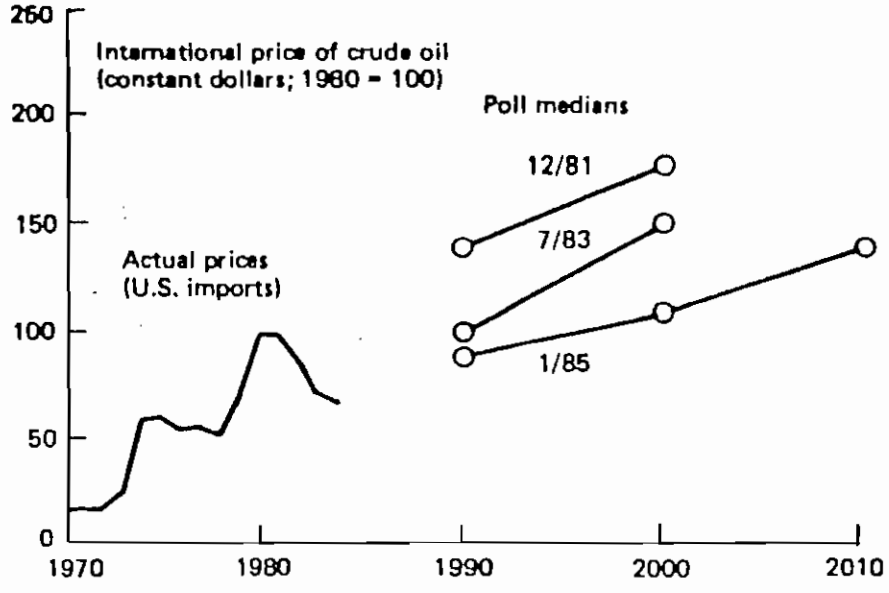
[18] Although there were some differences in the group of respondents between the different years, the authors conclude that this cannot explain the dramatic revision of projected prices.

Figure 6
Comparison of World Oil Price Projections from the International Energy Workshop



Comparison of poll medians, 1981-1983

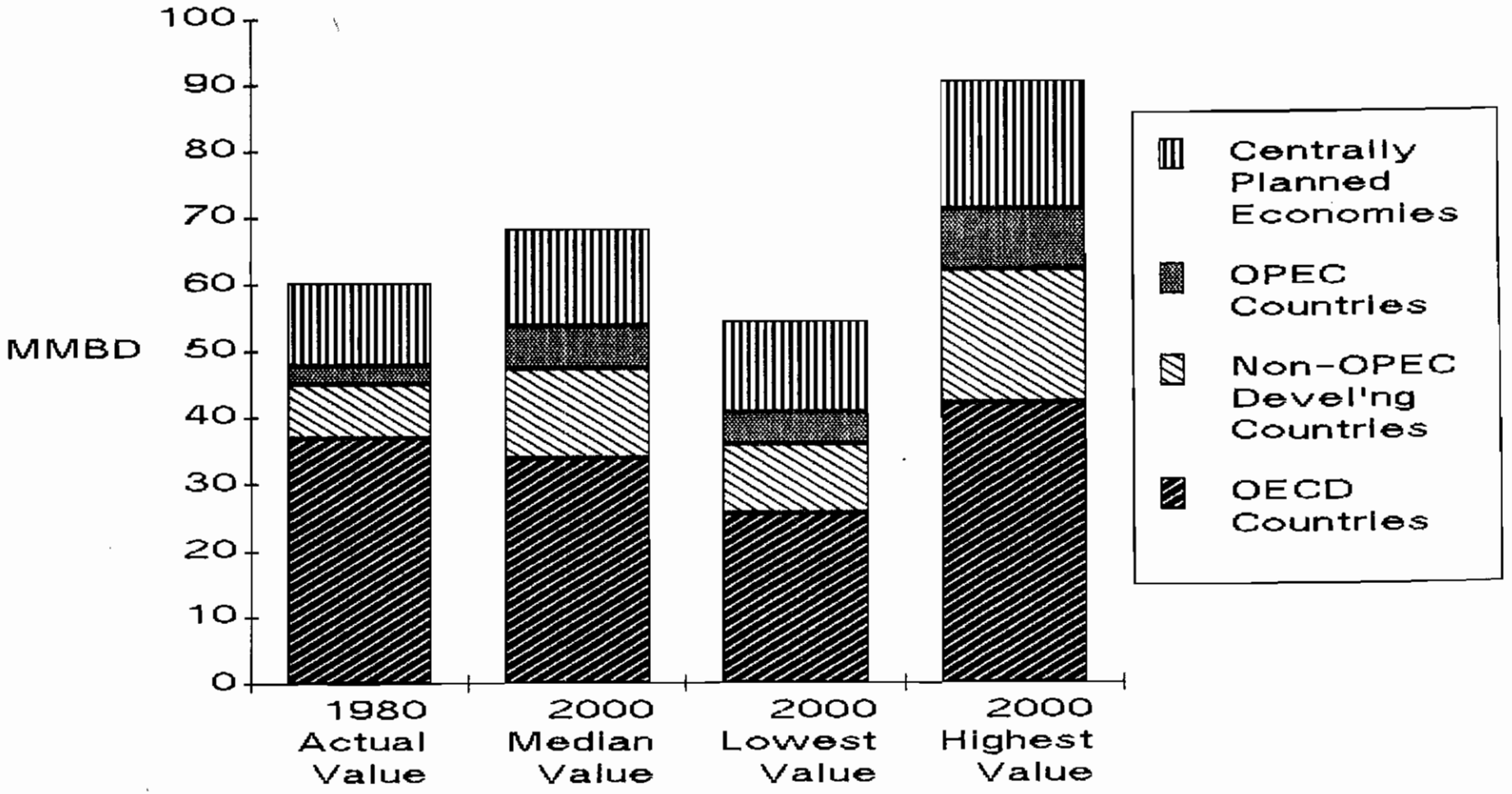
Source: Manne and Schrattenholzer (1985)

With respect to quantities of oil in the year 2000, the following figures depict the median projections for consumption (Figure 7) and production (Figure 8), disaggregated by region. In addition, in order to show the range of projections, we include the lowest value projected for each region and the highest value for each region. Note that World totals are not identical for consumption and production, especially for the highest values projected, due to the way in which the totals are calculated.

As can be seen in the median projections in Figure 7, oil consumption continues to grow in the Developing Countries, both OPEC and non-OPEC, but it grows very slowly in the CPE and declines slightly in the OECD. World consumption grows very slowly, at an annual rate of seven-tenths of one percent. In the Lowest projections, it declines at an annual rate of three-fourths of one percent. In the Highest projections, it grows at an annual rate of 1.9%

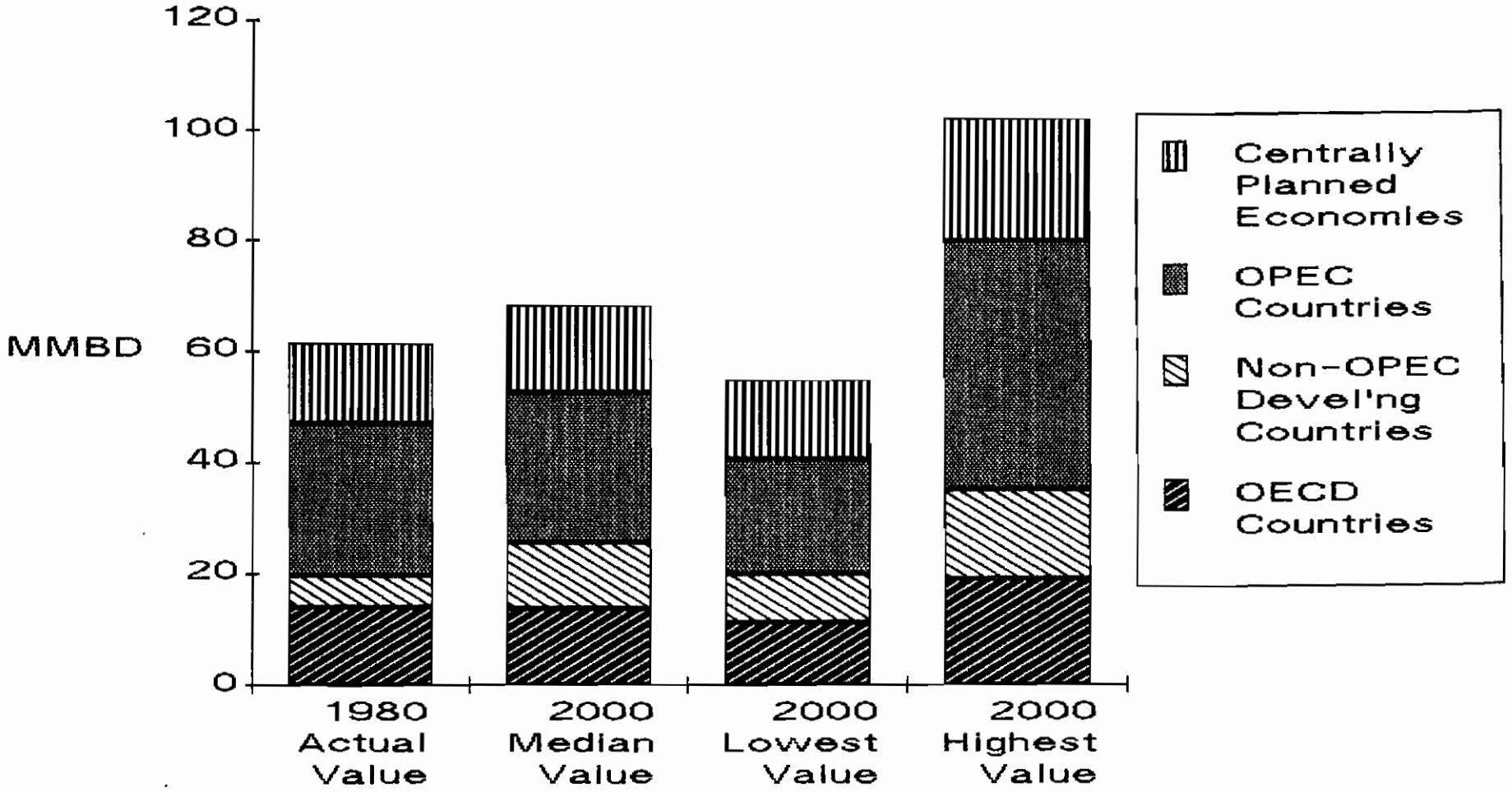
With regard to oil production in Figure 8, OECD output is expected to be fairly flat, with declines in US output being offset by increases elsewhere. Output is expected to double in the Non-OPEC Developing Countries, and to be flat in the CPE. Since the residual supplier will continue to be OPEC, its production is expected to increase significantly by 2000, to slightly above its 1980 value (about 30 MMBD), or 50% higher than its 1985 output level. As with oil consumption, there are

Figure 7
Projected Oil Consumption in Year 2000
from 1985 International Energy Workshop Poll



Source: Manne and Schrattenholzer (1985)

Figure 8
Projected Oil Production in Year 2000
from 1985 International Energy Workshop Poll



Source: Manne and Schrattenholzer (1985)

also dramatic differences in projections, between the lowest and highest values.

There are also sharp differences in projections on a product-by-product basis. Conoco, in a fairly representative view, presents its outlook:

> "Gasoline consumption will grow slowly but decline as a share of the product barrel due primarily to improvement of the fuel efficiency of the U. S. vehicle fleet. Growth in middle distillates demand will be relatively robust as expanded use of kerosene jet and diesel fuel offsets slow growth in consumption of heating oil, which will face generally stiff competition from gas and electricity in North America and Western Europe. Residual fuel demand will be fairly stable over the remainder of the century. Given the oil price outlook, very few additional conversions out of fuel oil in the power and industrial sectors will go forward. ... Of the other petroleum products, petrochemical feedstocks demand will grow strongly with industry output."[19]

An opposing view, however, comes from Arlon Tussing:

> "When the price of oil went above $20 per barrel, it pretty much priced itself out of the world's markets for electric-utility and industrial boiler fuels ...
> With crude oil prices on the order of $30, moreover, naptha and gas oil cannot with natural gas [and other inputs] ... as the primary feedstock for making a host of petrochemical products. ... If constant-dollar prices attained by OPEC in 1981 had held, oil would rapidly have lost its grip on transportation-fuel markets as well. By the end of the century, motor gasoline, diesel oil, and jet fuel would have largely given way to electricity, alcohols, and compressed and liquified hydrocarbon gases as

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[19] (16, pp. 5-6)

sources of motive power. Thus the overwhelming question for those who foresee future oil prices remaining long above historic peaks is why the world would bother with oil in most of its present uses if it cost $40 or $50 a barrel."[20]

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[20] (17, p. 11)

6. RESULTS FROM EXPLICIT MODELING EFFORTS

The broad coverage of the International Energy Workshop, however, made it virtually impossible to standardize the assumptions being made or to determine very accurately the sources of differences in projections. In contrast, a controlled model comparison of 10 prominent models of the international oil market[21] was done in 1980-82 by the Energy Modeling Forum (EMF) of Stanford University (2). Standardized assumptions were made for a variety of parameter values, such as economic growth rates, the size of the resource base for conventional oil, the cost of alternative energy sources, the amount of OPEC capacity, and the responsiveness of oil demand to changes in price and in economic growth. For each of 12 "scenarios" (each defined by a given set of assumptions about the world oil market), the models generated their respective projections.

Despite some things that might have been done differently with the benefit of hindsight, this study remains the best available piece of work in this area. It provides a valuable benchmark against which to judge the results of other models and analyses.

This study's conclusions about world oil prices were

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[21] Included were models from the US Department of Energy, from universities, and from corporations; several are available commercially.

fairly pessimistic: none of the models under any of the scenarios had world oil prices lower in the year 2000 than they were in 1980, and most had price considerably higher. This is different from saying, however, that none of the models had price declines in the 1980's, a point to which we shall return.

> "While there remains a high degree of uncertainty about future world oil prices, our analysis suggests that most of this uncertainty concerns not whether real prices will rise during the next several decades but rather how rapidly they will rise... We expect a soft oil market during the first half of the decade unless another supply disruption occurs, but by 1990 real prices can be expected to exceed their current high levels." [22]

The EMF results for price in the year 2000 are summarized in Figure 9. The range of prices from different models within a given scenario is especially striking. Even with a large number of parameter assumptions that are standardized, there is enough disagreement about other parameters and about the structure of such models, that different models can generate quite different results. As the EMF report observes:

> "This figure clearly illustrates the difficulty of forecasting world oil prices. For any one scenario differing beliefs about the world incorporated into differing models result in different forecasts of future prices. For any one model reasonable variations in the assumed state

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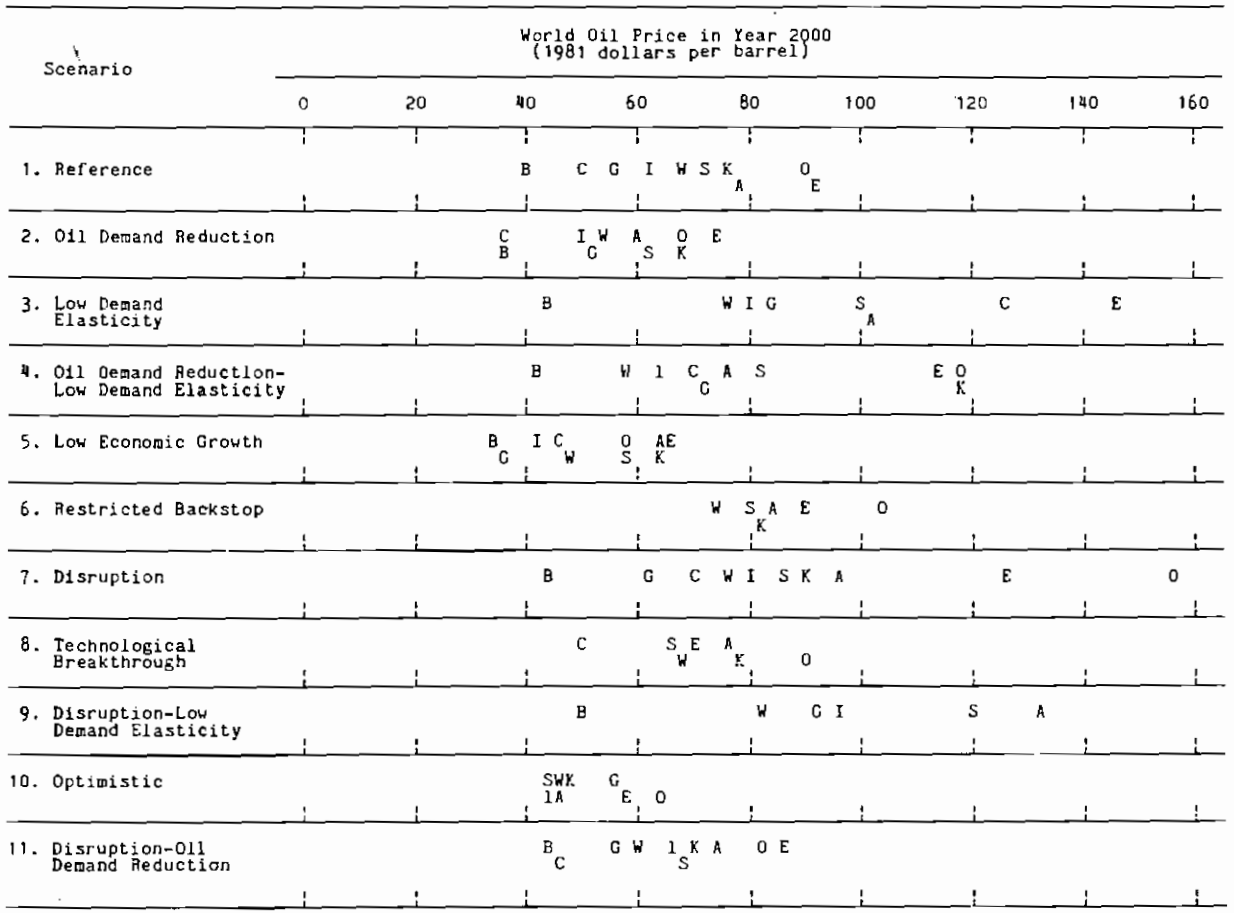
[22] (2, p. 2)

Figure 9
Energy Modeling Forum, World Oil Study
Projections of World Oil Price in Year 2000
for Different Scenarios



Models: G = Gately, I = IEES-OMS, C = IPE, A = ETA-MACRO, K = Kennedy-Nehring, O = OILMAR, E = OILTANK, W = WOIL, S = Salant-ICF, B = Opeconomics

Note: For all models other than IEES-OMS and IPE, the average of prices between 1995 and 2005 is given. For IEES-OMS, the 1995 price is presented; for IPE, averages between 1995 and 2000 are presented. Several projections are higher than $160/bbl and thus do not appear above. These include: for the low demand elasticity scenario, Kennedy-Nehring ($175) and OILMAR ($177); for the disruption-low demand elasticity scenario, OILTANK ($184), IPE ($198), Kennedy-Nehring ($217), and OILMAR ($417).

Scenarios and Price Results

Source: Energy Modeling Forum (1982)

> of the world -- technology, OPEC capacity, economic growth, demand elasticity, demand growth -- lead to additional variations in the projections.[23]

To put these projections for the year 2000 into perspective, it is useful to compare what has actually happened in the years 1980-85 with the EMF model projections for these years. But, at the start of such comparisons, it should be noted that the EMF Reference Case is not appropriate as a basis for comparison, if only because it assumed constant growth of about 3.5% for the world economy[24]. Clearly, because of the recession in the early 1980's, economic growth was much less on average[25]. Instead, the appropriate comparison for 1980-85 (with more accurate economic growth assumptions) would be the Low Economic Growth scenario, which assumed two-thirds of the Reference Case economic growth rates. For that scenario, 3 of the 10 models[26] had price declines comparable to what actually occurred: Choucri's IPE model, the Gately-Kyle model, and IEES-OMS. None of the models, however, had declines in the demand for OPEC oil greater than about 5 MMBD -- in contrast

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[23] (2, p. 48)

[24] Note that this is considerably higher that the median economic growth rate of 2.9% assumed in the International Energy Workshop poll.

[25] However, this is not to fault the EMF assumption-makers, given the difficulty of forecasting economic growth rates.

[26] These comparisons are based on the EMF's "World Oil Graphics" (18), which summarized the model results for different scenarios.

with the actual decline of more than 12 MMBD. Only Ervik's OILTANK model and Choucri's IPE model had declines in oil consumption of as much as 5 MMBD, and only Choucri's IPE model had non-OPEC oil production increases similar to what actually occurred.

However, another scenario might also be viewed as a good indicator of what actually happened: Scenario #2, the Conservation Scenario. Here it was assumed that there would be some aggressive policies to reduce oil demand, or at least its rate of growth; but the economic growth rate would be the same as in the Reference Case. The demand reductions would be 1 MMBD in each of the years 1981 through 1985, so that the 1985 demand curve would be 5 MMBD to the left of its Reference Case position. Reductions would continue at a slower rate, until demand was 10 MMBD to the left by the year 2000. Even with this change, however, with most of the models the demand for OPEC oil during 1980-85 did not fall off as sharply as it did in actuality. Only Choucri's IPE model had OPEC production falling below 20 MMBD by the mid-1980's: the next lowest was the BP model, at 23 MMBD. Likewise, for most models the real price of OPEC oil did not decline significantly during 1980-85 under this scenario, except for Choucri's IPE model, the Gately-Kyle model, and the IIES-OMS model.

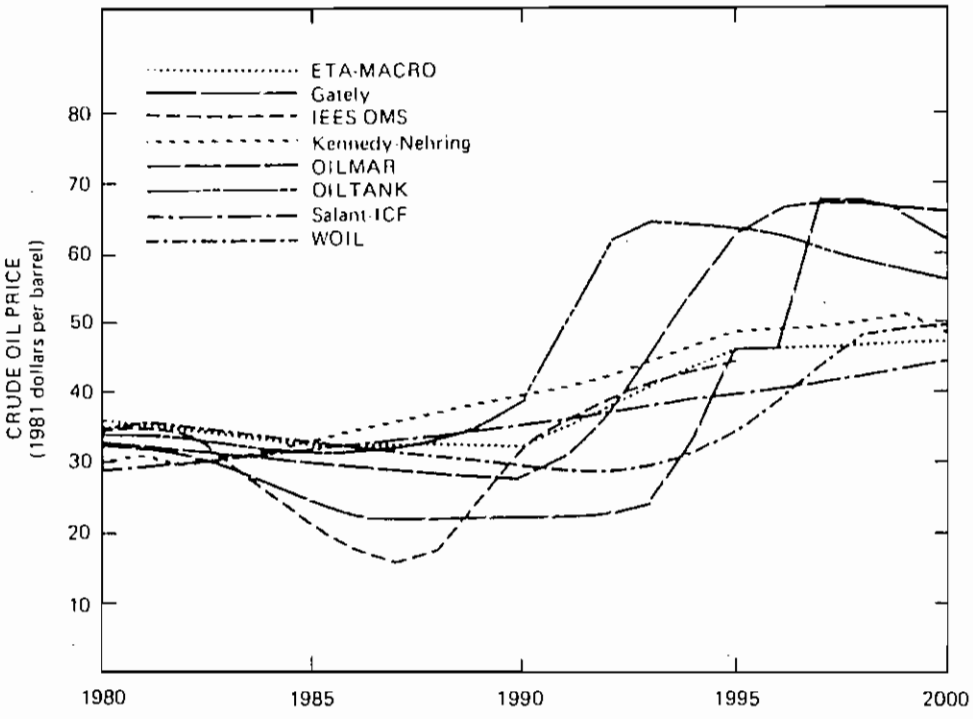
Still another scenario might be appropriate to look at, the Optimistic Scenario. This made the same assumption about

demand reduction as the Conservation Scenario, and it also assumed expanding OPEC capacity and a cost for alternative energy sources that was one-third lower than the Reference Case. The price-path results from this Scenario are depicted in Figure 10 below. There it can be seen that two of the models (the Gately-Kyle model and the IIES-OMS model) have price declines well into the 1980's. However, all models still have higher prices in the year 2000 than in 1980.

What can we conclude from this? For one thing, the price-responsiveness of world oil demand was probably underestimated in the EMF-standardization. The declining demand for OPEC oil during 1980-85 was greatly underestimated by all the models. In addition, most of the models were too pessimistic about the near-term possibilities for increasing non-OPEC production. This was not an assumption that had been standardized by EMF, so that the fault lies with the individual modelers.

Despite these shortcomings, however, there are some scenarios in which at least some of the models did a reasonably good job in tracking what actually occurred during 1980-85. And it is important to note that, for these models and cases (as for all the others), the price does increase substantially during the 1990's, to well above its 1980 value by the year 2000. World oil demand growth, especially during the 1990's, results from the demand-increasing effect of continuing

Figure 10
Energy Modeling Forum, World Oil Study
Projections of World Oil Price for the Optimistic Scenario



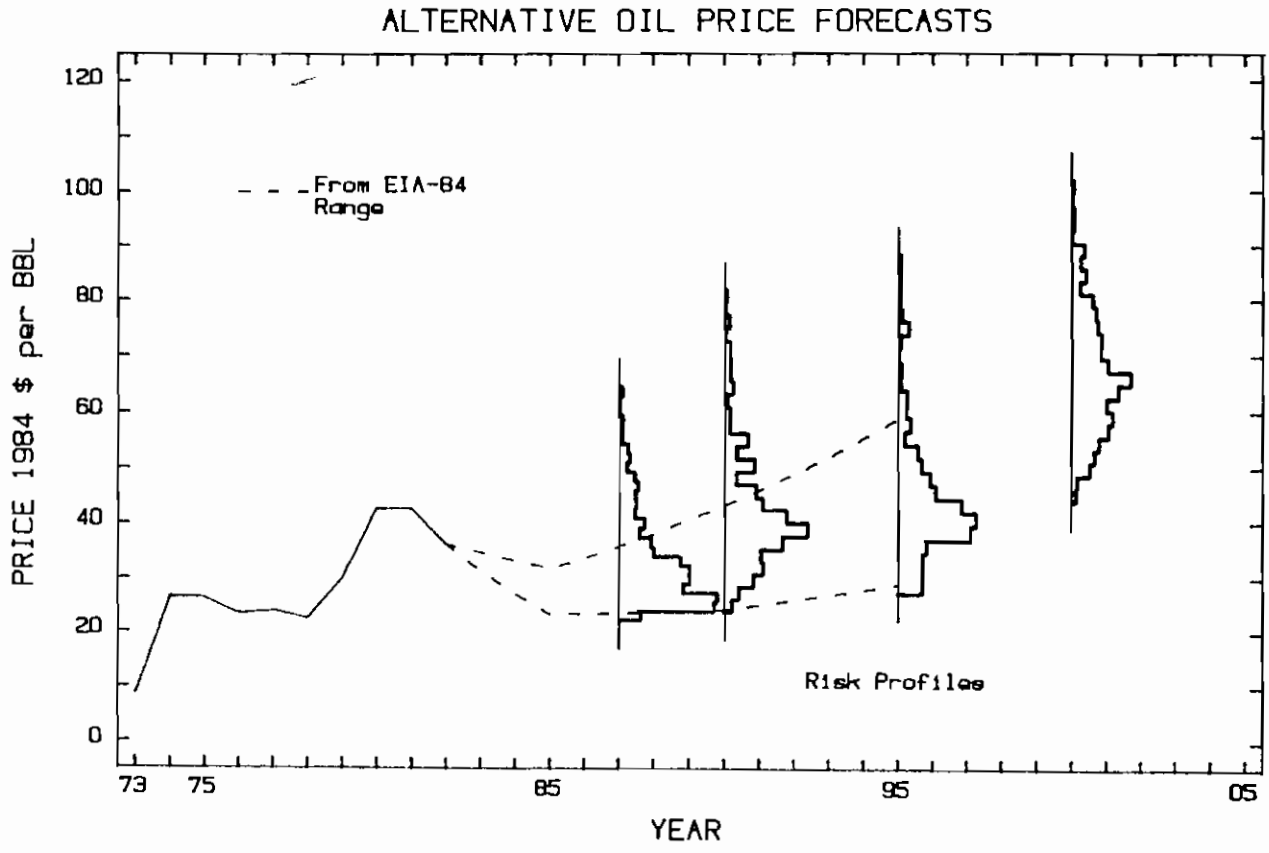
World Oil Price Projections for the Optimistic Scenario

Source: Energy Modeling Forum (1982)

economic growth eventually outweighing the gradual completion of the demand-reducing adjustment to the two major price increases. Given the limited prospect for continuing expansion of non-OPEC production, the demand for OPEC oil grows substantially, and OPEC responds by raising the price.

Subsequent to the EMF study, perhaps the most interesting analytic approach to the problem of handling some of the uncertainty involved in such models has been that of Hogan and Leiby (6) . Using a version of the US Department of Energy's IIES-OMS model, they adopt a "risk-analysis" approach to projections of world oil prices. This approach focuses on a few key parameters, whose true values are not known precisely. They examine three alternative values for each, with specified probabilities assumed. These key parameters are: the level of OPEC capacity; the "target" level of capacity utilization at which OPEC is implicitly aiming; the probability of a disruption; the OECD and non-OECD exchange rates; the responsiveness of oil demand to economic growth and to price changes; and the percentage of demand adjustment to the price increases of the 1970's already completed by 1985. The result of this analysis is a distribution over future prices, depicted in Figure 11. Hogan and Leiby conclude:

Figure 11
Risk Analysis Projections of World Oil Prices:
The Wide Range of Oil Prices
Illustrates the Energy Security Exposure



Source: Hogan and Leiby (1985)

"These are valuable lessons gained from the experiments with HOMS [the model], but uncertainty remains the most important issue for energy security policy analysis. ... The result [of the analysis] illustrates the wide range of outcomes and the asymmetry of the distributions of oil prices. The tails of these distributions, that is the long section of outcomes trailing off into the very high price range, are the costly world outcomes where energy security policies would come into play. These tails are particularly important since economic costs increase rapidly with higher prices, implying an even more asymmetric distribution of economic costs. Policy analysis should focus attention not only on expected values or most likely outcomes, but should also examine how policy addresses these distribution tails."[27]

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[27] (6, p. VII-4.)

7. PROJECTIONS FOR US OIL DEMAND THROUGH 2000

One of the most important uncertainties is the price-responsiveness of world oil demand, not only its response to future oil-price changes, but also its continuing response to the price increases of the 1970's[28]. We have done some econometric analysis of oil demand - for the US only - over this period and can report some conclusions.[29]

The length of lagged adjustment is at least 10 years. Hence, the adjustment process to the two major price increases will continue into the 1990's. The ultimate length of the lag remains uncertain.

The sum of the lagged-price coefficients is at least -0.4 and will be larger (in absolute value) the longer the period of adjustment.

The shape of the distribution of lagged-price coefficients, at least for the first 8 or 9 years, is well characterized by that of a cubic polynomial-distributed-lag[30]. The estimated coefficients are depicted in Figure 12. The

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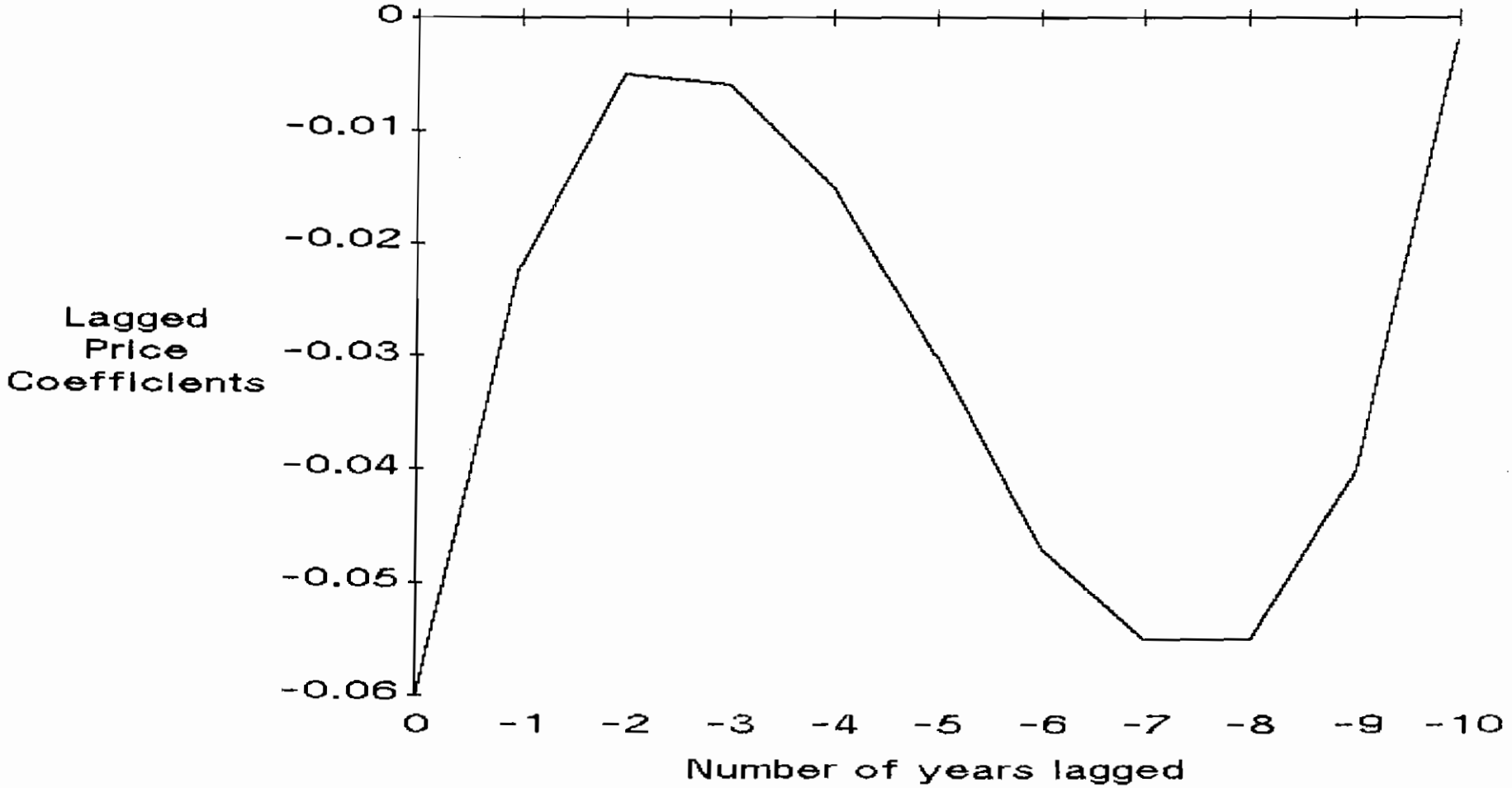
[28] See also the work on demand response to higher prices that is presented in Hogan (19), Bohi (20), Hogan (21), and another study by the Energy Modeling Forum (22).

[29] See the paper by Gately and Rappoport (23). They specified demand as a log-linear function of price and income, which implies constant elasticities of demand. Similar work had been done for US energy demand by Johnson and Lascar (24).

[30] We also estimated the demand equation without any constraints on the structure of the lagged-price effects and the results were virtually the same as these.

Figure 12
Lagged Price Coefficients for US Oil Demand
using a cubic polynomial distributed lag
for the effects of past prices



Source: Gately and Rappoport (1985)

weights on past prices decline when the short-run price-response tapers off after 2-3 years, but then the weights increase for prices lagged 4 to 9 years[31]. For prices lagged 10 or more years, the weights are still uncertain because we have few (if any) years of high-priced oil that long ago.

What do these results imply for US oil demand, say out to the year 2000? This depends, of course, on our assumptions about economic growth, the level of real oil prices, and the amount of remaining adjustment to past oil price changes. In Figure 13 we present the projections from three cases, each of which assumes constant real prices and 3.3% economic growth, but with different assumptions about the ultimate lag-length and the amount of adjustment still to come. The three cases are the following:

1. no adjustment to prices lagged more than 10 years: here we use the lagged-price coefficients from Figure 12; this implies a long-run price-elasticity of -.4.

2. the lag-length is 15 years: we use the above coefficients for years 0 through 9, then assume the coefficients decline linearly to 0 in year 16; this implies an elasticity of about -.6. This elasticity value is what was used in the EMF World Oil study; it is also similar to that in an International Energy Workshop elasticity poll.

3. the lag-length is 20 years: we use the above coefficients for years 0 through 9, then assume

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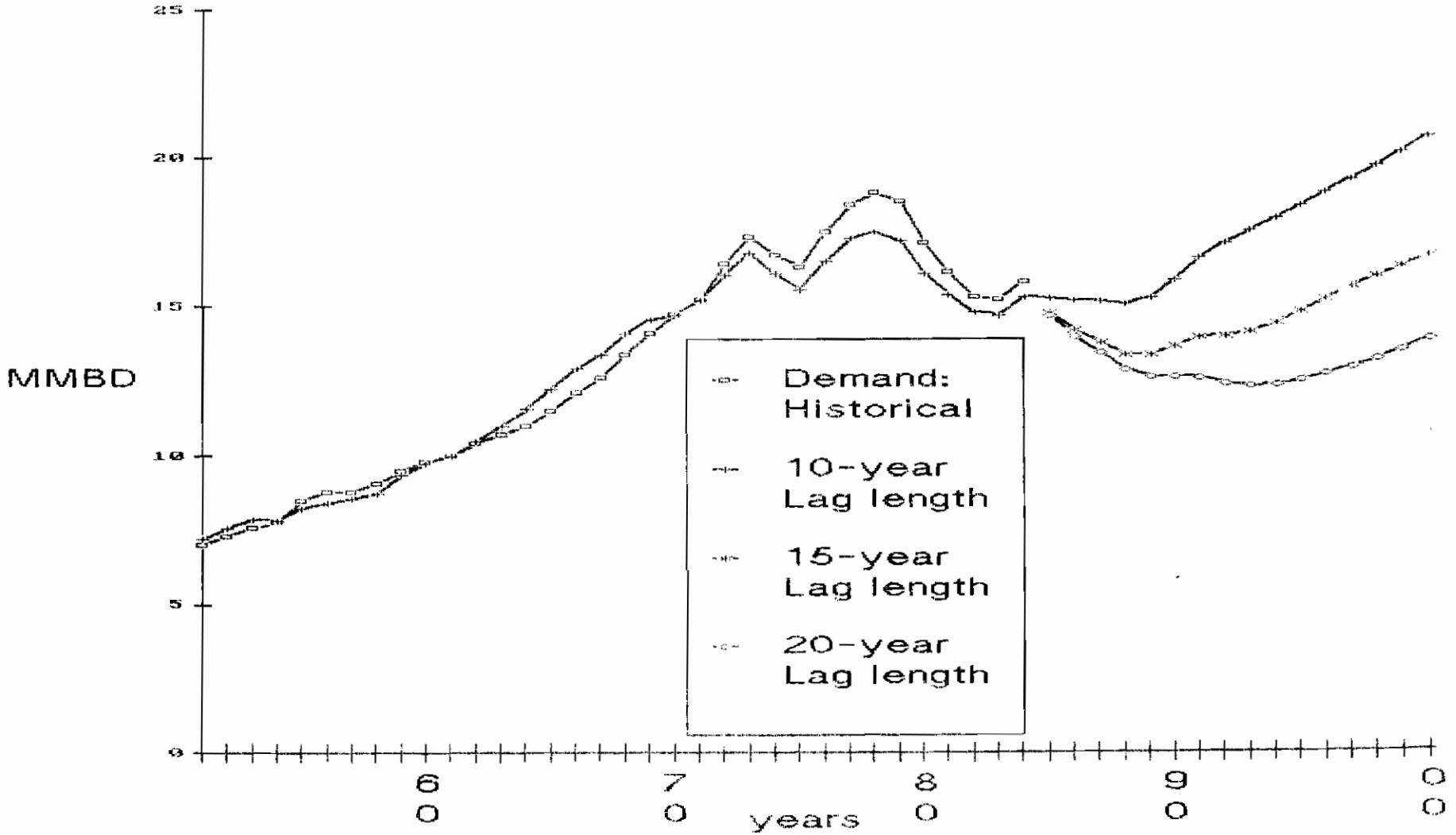
[31] Note that this lag structure is quite different from the more common Koyck-lag, in which the weights on past prices decline geometrically over time.

Figure 13
Projections of US Oil Demand to the Year 2000
depending on the length of lagged price adjustment:
10 years, 15 years, or 20 years
(assuming constant real price and 3.3% economic growth)



Source: Gately and Rappoport (1985)

the coefficients decline linearly to 0 in year 21; this implies an elasticity of about -.75.

In the first case, with a 10-year lag-length, demand resumes its growth in the late 1980's, when the price-adjustment to the 1979-80 price increase tapers off; by the late 1990's, demand exceeds its previous maximum of 19 MMBD from 1978. In the second case, with a 15-year lag-length, demand continues to decline well into the late 1980's, before it begins to grow again. Similarly, with a 20-year lag-length, demand declines into the early 1990's. In both of these last two cases, demand in the year 2000 is well below its previous maximum level.

It should be emphasized that Figure 13 illustrates the main idea behind the projections of increasing oil demand in the 1990's, which is essential to an understanding of the EMF results and similar modeling efforts. Demand is specified as a function of income and price, with a length of adjustment to price changes of 20 years or less. With continuing economic growth, at some time in 1990's demand will have become fully adjusted to the price increases of the 1970's, and it will then begin to rise.

8. PROSPECTS AND UNCERTAINTIES

In the near-term, barring a significant widening of the Iran-Iraq War or some other catastrophic event in the Persian Gulf, the outlook for world oil prices is more of the same: continuing downward pressure on world oil prices. The main uncertainty is how quickly reversed will be the declining demand for OPEC oil. How long will it take for OPEC output to get back up to 25 MMBD: three years, six years, ten years? By how much would a declining price slow down the continuing movement toward oil efficiency and fuel-switching away from oil? By how much would a depreciation of the dollar, relative to European and Japanese currencies, encourage oil consumption in those countries? By how much would a declining price deter non-OPEC production? Might non-OPEC output soon start a gradual decline anyway, as oil production has done in the US, or could it continue its increase of the past decade?

Although some anticipate a price collapse, this seems unlikely given the incentive for "orderly marketing arrangements" on the part of Saudi Arabia and its allies (Kuwait, Qatar, and the United Arab Emirates). In the short run, the demand for their oil - and for that of OPEC as well - is still relatively unresponsive ("inelastic") to price cuts, which would only cause revenue declines. Over the longer term, however, they face an elastic demand for their oil: it is in their interest to increase their output (gradually) and thus

their revenue, tolerating modest price increases or even modest declines.[32]

But, within 5 to 10 years, it is possible - if not inevitable - that the oil importing countries would drift back into a dependence on OPEC similar to that of the 1970's. In that event, they would be vulnerable again to major, abrupt price increases, either intentional or not. Even if such price increases were not to be permanent, they certainly would be costly in the meantime.

What would prevent a repetition of 1979-80 if OPEC production were to increase to close to its capacity? Embarrassingly little. When the cushion of excess capacity has been compressed, it is a hard landing, a difficult adjustment. On the supply side, nothing is substantially different: OPEC will still have the bulk of the world's excess production capacity and oil reserves. Although there is some additional non-OPEC oil production since 1979-80, it is high cost and of limited capacity. Similarly for the strategic oil stockpiles built up in the consuming countries: only relatively small amounts have been acquired, which would be inadequate in the face of a major disruption. On the demand side, there have been some improvements over the past decade, in oil-efficiency

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[32] These conclusions are based, in part, on work with our own model, which is described in Gately (25) and is commercially available.

and fuel-switching away from oil, but there has been very little improvement in short-term price-responsiveness. Perhaps we would have to look to a more responsible OPEC, for a greater willingness to prevent abrupt price increases during a disruption, as being neither in the interests of the oil-importing countries nor in their own long-term interests.

Yet, renewed dependence on OPEC and vulnerability to disruptions are not inevitable; they are only possible. Other scenarios, of a more optimistic nature, would envision continuing improvements in energy-efficiency and fuel-switching away from oil, together with dramatic improvements in the cost and scale of alternative energy sources. Also possible, and part of a relatively optimistic outcome, would be a consistent OPEC policy to maintain a price high enough to ensure a level of excess capacity sufficient to preclude virtually any market disruption.

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