A RAND NOTE

Forecast Models and Policy Analysis: The Case of Oil Prices

Janet Syme

December 1987

RAND

This publication was supported by The RAND Corporation as part of its program of public service.

Published by The RAND Corporation
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138

A RAND NOTE

N-2524-RC

Forecast Models and Policy Analysis: The Case of Oil Prices

Janet Syme

December 1987

RAND

FOREWORD

This Note was written during the summer of 1986 when the author, a graduate student at Duke University, was a summer intern at RAND. When Janet arrived, I proposed that she investigate the numerous forecasts of mid 1980s' oil prices that were made in the 1970s by well-known experts and institutions, the analytical models used in making the forecasts, and the explanations of why and to what extent the forecasts have turned out to be so extraordinarily wrong. Finally, I asked Janet to reflect on the general analytic issue raised by this case: that policy analyses generally develop or employ fairly precise forecasts about future states of the world, yet these forecasts are very likely to be in error, and often very substantially so. What general implications follow from this set of circumstances for the methods and content of policy analysis?

Janet Syme's Note is a useful, if preliminary, response to this formidable set of issues.

Charles Wolf, Jr.
January 1987

SUMMARY

The oil price forecasts made following the 1973 oil shock critically shaped the investment and energy policies undertaken by industry and government. Even though these forecasts were made by different models and researchers, all of them predicted oil prices would be over three times their present level. To attempt to find out why all these forecasts were so wrong, this Note compares the assumptions made by different models and the effect upon the forecasts when these assumptions are changed.

The results show that the probable source of error is the price elasticity of demand for oil used in the models. The actual elasticities are considerably higher than the elasticities assumed by the models, indicating the prevailing misconception that consumer demand response to changes in oil prices is small.

The analysis provides a preliminary look at the problems inherent in forecasting oil prices. Further research is needed to determine the source of the erroneous price elasticities and the consequences for future forecasts.

CONTENTS

FIGURE

TABLES

FORECAST MODELS AND POLICY ANALYSIS: THE CASE OF OIL PRICES

INTRODUCTION

Predictions of oil prices critically affect decisionmaking in both government and the private sector. Such predictions influence both policymakers when they are designing tax and energy policies, and business analysts and bankers when they are evaluating and choosing among investment strategies. Reputable institutions and individuals made numerous forecasts of 1986 oil prices in the 1970s and early 1980s, predicting oil prices over $40 a barrel, more than three times the July 1986 price of $11 a barrel. These large errors have had major consequences for the oil and banking industries. For example, the oil industry overinvested in almost all sectors and suffered idle capacity, low profits, and reduced demand for their services.[1] International banks, also anticipating rising oil prices, increased their long-term lending to developing oil countries: Mexico's acute debt predicament is a consequence. A study by the Cambridge Energy Research Associates estimates that one-half trillion dollars was invested in 1980–81 on the expectation that oil prices would continue to rise.[2]

These events suggest that considerable attention should be devoted to the proper role of forecasting in policy analysis, both in general and in the specific case of oil prices. This Note will examine the extent to which oil price forecasts were wrong and the assumptions that could have accounted for these errors. This analysis is limited in scope and attempts only to illuminate certain aspects of forecasting oil prices. The behavior of neither OPEC nor of oil suppliers in general was examined here. In addition, only the models included in the Energy Modeling Forum 6 study in 1980 were examined in detail; further research should include analysis of a wider range of forecasts.[3] The object is not just to explain why different models predicted different prices, but rather to examine why so many models and approaches incorrectly predicted the general trend of oil prices.

---

[1]"The Forecasters' Dilemma," *Petroleum Economist,* Vol. LII, No. 6, pp. 190–191, June 1985.

[2]Cambridge Energy Research Associates and Arthur Andersen & Co., *The Future of Oil Prices: The Perils of Prophecy,* Chicago, 1984.

[3]See, for example: (1) Energy Information Administration, *Outlook for World Oil Prices,* U.S. Department. of Energy, June 1982; (2) articles by Walter Levy (including *New York Times*, January 4, 1979); (3) Alan Manne, *International Energy Workshop,* International Energy Project, June 1985.

MODELS REVIEWED

The oil price forecasting models in the 1980 Energy Modeling Forum were used for this analysis.[4] The models cover a range of approaches from well-respected researchers and institutions. In addition, they were all developed around the same time (late 1970s) to predict oil prices, as well as demand and supply conditions.

On average, these models predicted prices of over $40/barrel for 1986 (1981 dollars). The predictions lie well within the range of other forecasts made at the time. For example, the International Energy Workshop forecasts equalled or surpassed those of the forum models, and the Energy Information Administration predicted a 1986 "base price" of $36/barrel (1981 dollars).

Table 1 lists the ten models examined, their representatives, and their affiliations. Although the models differed widely, each model generally included representations of supply, demand, and world oil price-setting mechanisms.

The authors of the ten models standardized the model input assumptions to better compare the results of their models. After using assumptions about probable future GNP growth rates, income elasticities, and Organization of Petroleum Exporting Countries (OPEC) capacity, the modelers ran their models independently and reported their results. The models were run in early 1980, predicting conditions for 1990, 2000, 2010, and 2020. 1980 levels were provided for comparison.

The models in the study made predictions for a (most likely) reference case and for 11 scenarios including combinations of reduced demand, disrupted supply, technological breakthrough, reduced price elasticity of demand, and low economic growth. This analysis will use the average of only the reference case scenario predictions.

The set of models included seven simulation models—International Energy Evaluation System/Oil Market Simulation (IEES/OMS), "Oilmar," "Woil," Gately-Kyle, International Petroleum Exchange (IPE), "Oiltank," and "Opeconomics"— and three optimization models—ETA-MACRO, Kennedy-Nehring, and Salant-Stitt. Although the simulation models assume that decisionmakers respond only to the past and present actions of others, the optimization models assume that information about the future behavior of other actors is utilized. Thus, the presence or absence of assumedly perfect foresight distinguishes the optimization from the simulation models. For further descriptions of the models, see the appendix.

---

[4]Energy Modeling Forum, *World Oil*, EMF Report 6, Palo Alto, California, February 1982.

Table 1

MODELS USED IN THE ENERGY MODELING FORUM'S SIXTH STUDY (1980)

Model	Representative	Organizations
Gately-Kyle-Fischer	Dermot Gately John Kyle	New York University Imperial Oil Ltd.
IEES-OMS (International Energy Evaluation System—Oil Market Simulation)	Calvin Kilgore	U.S. Department. of Energy
IPE (International Petroleum Exchange)	Nazli Choucri	Massachusetts Institute of Technology
Salant-ICF	Stephen Salant William Stitt	U.S. Federal Trade Commission; ICF, Inc.
ETA-MACRO	Alan Manne	Stanford University
WOIL	John Stanley-Miller	U.S. Department of Energy/Energy and Environmental Analysis, Inc.
Kennedy-Nehring	Michael Kennedy Richard Nehring	University of Texas The RAND Corporation
OILTANK	Leif Ervik	Christian Michelsen Institute, Norway
Opeconomics	John Mitchell	British Petroleum Co. Ltd.
OILMAR	Frank Potter	Energy and Power Subcommittee, U.S. House of Representatives

MODEL PREDICTIONS

Although the several models differed in structure and assumptions, forecasters unanimously predicted substantially rising oil prices through the 1980s. According to the average prediction, real prices were expected to increase by a total of approximately 29 percent in the 1980–1986 period; they actually fell by 66 percent.[5] Actual prices are

[5]Prices are for Saudi-Arabian Light-34, FOB, from various issues of *Petroleum Intelligence Weekly.*

deflated with the gross national product (GNP) implicit price deflator. Table 2 shows the predictions for the individual models for 1980, 1985, and 1990.

In sum, the predictions made by the models used in EMF were wrong—not just slightly, but remarkably so. Compared with the actual price path, the forecasts did not even predict the correct direction (see Fig. 1).

Given that the ten models' price predictions were all wide of the mark, where does the source of the error lie? At least two possibilities come to mind: One is that the models are in some sense flawed, another is that the models used inappropriate projections. Because all ten of the models were wrong, the likelihood is that the error lies in the projections. That is even more likely because the EMF group developed a consensus regarding projections,

Table 2

ENERGY MODELING FORUM REAL PRICE PREDICTIONS IN 1980
(1981 Dollars per barrel)

Model	1980	1985[a]	1990
Gately-Kyle-Fischer	32.10	42.50	52.90
IEES-OMS	33.90	40.00	46.10
IPE	36.30	36.75	37.20
Salant-ICF	43.70	49.60	55.50
ETA-MACRO	32.10	41.35	50.60
WOIL	34.60	41.20	47.80
Kennedy-Nehring	38.30	47.55	56.80
Oiltank	33.30	48.15	63.00
Opeconomics	28.90	34.30	39.70
Oilmar	32.50	48.25	64.00
Average prediction	34.57	42.97	51.36
Actual price	32.21	23.48	—

[a]EMF provided predictions only for 1980 and 1990: 1985 prices were calculated using the average of the two periods.

and all of the models used a standardized set of projections. If that consensus were incorrect, all of the models would fail; but that result would not be due to flaws in the models themselves.

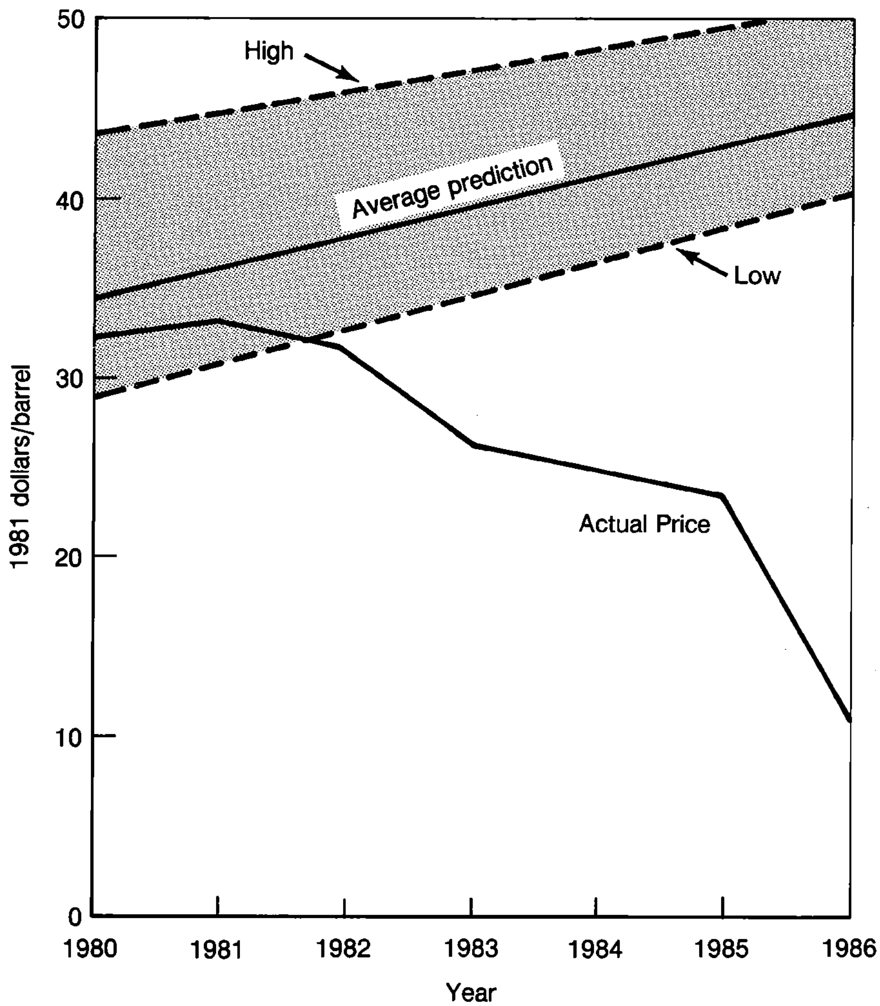

Fig. 1—Predicted vs. actual oil prices

ASSUMPTIONS USED

One reason for the inaccurate predictions could be that the forecasters used erroneous assumptions about the future conditions of the world or U.S. economy and the oil market. In particular, the EMF study did not correctly project the rates of economic growth in different countries or the price elasticity of demand for oil.

One key assumption in determining price is the rate of aggregate economic growth assumed in the various models. The EMF study used standardized annual growth rates of slightly over 3 percent for the Organization for Economic Cooperation and Development (OECD) countries and 5.1 percent for less-developed countries. The actual gross domestic product (GDP) rates have been lower: 2.3 percent for OECD countries and 2.9 percent in developing countries.[6] World growth rates influence oil prices through their effect on the demand for oil: that is, through the income elasticity of demand for oil.

The second assumption affecting the price of oil is the price elasticity of demand. Determining price elasticities is not as straightforward as GNP growth rates. Each model contained its own assumption concerning price elasticity—how each modeler believed that demand would respond to changes in price. Although real world price elasticities are difficult to estimate, history suggests that they are considerably higher than the model's assumptions for reasons relating to individual changes in both consumer behavior and technology.

A useful tool for calculating the actual price elasticities that prevailed is the following equation:

$$\frac{dQ/dt}{Q} = \frac{\beta(dY/dt)}{Y} + \frac{\gamma(dP/dt)}{P} ,$$

where

$$\frac{dQ/dt}{Q} = \text{growth rate of oil consumption}$$

$$\frac{dY/dt}{Y} = \text{growth rate of GDP}$$

[6] OECD and World Bank estimates.

$$\frac{dP/dt}{P} = \text{growth rate of oil prices}$$

β = Income elasticity of oil demand

γ = Price elasticity of oil demand.

This equation is used as an indicator of how close the EMF price elasticity assumptions are to the actual values. Consistent with previous estimates[7] the models assumed an income elasticity of oil demand equal to one. The implied price elasticity was calculated with the predictions of GDP, oil demand, and price. Similar calculations were found for the actual growth rates.

The periods 1973–1985 and 1978–1985 were used because they allow time for adjustments in consumer behavior. The 1980–1985 period was not examined here because the actual derived price elasticity was positive. This indicates the continuing demand reductions in response to rising prices of the previous period, even though prices in 1980–1985 were falling. The results are shown in Table 3.

Table 3

OIL DEMAND PRICE ELASTICITY ESTIMATES FOR INDUSTRIAL NATIONS
(Percent)

	Model Predictions		Actual Growth	
	1973-1985	1978-1985	1973-1985	1978-1985
Annual oil demand growth	1.5	2.1	–1.4	–3
Annual GDP growth	3	3	2.6	1.9
Annual oil price growth	19	13	14	5.2
Implied elasticity	–0.08	–0.07	–0.29	–0.94

[7]Energy Modeling Forum, *Aggregate Elasticity of Energy Demand,* EMF, Palo Alto, California, 4 November 1981.

For the 1973–1985 period, the actual price elasticity for industrial nations, using the above equation, is –.29, over three times more than the –.08 value implied by the average forecast. From 1978 to 1985, the discrepancy is even larger; the models' price elasticity for industrial nations was –0.07, whereas the actual value was –0.94.

The unprecedented conservation effort following the 1973–74 price shock defied the then-common belief that price elasticities were near zero. Reductions in energy use continued after the second shock of 1979 and confirmed the structural change that had taken place. The decline in oil consumption has continued through the 1980s even in the presence of falling oil prices. The models predicted an increase in oil consumption in the noncommunist world of 2 percent from 1980–1985, when consumption actually decreased by 7 percent.[8]

The data shown in Table 3 for elasticity estimates, GDP growth rates, oil demand, and oil prices record how far from the mark the EMF estimates were. The model estimates of price elasticities were incorrect, and the resulting estimates of oil consumption and prices were similarly so.

REVISED PREDICTIONS USING "CORRECT" PROJECTIONS

Because of the erroneous projections that were used, it might appear that if only the models had made the correct GDP growth projections and price elasticity assumptions, the predictions might have been closer. To see if this is true, more accurate assumptions about GDP growth will be used to see if they provide correct results.

If the models had used lower rates of GDP growth, both the price and consumption predictions would have been lower. According to the EMF "reduced growth" scenario, price would be reduced by a median value of 24 percent for every 10 percent reduction in the 3.1 percent reference case growth value. Similarly, consumption would decrease 2 percent for every 10 percent GDP reduction.

This results in a revised 1986 predicted price of approximately $22/barrel for the median case (1981 dollars), and depresses consumption to around 49 million barrels a day (mmbd) for the noncommunist world. The actual price of oil in 1986 is around $11/barrel (1981 dollars as of July 1986) and consumption is just over 45 mmbd. Thus, even if the correct growth assumptions had been made, the predictions would still have been unacceptably wide of the mark.

---

[8]*British Petroleum Statistical Review of World Energy*, British Petroleum Co., London 1985.

Performing a similar "correction" with the elasticity estimates was not as straightforward. In fact, when the EMF study performed a sensitivity analysis of the elasticity values, the only alternative case considered was when the price elasticity was lower than the reference case. This indicates the prevailing notion that consumer demand response to price changes is small. As was shown earlier, the actual elasticity estimates were considerably higher than the elasticities assumed by the models.

CONCLUSIONS

This review of oil price predictions has summarized the models used, and their price and demand predictions, and revised predictions that used updated growth projections. Forecasting oil prices since the first oil shock of 1973 has proven to be problematic, the primary reason being that the modelers misestimated the price elasticity of demand for oil.

Both actual oil prices and consumption in 1986 were *lower* than had been forecast. The large error in the forecasts, therefore, cannot be explained by the lack of OPEC cohesion. If the models were wrong because they failed to anticipate OPEC's breakup, we would have seen lower prices and *higher* consumption. Thus, the modeler's uncertainty of OPEC's actions does not account for the incorrect price predictions.

Part of the error in the forecasts was due to overestimated economic growth rate projections in both developed and developing countries. The growth forecasts were, however, not too far off and did not pose a severe problem for the accuracy of the forecasts. The models themselves, independent of economic and political fluctuations, were flawed.

In particular, the estimates of the price elasticities built into the models were inaccurate. All the models included here grossly underestimated the price elasticity of demand for oil. They did not anticipate the degree to which people would reduce their energy use given the rising prices of the 1970s. Furthermore, oil consumption continued to decline even when prices began to fall in the 1980s.

It is not too surprising that the modelers misestimated the price elasticity of demand for oil, yet they were all wrong in the same direction. Why was this so? The answers are not clear, and further research is necessary to determine the source of the erroneous elasticities.

Appendix

MODEL DESCRIPTION

These descriptions were taken from an Energy Modeling Forum paper.[1]

IEES-OMS

The International Energy Evaluation System (IEES) and Oil Market Simulation (OMS) models are part of a system of models used by the DOE Energy Information Administration to forecast midterm world oil prices. OMS requires as inputs regional supply and demand information obtained from IEES, the Midterm Energy Forecasting System (MEFS) and various econometric models; these reference projections are modified by the prices calculated within OMS. Iteration of the system of models is used to achieve consistency between the price used as underlying input assumptions to OMS and those produced as output.

The OPEC price-change rule used in OMS depends only on current capacity OPEC utilization, and is of the form

$$y = a + \frac{b}{(1 - x)},$$

where x is capacity utilization and y is percent (real) price change. The constants a and b are estimated from data obtained since 1973. OPEC capacity is exogenous.

Within OMS, demand responds to price both directly and through GNP feedback, by means of price and income elasticities.

The OMS time horizon extends to 1995 and is an oil-only model; the IEES and MEFS models determine the amounts of substitution of other energy sources.

---

[1]Perry Beider, *A Structural Comparison of Ten Models of the World Oil Market*, EMF 6.4, Energy Modeling Forum, Palo Alto, California, August 1980.

OILMAR

OILMAR is a system dynamics model developed by the staff of the House of Representatives Subcommittee on Energy and Power. The world is divided into the United States, OPEC, and the Rest of the World (ROW) with a time horizon of 2020.

The explanatory variable in OPEC price changes is the demand/capacity ratio, a capacity utilization measure with arguments that can exceed unity. However, capacity is defined not only by capital stock but also by a minimum reserve-to-production ratio; if this R/P ratio becomes binding, capacity is considered to have decreased along with actual production, leading to larger price increases. Physical capacity and reserve additions are exogenous.

Consumers in the United States and ROW exhibit a lagged demand response by means of elasticities to price and GNP, with GNP exogenous; the lag is a five-year exponential delay (2/3 of the response occurs within five years). Non-OPEC oil production responds only indirectly to price changes in OILMAR.

WOIL

WOIL is a system dynamics model of the world oil market designed to be run in conjunction with the national energy model FOSSIL2, for use at the DOE Office of Analytical Services. Regions considered in the EMF 6 study are the United States, rest of OECD, OPEC, Mexico, and remaining less-developed countries. The time horizon is 2020.

Oil price is the sum of OPEC production cost and profit margin; changes in the OPEC profit margin are given by the weighted sum of two tabular functions, depending on current capacity utilization and projected future utilization. The latter term does not represent perfect foresight on the part of OPEC but is an extrapolation of available "historical" information. Capacity is exogenous. The production cost term, which is not subject to OPEC control, increases with cumulative production to represent the effect of depletion.

Regional oil demands respond to changes in income and energy prices through changes in capital stock utilization and energy efficiency of new investments (for the United States, these calculations are made in FOSSIL2). Feedback from oil prices to GNP growth occurs with a short lag by means of a constant "price elasticity of GNP." Natural gas and coal prices are required as inputs.

Conventional oil production in the ROW is a reference projection at constant price, modified by a supply elasticity and a depletion effect.

GATELY-KYLE

Originally developed by Dermot Gately, John F. Kyle, and Dietrich Fischer, this model divides the world outside Centrally Planned Economies into OPEC (Middle East OPEC and other OPEC) and non-OPEC.

Percent price change is a piecewise linear function of current OPEC capacity utilization. Capacity is exogenous, and internal OPEC consumption grows at 4 percent annually.

Both non-OPEC supply and demand curves are in terms of energy, not oil. This implies perfect substitutability between oil and other energy sources. Adjustments to price changes by consumers and producers are lagged by two effects: fairly short lags between actual and expected prices, and longer delays in adjusting the capital stock to reflect the expected prices. The long-run supply and demand curves shift at exogenous rates, representing technological improvements and GNP growth, respectively.

IPE

Nazli Choucri's International Petroleum Exchange (IPE) model, unlike the other models included in EMF 6, explicitly considers the multinational oil corporations as separate actors in the world oil market. This perspective allows for consideration of such items as oil company profits and OPEC foreign investment capital; for the variables the analysis is concerned with, however, the oil companies may be considered part of the OPEC sector. IPE considers only the Persian Gulf members of OPEC and the OECD countries; the time horizon is from 1970 (for validation purposes) to 2000.

Price is the sum of several components: OPEC royalties (exogenous and constant after 1978), production costs (exogenous and rising with time), discovery costs (rising with depletion), and oil company markups. The latter are calculated by adding the 1970 markup on Saudi Arabian light crude oil to a tabular function of current capacity utilization, and multiplying the result by factors derived from the decline rate (the reciprocal of the reserves/production ratio) and any gap between gulf supply and demand.

IPE is the only model in EMF 6 to calculate capacity endogenously. There is lagged response, through investment, of capacity to expected demand and of new oil discoveries to the decline rate.

Reference projections of oil supply and demand from OECD documents respond to lagged prices through elasticities. As in the Gately-Kyle model, the lags are from two sources: a three-year exponential delay between actual and expected price, and a five-year exponential delay between expected price and quantity supplied or demanded. There is no GNP feedback effect in IPE.

OILTANK

OILTANK is a systems dynamics model developed by Leif K. Ervik at the Chr. Michelsen Institute in Norway. It has a high degree of regional disaggregation and is thus particularly useful for simulating the international flows of oil.

The OPEC price-change rule is:

$$y = f + (CU)^2 g \,,$$

where y is percent price change, CU is current capacity utilization, and f and g are functions of current utilization and change from the previous year's utilization, respectively. OPEC capacity is exogenous in the EMF 6 runs.

Oil demand responds regionally to GNP growth and lagged prices through elasticities. The lag in the price effect is set to correspond with that suggested in the study design; there is no GNP-feedback effect.

Non-OPEC conventional oil is produced at constant regional reserve/production ratios; the only effect of price on conventional oil is a lagged one through new discoveries and the recovery factor.

OPECONOMICS

Opeconomics, developed by British Petroleum, divides the world into Iran, Saudi Arabia, and the rest of the world. It has a time horizon of 1975–2000.

Iran and Saudi Arabia set price in response to capacity utilization along an "implied" linked supply curve, unless their ratio of foreign currency reserves to foreign imports falls below a "trigger" level (two years import cover). If this minimum ratio is not met by one country, an attempt to adjust relative market shares is made; if this is not sufficient, a shift in the supply curve takes place. Oil production capacity is exogenous.

Like the Gately-Kyle model, Opeconomics considers world demand in terms of energy, not oil; as previously noted, this implies perfect substitutability of energy forms. Demand responds to lagged oil price both directly and through feedback on the demand growth rate.

ETA-MACRO

Alan Manne's ETA-MACRO is an optimization model, operating in five-year intervals from 1975 to 2050. OECD consumers have "perfect" foresight concerning energy supply possibilities (except in the disruption scenarios) and use this information to determine the time paths of their oil purchases from OPEC and their own investments.

Consumers seek to maximize the discounted utility of consumption where the utility function is assumed to be the natural log. Output of the aggregate OECD economy is a function of capital, labor, electricity, and nonelectric energy inputs. Key parameters of the production function are the optimal value shares of capital to labor and electric to nonelectric energy, and the elasticity of substitution between energy and nonenergy inputs. The labor force growth rate is calibrated to the potential GNP growth rates in the EMF 6 study design.

OPEC is represented in the model by an explicit supply curve, which shifts leftward at an exogenous rate to represent increased consumption by OPEC and other less-developed countries.

KENNEDY-NEHRING

Developed at The RAND Corporation by Michael Kennedy, Richard Nehring, and Fred Hoffman, this model uses Hotelling's theory of depletable resources to derive profit maximization conditions for non-OPEC conventional oil producers with perfect foresight. Three consumption and nine production regions are considered.

In the model, conventional oil producers actually operate with "perfect" foresight about the price path; this path must be iteratively adjusted to achieve market clearing in every year. The end result is as if conventional oil producers knew OPEC production, the demand behavior of consumers, and the supply behavior of unconventional oil producers. Because non-OPEC producers are assumed to be competitive, they would not be able to exploit this information in a monopolistic fashion.

OPEC production is fixed at an exogenous level throughout the time horizon, and hence there is no response to price. Consumers respond to price through a short-run elasticity for existing capital and a larger long-run elasticity for new capital; capital is purchased at a constant rate that includes replacement of depreciated stock and GNP growth (exogenous). Consumers respond myopically (with no foresight regarding future prices) in making their capital purchases.

The producers' decision variable is how many new fields to develop in a given year. The result is based on Hotelling's theorem that the rent accruing to owners of a depletable resource should rise at the rate of interest (the discount rate) until the backstop (unconventional oil) price is attained.

SALANT-STITT

Developed for ICF by Stephen Salant and Will Stitt, this optimization model uses a "Nash-Cournot" noncooperative game theory approach. Oil suppliers are divided into Nash-players (OPEC and Mexico) and the smaller competitive fringe players.

The Nash-players use their perfect knowledge of consumer demand to maximize discounted profits, given certain assumptions about the production of the competitive fringe and the other Nash-players (they assume that they are too small to affect the world oil prices). Iteration is necessary to equate the assumed price and quantity paths with those actually resulting from the individual decisions.

Each oil producer has several pools, described by constant production costs, exogenous capacity paths, and total extraction constraints.

A reference price path is put into a demand preprocessor containing regional lagged demand functions; a set of linear, nonlagged aggregate demand functions over time is used in the actual world.

RAND/N-2524-RC