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" International Changes in the World Oil Market: A Simulation Perspective"

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INTRODUCTION

This special issue of the *International Political Science Review* is devoted to recent developments in mathematical, statistical, and simulation approaches to international relations. The issue illustrates several distinct traditions in the field, and different conceptual and methodological approaches. More important, however, is the range of substantive issues and problems to which these methods have been applied.

Each of the articles in this issue addresses itself to a critical problem in international politics, draws upon the theoretical and conceptual underpinnings of the field and specific writings on the issues at hand, and develops a rigorous formulation of the problem, a mathematical representation, and in some cases a set of policy "solutions." All six articles make distinct contributions to the development of theory for the study of international relations. Together they represent an international blend of skills, in terms of both geographical and political orientation with attendant methodological perspectives. The essays all focus on international relations at the macrolevel—relations among nations and/or on transnational corporations. The substantive issues differ as do the units of analysis and degree of aggregation.

The first article focuses on the problems of adjustments in the world oil market. It presents a perspective in international relations that enables analysis of market adjustments to oil price changes worldwide and their implications for producers, consumers, and international oil companies. This essay draws upon ongoing research at the Massachusetts Institute of Technology (USA).

The second essay illustrates the orientation and methodological commitment at the University of Geneva (Switzerland). Urs Luterbacher and Pierre Allan have prepared an article that examines the substantive problems of public spending. They highlight their simulation approach to political and economic interaction among nations, including the dynamics of military spending in a comparative context.

The third article, written by Sam Cole, is in the global modeling tradition within the context of general equilibrium models. It is representative of the style of research at The University of Sussex (United Kingdom). Dr. Cole examines the effects of technological change on income distribution. Nations are categorized into four groups of countries and the results show some of the effects of a practical, technological innovation.

The fourth article, prepared by Margee Ensign and Warren Phillips of the University of Maryland (USA), represents a modeling tradition that draws upon the field of artificial intelligence. Their purpose is to simulate the factors that enter into decision making in developing countries. The "inner environments" stand in sharp contrast to models of external environments in which attributes of nations are quantified and international relations among attributes are specified.

The fifth essay, written by Susumu Yamakage, Institute for Future Technology (Tokyo, Japan), illustrates formal mathematical representation of the condition and process of interdependence. The example is simple, but it shows the powerful application of mathematical representation to a phenomenon that everyone acknowledges as being important in world politics today.

The final article in this issue is a critical review by Brian Pollins, Science Center, Berlin (West Germany) of the models of international trade. Trade among nations has been one of the earliest issues analyzed by the social science quantitative traditions. Pollins's review clarifies the dominant characteristics of major traditions in trade analysis, the variety of uses to which the models have been put, and their potential for advancing the state of knowledge in the field.

Together, the contributions in this issue highlight some of the new thrusts in international relations analysis. Clearly, not all the new directions in the field are represented here, for this would have been an impossible task. However, each of the essays points to directions that are extremely promising and are based on extensive work already completed. In the years to come we can expect further developments in international relations that will, almost certainly, draw upon the analyses presented here.

—Nazli Choucri

INTERNATIONAL CHANGES IN THE WORLD OIL MARKET
A Simulation Perspective

NAZLI CHOUCRI

The oil price increases of October 1973 triggered a set of changes in the international system that promise to have continued, long-term effects. This article begins with a review of the major attempts to model the world oil market and provides syntheses of their characteristics and worldview. The structure of the International Petroleum Exchange Model developed at MIT is then presented, followed by a set of simulations (forecasts) of future changes in petroleum supply and demand associated with alternative price paths. The simulations are also compared with empirical data to provide some insights into the potential accuracy of the forecasts.

The oil price increases of October 1973 triggered a set of changes in the international system that promises to have continued, long-term effects. Among the most pervasive changes is the shift in power relations between consumers and producers of petroleum, as well as a change in the role of the international oil companies. The entire system of relations governing the international oil industry since the 1930s has been transformed, and with it, the underlying relations between importer and exporter countries. Debates about the causes of the events of 1973 still abound in both scholarly and policymaking communities, as do arguments about the alternative directions of future changes in the international system.

Throughout the decade of the 1970s a variety of arguments and position papers about different features of the crisis were developed yielding diagnoses of the problem and prescriptions for its solution. Much of this literature is dominated by a view that the problem has been created by the oil-exporting countries and that the solution is some form of induced price reduction. At the same time, however, there is a new line of research that seeks to apply techniques of mathematical modeling and simulation to analyses of the problem. The importance of this new work on the world oil market lies in its intended contribution to our

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understanding of that market by seeking to yield insights into precise relationships and to provide specific predictions or forecasts. In addition, it has drawn attention to the usefulness of mathematics and simulation methods for analyzing relations among nations, worldwide adjustments to changing conditions in the market for a critical commodity, and the role of transnational corporations as managers, then mediators, in these exchanges.

ALTERNATIVE VIEWS OF THE WORLD OIL MARKET

There have been numerous efforts to model the determinants and consequences of market changes since 1973. I have previously compared the analytical structure of twelve models of the world oil market, identified the analytical formulations employed, and rendered explicit the worldview adopted by each model and its implications for understanding the changes in the global network of trade in petroleum (Choucri, 1979). The comparison was designed to highlight both the dominant assumptions and the characteristic features of price determination in the world petroleum market. I concluded that the twelve models reviewed all shared the same general paradigm, that the implicit worldview employed poses inherent difficulties, that important features of reality in international oil trade are omitted, and that some of these difficulties can be overcome by an explicit recognition of the broader international exchanges within which this particular market is imbedded.

Some models seek to compute optimal prices or to calculate future prices; other models begin with price and inquire into the alternative implications for consumer or producer countries; and still others make specific forecasts of supply and demand. However, these models all share a perspective on the oil industry and attendant relationships in terms of a market, with the major characteristics of these relationships viewed exclusively in economic terms that see the interdependence of supply and demand as determining price and setting the boundaries of economic exchange. Most oil models seek to compare OPEC-generated prices with those likely to prevail under competitive conditions. The referent (implicitly, if not explicitly) is a market in which the OPEC phenomenon is regarded as an aberration of normal conditions, and the solution to market imperfections is a return to competitive conditions.

While competition is, strictly speaking, only a useful idealization that is seldom even an approximate representation of reality, many studies succumb to the temptation to treat oil exchanges as if they should be

competitive ones. That the conditions in the world oil exchanges prevailing prior to October 1973 were not characteristic of a competitive market is rarely observed in the rationale and background discussions for models, nor are the noncompetitive features of the market given preeminence in the input specifications of most models. Indeed, the changes from a market dominated by a company cartel to one dominated by a country cartel are seldom even acknowledged. In short, the theories of price formulation imbedded in these twelve models indicate the implicit world view and the methodological dispositions of their authors and determine the results obtained.

One of the most extensive exercises in analyzing the characteristic features of models of the world oil market was undertaken at Stanford University (USA) under the auspices of the Energy Modelling Forum. For more than a year, a group of modelers and policy analysts from different backgrounds and perspectives interacted to share insights obtained from different models of the world oil market. The final report, completed in early 1982, presents the most recent analyses in the modeling literature (EMF, 1982).

THE CONSTRAINTS OF CENTRAL TENDENCIES

With the benefit of hindsight, it is now clear that assessments made of this literature several years ago (Choucri, 1979) are still generally accurate and supported in the more recent comparisons (EMF, 1982). In general, modeling efforts tend to represent the world they depict in the following terms.

First, there is generally an explicit formulation of an adversarial situation in which only producers and consumers interact, and in which the emphasis is generally on the concerns and priorities of the consumer countries or on the constraints and optimal prices for producer countries. World oil models seldom adopt a systemwide perspective on the overall exchanges linking these countries.

Second, most models seek to determine the implications of various policies or interventions. But the evaluations are made largely in terms of comparing numerical values for the target variables rather than being broad policy assessments of overall gains and losses to reflect the interests of different parties in the oil market. There is seldom an explicit referent against which the impact of different policies is evaluated.

Third, a narrowly conceived market perspective continues to prevail. In only a few cases is there reference to a broader view of oil exchanges. The market imposes a closure on the interactions modeled that

precludes a more comprehensive international analysis or evaluation of the extent, type, and economic and political consequences of trade in petroleum under different supply, demand, and price assumptions.

Fourth, by defining the problem as created by the oil-exporting countries for the oil-importing countries, analysts uniformly ignore the role of the international oil companies. Reference is rarely made to these companies and in no case is there an explicit inclusion of their influence or leverage in representation of the oil market.

These four tendencies are particularly common in the world view (or paradigm) prevailing in world oil models, and they point to a profound irony: While everyone has recognized the pre-OPEC (and, by some observers' assessments, post-OPEC) importance of the oil companies in shaping the world petroleum market—in setting prices, allocating market shares, and controlling production—both simulation and optimization models of the world oil market ignore the international oil companies' interests. No attempt is made to distinguish between the roles of the oil companies in worldwide oil exchanges and those of the producers and consumers. It may well be that at this writing the international oil companies are no longer as dominant in the world oil market as they were a decade ago. Nonetheless, no one could argue that they have become irrelevant.

TOWARD A RESPECIFICATION OF INTERNATIONAL PETROLEUM EXCHANGES

Against this background, we have proposed a view of the world oil market that takes explicit cognizance of the consumer countries, the producer countries, and the international oil companies in influencing the nature of the exchanges and the determination of price, and presents a more realistic representation of oil-related exchanges. An explicit recognition of the differences in the roles and functions performed by each entity and their potential effects upon price setting, oil policies, and overall economic transactions is an important extension of the market perspective presented in the oil models reviewed.

The simulation approach adopted entails a fairly comprehensive specification of global petroleum exchanges in terms of supply-and-demand relationships and the interactions and leverage available to producers, consumers, and international petroleum companies for influencing price. The main objective of this revised view is to delineate the structure of petroleum exchanges and determine explicitly the

influences on—and effects of—prices on worldwide economic transactions.

This view is imbedded in the International Petroleum Exchange Model (IPE). The model represents an integrated framework for thinking about our common resource predicaments. It is employed as a simulation model to examine the implications of alternative assumptions about energy demand and international relations, and consequences of policies designed to bring about preferred outcomes. This framework stresses the broader economic and structural contexts within which the oil market operates. Such a perspective contributes to the avoidance of state-centric, market-oriented distortions inherent in prevailing discussions of the energy crisis and the attendant bias of focusing on either the consumer or producer states alone.

Some of the characteristics of the IPE model are:

- The IPE model represents *generic* processes in the global exchanges revolving around trade in petroleum. The perspective adopted includes, but extends beyond, the confines of one market, and it takes into account oil production processes, oil trade, and international financial consequences.
- The model is structured in terms of interactions among *three entities:* producer countries, consumer countries, and international oil corporations.
- The quantity of oil supplied is determined largely in terms of oil *production* in the exporting countries; however, there is provision for the use of domestic sources of oil in the consuming countries and for the position of non-OPEC suppliers in the market.
- *Demand* is formulated in terms of total demand for oil and demand for imports from OPEC.
- *Imports* from OPEC are calculated taking into account domestic sources of production in the oil-importing countries as well as supply from non-OPEC producers.
- Imports and domestic production are influenced by the price of oil, which also determines the extent to which *energy substitutes* become available.
- Imports from the Persian Gulf generate *oil payments* that contribute to the producer countries' revenues and appear as a major claim against consumer countries' balance of payments.
- The *balance of payments* is computed on the basis of oil payments to the exporting countries, the investments of the oil producers in the economies of the consumer nations, and their purchases of goods and services from

the consumers, as well as the repatriation of profits by the international oil companies.

THE CORE CHARACTERISTICS

The IPE model is based on key equations that represent dynamic behavior and a set of accounting equations that monitor the effects of this behavior. The essential features are demand, supply, and price relationships. The tax rate is endogenous, as a function of the actual utilization of oil production capacity, the desired capacity utilization, and the decline rate.

Price changes affect both the quantity demanded and the amount supplied. There are time lags involved on both sides. On the supply side there are the lags associated with investment delays. In the short run demand adjusts to price, and supply from outside the Gulf is relatively unresponsive. Gulf supplies adjust to meet demand at the prevailing price. Over the longer run both supply and demand adjust to price and in turn influence the final determination of price.

Price at t_1 leads to a quantity demanded, which leads to an amount supplied. These amounts are constrained by previous demand patterns and by the costs and investments that have generated productive capacity. Demand in turn is influenced by past prices and by price expectations. Depending on price and quantity, the process may be extremely stable. But with rapid changes in the tax rate there is a dynamic interaction that may induce instabilities in the process because of the lagged response of both supply and demand. The driving mechanism in the model is for supply to adjust to the amount demanded, which in turn responds to price. In effect, an increase in the tax means the producers will sell the same quantity, only at a higher price; hence, the supply curve shifts to the left. The result is a new equilibrium at a higher price and lower quantity than before, with residual, non-Gulf suppliers acting to clear the market during the transition.

The model is written in a simulation language (DYNAMO) and can be reformulated for econometric estimation. Table 1 presents the core of the IPE model, with the caveat that this representation is for analytical purposes rather than to depict the precise relationships. The left-hand variables are endogenous, as are some of the right-hand variables. Once quantities supplied and demanded are generated—at a particular price—*consumer* oil imports, *producer* investments and imports of

TABLE 1
Analytical Representation of the IPE Model

Agents in the Market			
Supply	$TS = S_p + S_c + S_R$	where:	TS = total supply
	$S_p = f(PC, R)$		S_p = producer supply from Gulf
	$S_c = f(\hat{S}, P, DR)$		S_c = consumer supply
	$S_R = TD - S_p - S_c$		PC = production capacity
			R = reserves
			$\hat{S}$ = base OECD series
			P = price
			DR = decline rate
			S_R = output of residual sellers, inventory changes, and so on
Demand	$TD = D_c + D_p$	where:	TD = total demand
	$D_c = f(\hat{D}, P, E)$		D_c = consumer demand
	$D_p = f(Pop, K)$		D_p = producer demand
			$\hat{D}$ = base OECD series
			E = alternative energy sources
			Pop = producer population
			K = producer capital stock
Price	$P = T + C + MK$	where:	T = tax rate
	$T = f(PCU, DPCU, DR)$		C = cost
			MK = corporate markup
			PCU = actual capacity utilization rate
			DPCU = desired capacity utilization rate
Markup	$MK = f(MK_0, PCU, DR, \Delta COMD)$	where:	MK_0 = base markup
			PCU = production capacity utilization
			$\Delta COMD$ = change in consumer import demand
Consumer Import Demand	$COMD = D_c - S_c$		
Market Clearing	$S_R = COMD + D_p - S_p$		

goods and services, and *corporate* profits and investments in the oil industry are computed.

ADJUSTMENT MECHANISMS

The IPE model combines the characteristics of two types of economic models—the dominant firm model for a short-run analysis and a longer-run adjustment process of quantities to price. The dominant firm model applies to the Gulf producers who make price and quantity decisions in the short run by setting the tax rate on extraction and/or the amounts to be produced or capacity to be utilized and, in the longer run, on the size of the residual market (where excess demand is met in the short run by non-Gulf producers) and on the price responsiveness of demand. Figures 1 and 2 present the short- and long-term adjustment mechanisms (for details, see Choucri, 1981).

In the short run, consumers can influence the size of the residual supply, increase domestic production, and to some extent cut their imports. In the longer run they can reduce demand and expand the use of alternative sources of energy.

The companies' markups are their immediate adjustment to prevailing market conditions. In the longer run they influence exploration and development through investments in the oil industry. Their impact on Gulf supply is thus of a longer-run nature. The model is initialized at 1970 values to allow tracking the historical record during a period in which the influence of the companies on the market was stronger than today.

COMPUTATIONAL STRUCTURE

The IPE model is composed of seven sectors. It is designed to represent the physical characteristics of oil production, the economic context and constraints, and the international financial exchanges that ensue from the trade in oil. Figure 3 represents conceptual relationships, not the computer-readable equations. It summarizes the model as a whole, in that producers and consumers interact through financial and economic transactions, mediated by the activities of the international oil companies and constrained by the geological and technological features of the oil production process.

The sectors of the models can be described briefly as follows:

- The *supply* sector represents the physical stages of oil production, tracing the process from exploration for oil-in-place and the development of

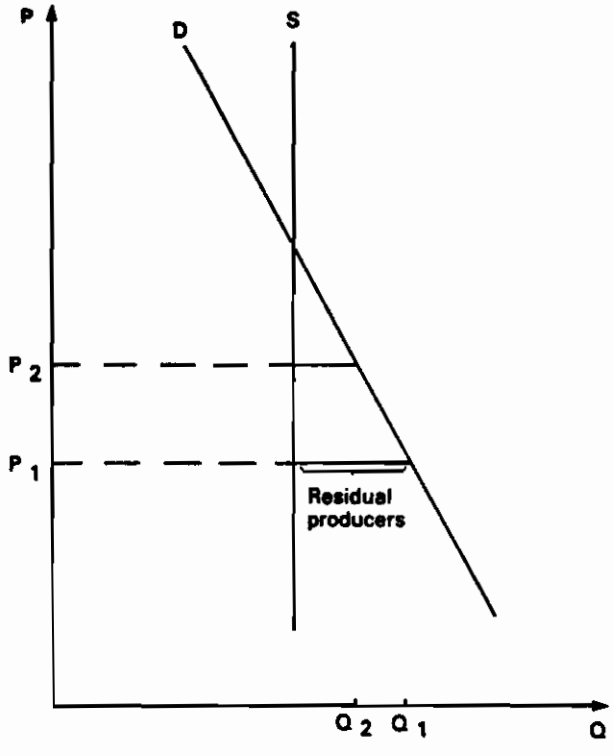

Figure 1: Short-Run Adjustment Process

SOURCE: Nazli Choucri with David Scott Ross, International Energy Futures: Petroleum Prices, Power, and Payments. Cambridge, MA: MIT Press, 1981, p. 22.

recoverable reserves to the installation of productive capacity and actual production.

- The *finance* sector makes key calculations for each of the three entities in the oil market: oil import expenditures for consumer countries, corporate profits and oil investments for the oil companies, and oil income for the producer countries.
- The *management* sector specifies the corporate investment decisions affecting the supply of oil. The major investments of the multinational corporations in development and exploration are based on information drawn primarily from the supply sector, in conjunction with considerations of oil demand from the consumer sector.

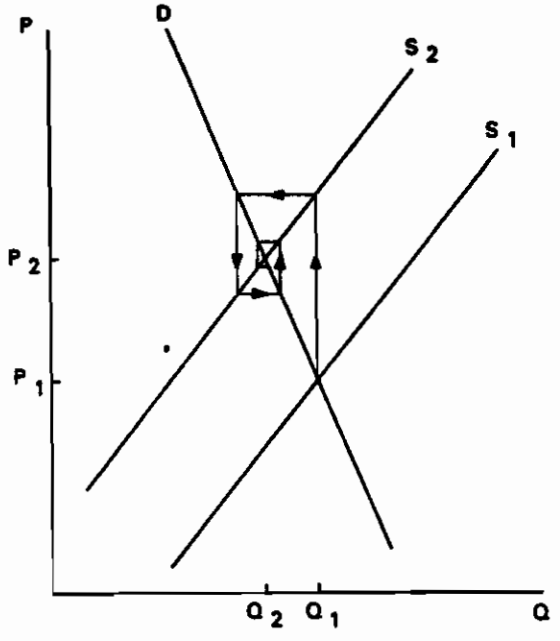

Figure 2: Longer-Run Adjustment Process

SOURCE: Nazli Choucri with David Scott Ross, International Energy Futures: Petroleum Prices, Power, and Payments. Cambridge, MA: MIT Press, 1981, p. 23.

- The *price* sector calculates the price of oil based on inputs from other sectors of the model. The tax rate, production costs, and the corporate markup are all endogenous. Once calculated, the effects of price are then transmitted throughout the model to compute its financial and security implications for producer and consumer.
- The *producer* sector models the process of industrial development in the Gulf states, which generates demand for development investment and for imports of goods and services. The tax rate is a key policy variable and input to final price calculations.
- The *consumer* sector computes demand for oil imports and monitors the consequences of such imports for the consumers' strategic vulnerability and dependence upon external sources of supply. This sector models supply and demand for oil from domestic sources in consumer countries and the availability of substitutes.

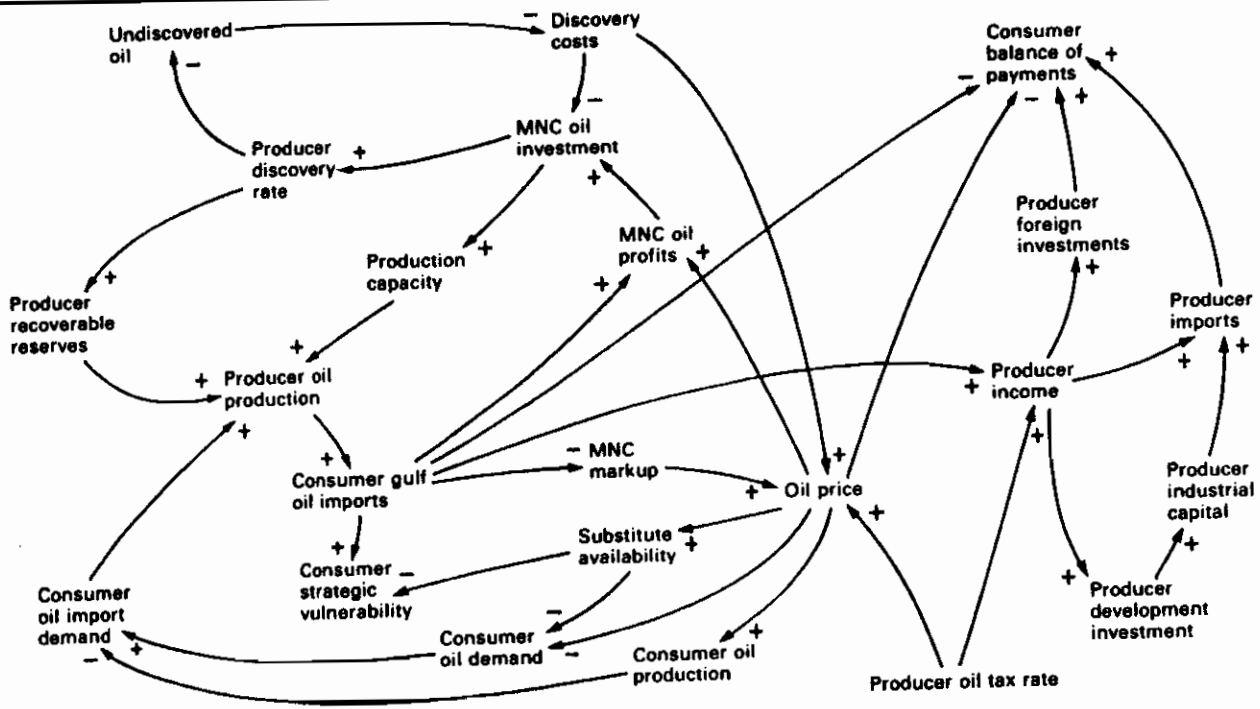

Figure 3: Simplified Model Overview of Major Causal Loops

SOURCE: Nazli Choucri with David Scott Ross, International Energy Futures: Petroleum Prices, Power, and Payments. Cambridge, MA: MIT Press, 1981, p. 30.

- The *international economic* sector calculates the consumer balance of payments and traces the foreign investment activities of the producing states; it registers and links the consequences of actions taken by the consumer countries, the producers, and the oil companies.

Figure 4 presents the linkages among the sectors.

The time frame of the IPE model is 1970 to 2000. Model behavior under different policy conditions yields good results to 2000. Few experiments have been run beyond 2000, although they are, of course, technically feasible. The results below bear largely on the analyses to 2000. Results are presented at annual intervals; however, the actual computations are done over ten increments per year. The demand, supply, and price formulations are computed iteratively.

Of the many ways to approach the validation problem for simulation models, we have chosen three: (1) comparing model results for the reference and select alternative cases with known values, 1970 to 1980; (2) comparing IPE model results with those generated by other world oil models, and (3) examining behavior for internal consistency and plausibility given known parameters of the world oil market (see Choucri, 1981, for results of validation).

EXTENSION AND RESPECIFICATION OF THE IPE MODEL

The generic structure of the model has been extended further in several directions in order to provide a more useful and precise guide for analyzing international economic exchanges associated with oil trade. Four types of extensions are noteworthy. First is disaggregation of the producer and consumer entities into specific groupings in world politics. Second are more detailed analytical specifications of the supply-and-demand relationships in the world oil market. Third is a more realistic economic adjustment mechanism. Fourth is a price specification that enables the producers' own base tax rate to be determined by market conditions.

DISAGGREGATION OF PRODUCERS AND CONSUMERS

The agents in the original IPE model are aggregate producers (divided between Gulf and non-Gulf), aggregate consumers (OECD), and aggregate international oil companies (majors). The following

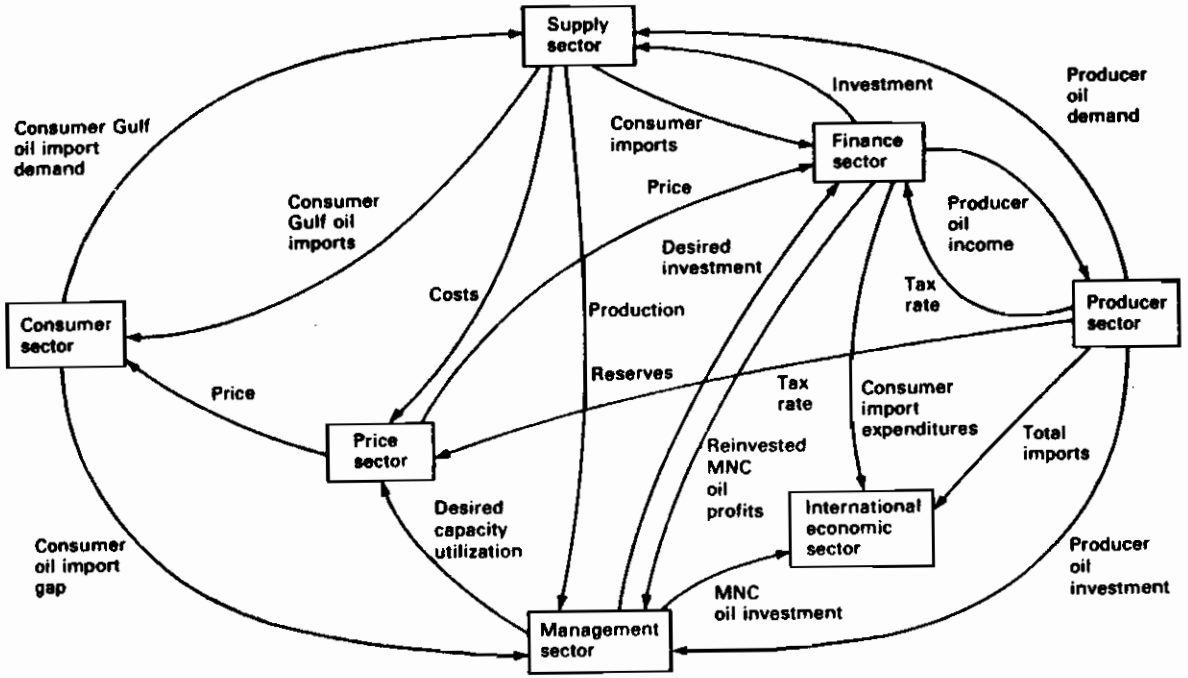

Figure 4: Major Linkages of the Sector Link Diagram

NOTE: Note that only one component of markup is derived in the management sector.

SOURCE: Nazli Choucri with David Scott Ross, International Energy Futures: Petroleum Prices, Power, and Payments. Cambridge, MA: MIT Press, 1981, p. 38.

regional sectors and the individual disaggregated components have been made:

- OECD, aggregated from individual sectors representing the United States, Western Europe, Japan, and Canada/Australia/New Zealand;
- OPEC, aggregated from Middle Eastern (including Algeria and Libya) and non-Middle-Eastern sectors; and
- other Third World countries.

This disaggregation is designed to test for adjustments of, and effects on, individual (national and regional) behavior.

RESPECIFICATION OF SUPPLY AND DEMAND

Demand Specification

Three types of demand functions have been developed further in the IPE model: (1) regression estimates for OPEC countries, (2) simple yearly growth and long-term demand elasticities for the smaller regions (Mexico and Canada/Australia/New Zealand), and (3) more complicated growth mechanisms with feedback from oil prices, modified by long- and short-term demand elasticities for the rest of OECD and the non-OPEC Third World.

This third type of demand specification is based on a combination of long-term and short-term factors. Base economic growth rates are assumed for the OECD and non-OPEC Third World countries, modified by a feedback due to increased import expenditures to derive actual economic growth. Price-independent growth in demand for petroleum is determined by an income elasticity coefficient. A base demand series is then developed using the initial (1970) demand and the year-to-year demand growth. This price-independent demand is then modified by multipliers representing short- (−.08) and long-term (−.3) price elasticities to generate demand. (These coefficients are based on data from the U.S. Department of Energy, Energy Information Administration.)

Supply Specification

Oil production is specified in four ways:

(1) For Canada/Australia/New Zealand, production is equal to the minimum of 95% of capacity of total demand. It is assumed that policies in

those countries preclude net exports. Production capacity is derived from initial capacity and a price multiplier.

(2) Non-OPEC Third World production is set at maximum levels, 90% of capacity. Oil is exported when production exceeds domestic consumption.

(3) Mexican production is determined directly from a base series, modified by a price elasticity. A gradual growth in production is designed, in accordance with the (apparent) current desires of Mexico to expand slowly.

(4) For the United States, production is determined by price and depletion, modifying an initial base production series. Western Europe's production is estimated by using price and depletion to modify a base production series that increases to show the effect of the North Sea coming on line in the 1970s. Japanese produciton is set at zero.

For OPEC countries, capacity utilization for the two OPEC groups is determined differently. Middle Eastern capacity is determined by investments based on estimated demand. Non-Middle-Eastern capacity is based on an initial level, modified by a price multiplier and reserve depletion. Capacity *utilization* is calculated by: (1) setting aside sufficient capacity to meet domestic demand, and then (2) sharing the remaining capacity equally between Middle Eastern and non-Middle-Eastern producers. Since non-Middle-Eastern producers always utilize a higher percentage of their capacity to meet domestic consumption than do Middle Eastern countries, their overall capacity utilization will always be higher.

Synfuels, defined as liquid fuels derived from coal or oil shale, are modeled as being produced only by the United States. This is done by using a price modified (.3) base production series. The base series assumes 50,000 barrels per day will be produced by 1990, and 5 million barrels a day by 2000.

ECONOMIC MECHANISMS

For the OECD region and the non-OPEC Third World, a basic economic growth rate is assumed, then modified according to the relation of change in oil import expenditures to GDP. For example, if the increase in oil import expenditures from one year to the next is an amount equivalent to 2% of a region's GDP, then the domestic economy will grow by 2% less than would otherwise be the case. This economic growth rate has a feedback effect on oil demand.

For OPEC countries economic growth is estimated in the form of nonoil domestic capital, which is a function of investment and depreciation. Investment is derived from regression estimates on population, oil income, and existing non-oil capital. Capital is assumed to be 2.5 times GDP, a rough indicator commonly used in development economics. On the basis of capital estimates, the equivalent levels of GDP can be calculated.

PRICE SPECIFICATION

Computationally, the tax rate levied on a barrel of Saudi light crude, f.o.b. (free on board) Ras Tanura, is the base price for crude oil, with production costs and markup added to yield final price. The endogenous mechanism represents the tightness of the market (as measured by capacity utilization in the Middle East) and the decline rate. It is assumed that 90% is the normal and desired capacity utilization rate. Adjustments occur due to deviations from that figure. The higher the capacity utilization goes over 90%, the greater is the price increase, and vice versa. The model is designed so that different curves of responsiveness can be tested. The decline rate of reserves is taken into account to allow an estimation of depletion impacts over the longer run.

THE EFFECTS OF ALTERNATIVE PRICE PATHS

To understand the overall adjustments that can (and must) take place as prices change (or that result in changing prices) we have examined four alternative cases. These are essentially price-related scenarios:

- *Reference* case, which assumes a gently increasing price into the foreseeable future, is calibrated to price estimates from the U.S. Department of Energy (issued in July 1981). This scenario is based on the premise that OPEC is able to implement something roughly akin to the OPEC long-term strategy, which called for maintenance of constant oil prices in the face of inflation (and currency fluctuations, which are not covered in this model), plus real price growth according to the economic growth in OECD.
- *Radical price* case, which assumes a rapidly increasing price (from 5% to 7%) into the foreseeable future. This is based on the assumption that OPEC is able to force the real price up almost continually at a rapid pace, as the more radical members would like.

- *Ratchet price* case, which assumes high price increases followed by periods of declining prices, as we saw in the early 1970s and appear to be experiencing now. The premise is that short-term conditions give high price increases to OPEC, but they are unable to maintain them completely over the long-term due to market pressures.
- *Market price* case, which computes price endogenously, based on the level of capacity utilization in the Middle East, as described above.

Figure 5 presents the four price paths that form the basis of the scenarios examined in this analysis. Note path D, which represents the endogenous price path. This path shows a slight decline in prices by the end of the 1970s and a subsequent flattening in real terms followed by a gradual increase. This increase is due to the market tightening that occurs concurrently. The market price tracks the real prices fairly well in the early 1970s but undershoots for the following years to 1982. Thus the IPE model seems to underestimate slightly the shocks in the market. Nonetheless, it does show a leveling off in prices that is entirely consistent with the adjustments we have seen late in the 1970s and in the first two years of the 1980s.

Figure 6 shows the IPE model's projections for U.S. oil demand to 2000. The obvious trend is that a radical price path would force U.S. demand down even further than it has been so far. Such a price, however, must be sustained by production cuts (evidenced in Figure 9) to generate the market tightness required to keep this trend in demand consonant with the price path. The U.S. demand generated by market conditions associated with the endogenous price case is among the highest of the demand paths for the latter years of this decade and the early to mid-1970s. With this path comes an OPEC production that essentially meets this demand (Figure 9). This dual adjustment occurs because of the market-induced prices in the 1970s, which led to a softening market by the early 1980s, and hence a leveling of prices and an attendant growth in demand. OPEC countries of the Middle East, responding to this demand path, increase production accordingly. The ratchet price (set exogenously) forces the demand for oil downward and, with appropriate lags, OPEC's production as well. Since the market cannot sustain a downward spiraling of demand—alternatives not being sufficiently developed to absorb all the demand for oil—the upward pressures on demand enable (or require) OPEC to increase its production. In none of these scenarios, however, do we endow OPEC production with independent intelligence to impose production cuts at will. (This can be done at the discretion of the analyst.)

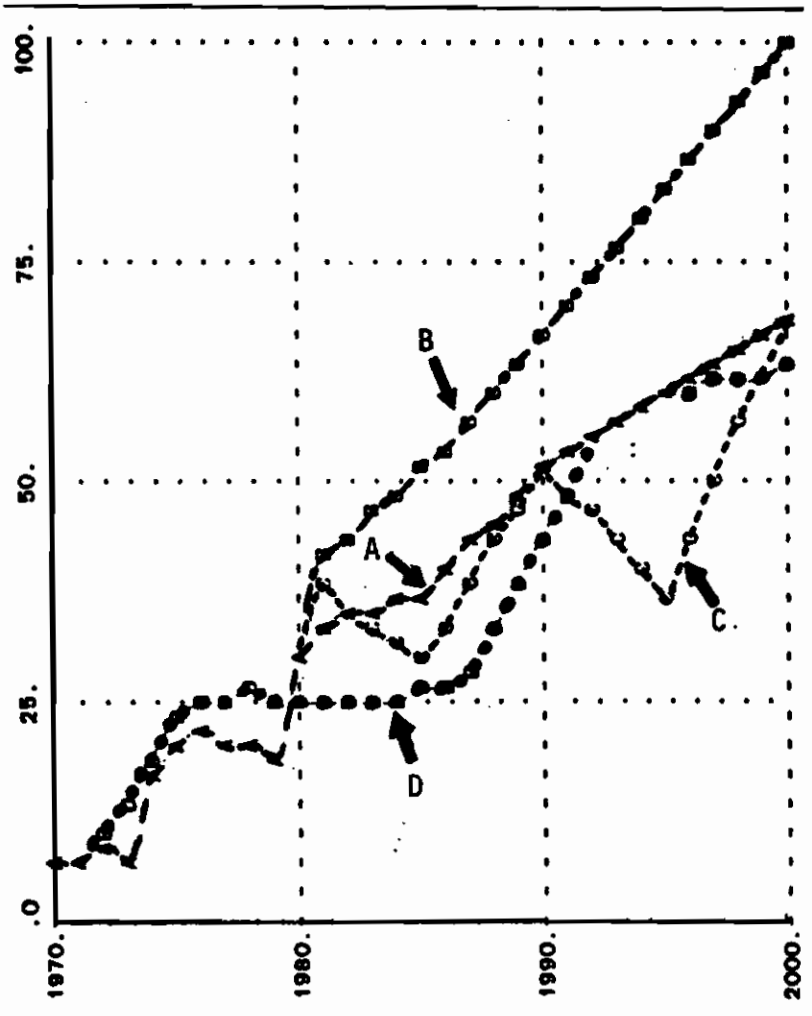

Figure 5: Price of Saudi Light (1980 dollars)

Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

Demand from the OECD countries (excluding the United States), presented in Figure 7, follows the same type of responses as in the U.S. case, with differences in magnitudes and phasing. These are due to differences in domestic production capabilities on the one hand and

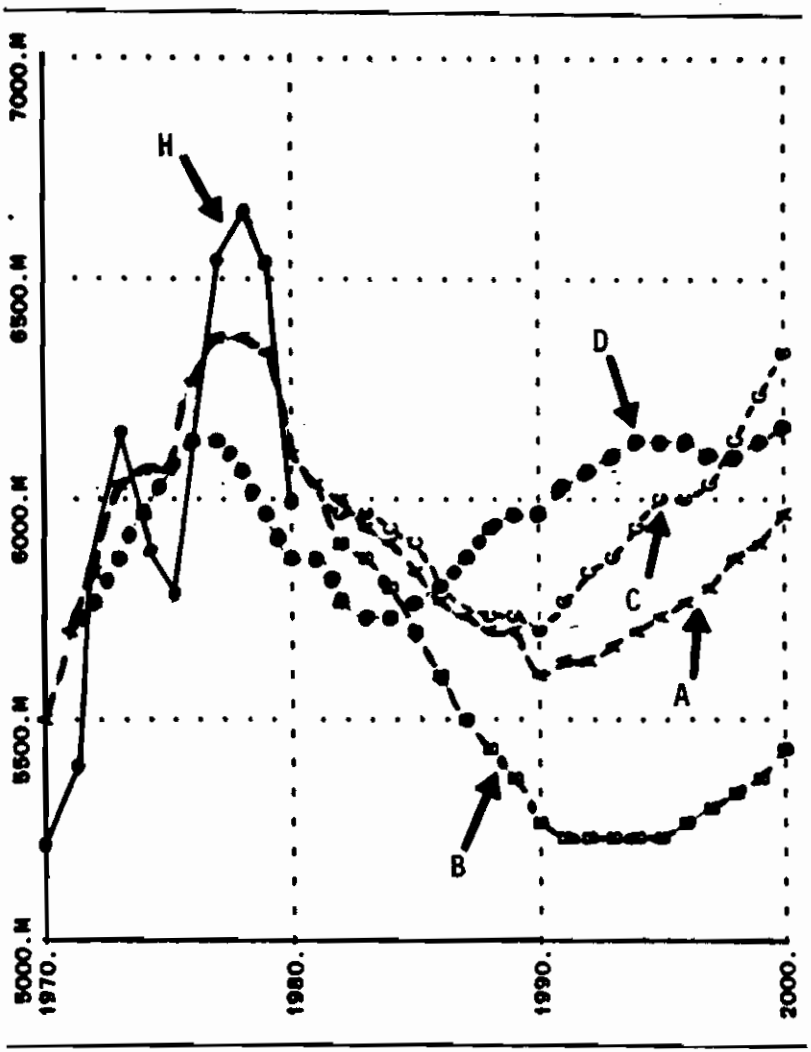

Figure 6: U.S. Oil Demand (million barrels)

Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

demand requirements on the other. Figure 8 shows the time paths for demand from non-OPEC Third World countries. The message is clear: Under all circumstances demand for oil will continue to grow. This is due to the fact of economic growth, despite the burdens imposed by the prevailing price of oil.

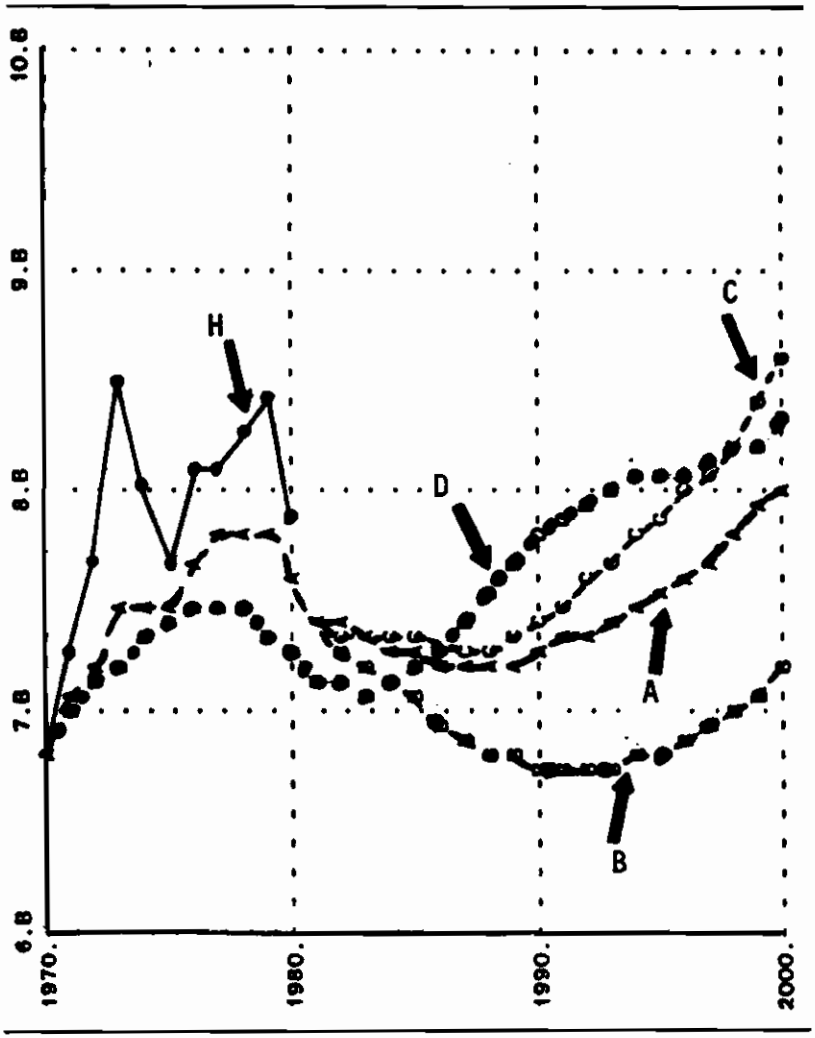

Figure 7: Non-U.S. OECD Demand (billion barrels)

Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

The responsiveness of OPEC Middle Eastern production to the demand of consumer countries (under alternative price and market conditions) is shown in Figure 9. Clearly a radical price path (set exogenously) results in lower production (due to the sharpness of consumer responses by cutting their own demand). This is the scenario

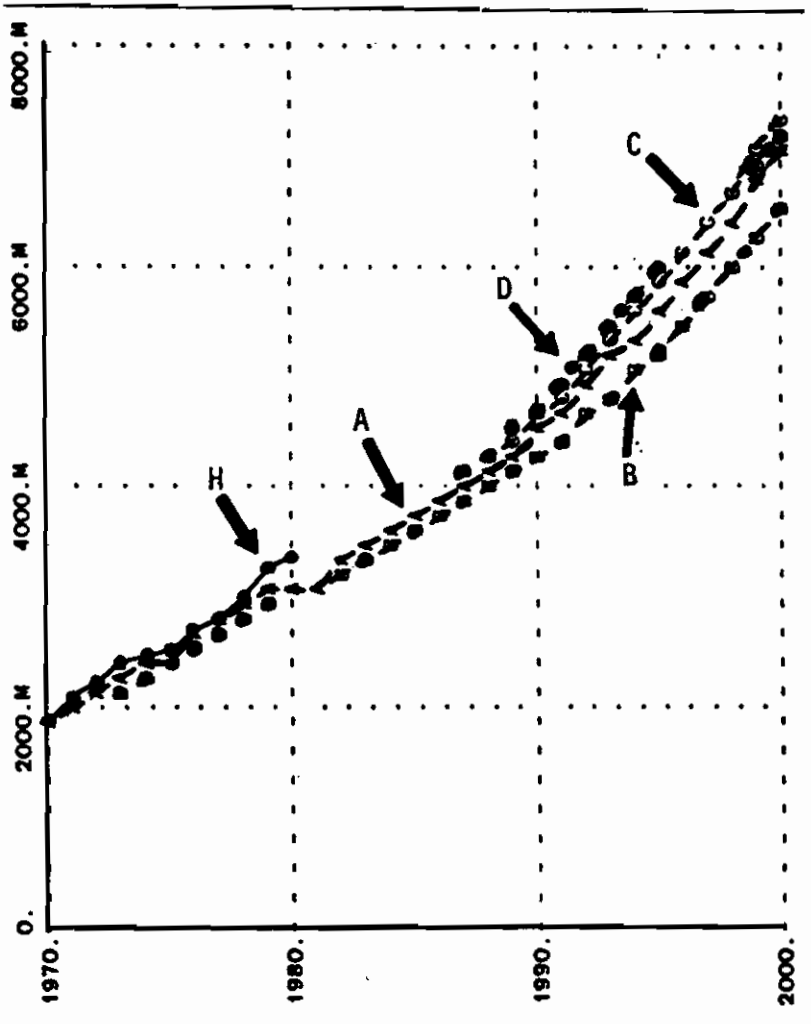

Figure 8: Non-OPEC Third World Demand (million barrels)

Key; A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

that preserves OPEC resources most assuredly—at least relative to the other cases. The market-induced production (associated with a price set by market conditions at each point in time) is among the highest by the early 1990s.

The oil revenues of the OPEC countries of the Middle East, presented in Figure 10, show their sensitivity to oil prices and to the volume of

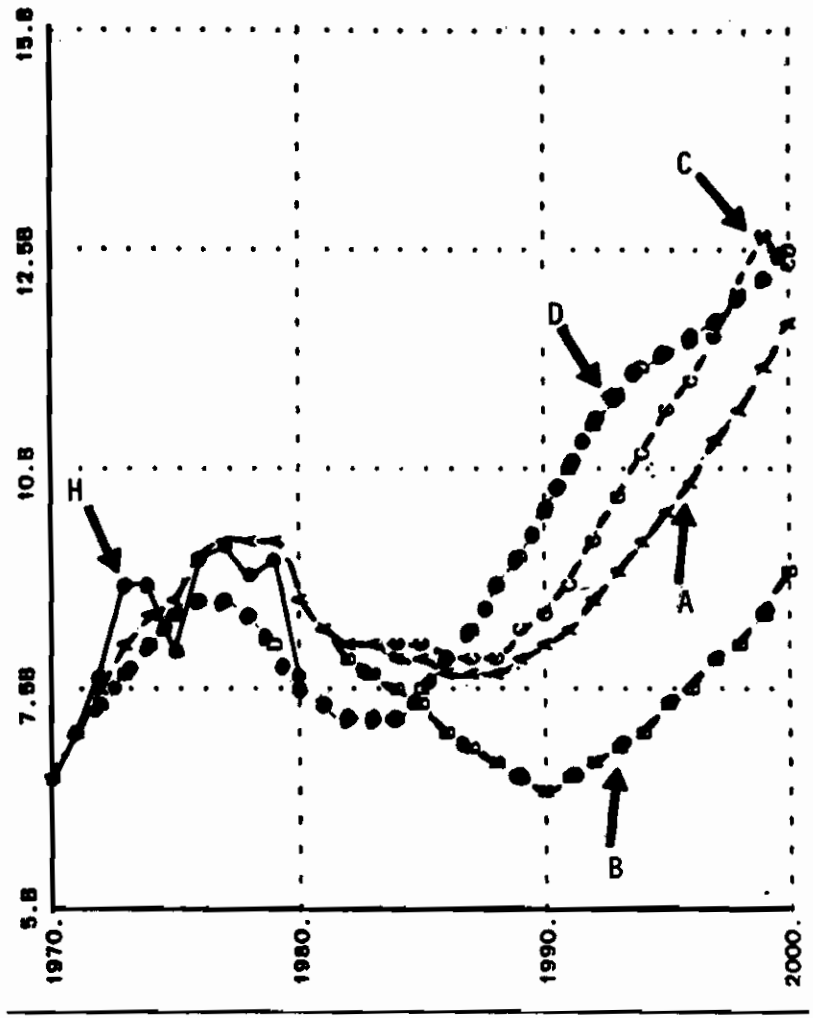

Figure 9: Middle East OPEC Oil Production (billion barrels)
Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

exports. Radical prices—if indeed such prices are allowed to persist by market conditions—would generate the greatest income for them. The income stream associated with the endogenous price path increases sharply late in the decade of the 1980s, following years of decline and leveling off. The trend in the late 1970s is due to decline in the volume of oil traded; subsequently it is due to the conjunction of this effect plus

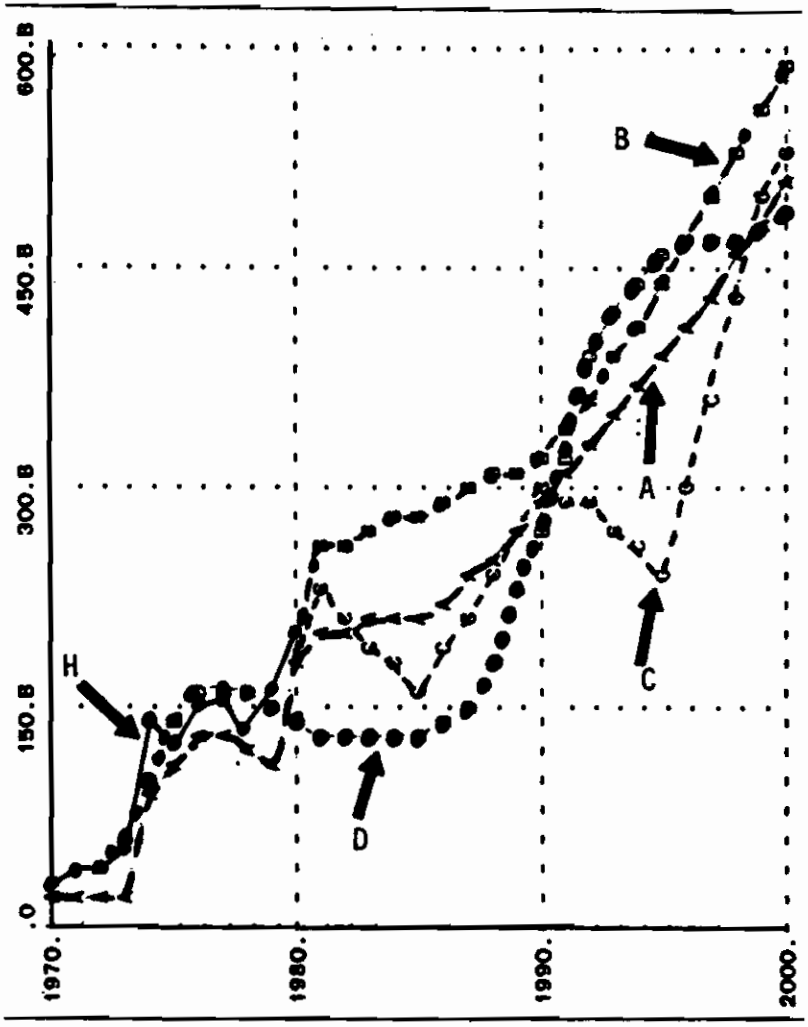

Figure 10: Middle East OPEC Oil Income (billion 1980 dollars)

Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

the declines in price of the early 1980s. (These price declines are too small to appear clearly in Figure 5, where they are depicted as leveled).

The consumer-side exchanges are illustrated in Figure 11, which presents the OECD oil import expenditures, that is, payments for oil imports. These payments reflect both the amount paid per barrel of oil imported at any point in time *and* the volume of oil imported. In the ratchet case the price is highest, but the volume of imports is the

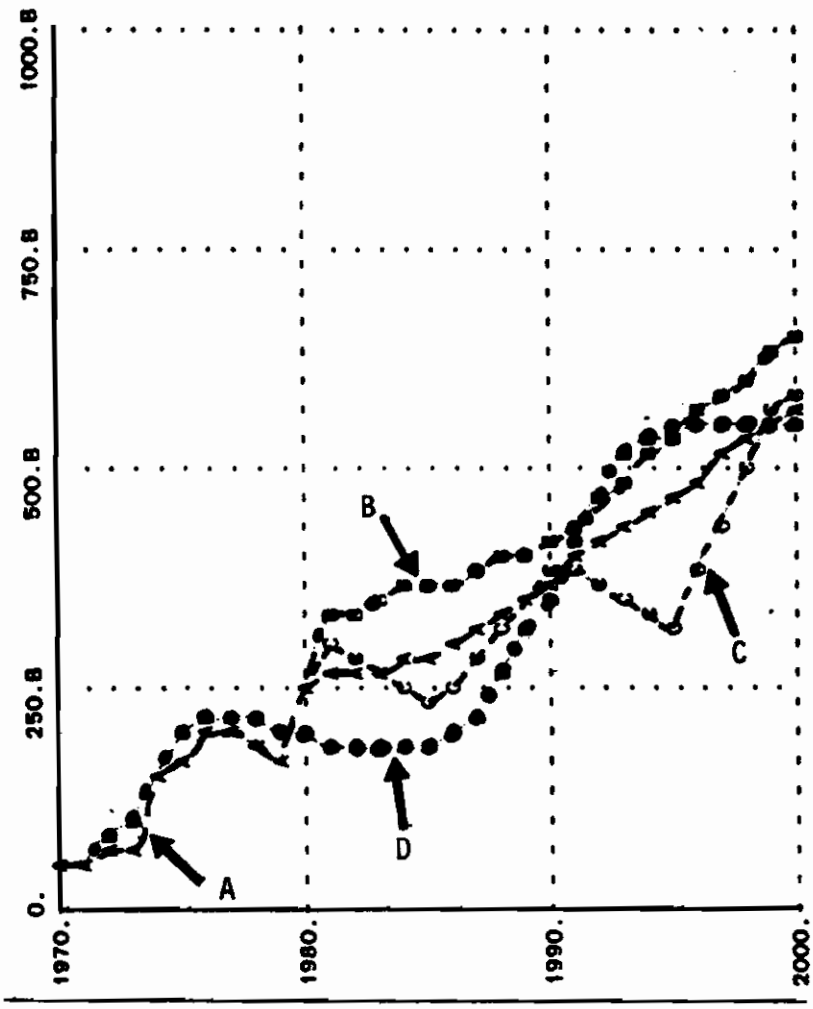

Figure 11: OECD Oil Import Expenditures (billion 1980 dollars)
Key: A = reference case; B = radical price; C = ratchet price; D = endogenous price; H = historical data.

smallest; combined effects result in a high import bill relative to the other cases. The message in Figure 11, however, is that regardless of the price path at hand, the consumer would be increasing costs associated with oil imports—in some cases because of the price, in others because of the volume of imports. The market price path (labeled as the endogenous price case) shows the oil bill declining slightly in the early 1980s. leveling off, and then increasing sharply to the mid-1990s. The

increase in payments shows the effects of greater imports associated with more modest prices (relative to the radical and the reference cases). Thus price moderation encourages consumer imports and, by extension, expands the size of the import bill. By contrast, higher prices simply depress demand and hence the propensity for imports.

CONCLUSION

This article has summarized the major characteristics of a model of the world oil market and of the economic and (to some extent) political attributes of that market. Politics is embedded in the capabilities of the actors and in the relationship among them. The IPE model depicts both structure and processes of the world oil market.

The simulations and projections presented for illustrative purposes show how the market responds to alternative price paths, and the attendant effects for producers, consumers, and international oil companies. These projections were made to indicate the capabilities of the IPE model and its contribution to our thinking about future changes in the international system. Elsewhere I have presented the most recent forecasts generated by the IPE model (Choucri, forthcoming). I expect the demand for oil from advanced countries to decline slightly further by the middle of this decade and then to pick up somewhat before growing by the mid-1990s. I do not expect the trends evident in the early 1980s to persist—in a continued downward trend in demand over the long run—some upward adjustments will occur.

Production from OPEC countries has declined in the 1980s relative to the 1970s. I expect a further, slight decline, followed by upward trends in output. These projections are contingent, of course, on the rate of economic growth assumed in both industrial and developing countries. The assessments summarized here are robust: Some stiffening of prices is expected as well. At this writing, there is already some evidence that the price declines of the early months of 1982 have been arrested, with some tendency toward stiffening of prices. The IPE model forecasts a substantial growth in prices by the end of this decade. Thus the short respite consumers have seen early in 1980s is not likely to persist. The future will show new pressures.

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