ENERGY LABORATORY

MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

CARTEL BEHAVIOR AND EXHAUSTIBLE RESOURCE SUPPLY: A CASE STUDY OF THE WORLD OIL MARKET

(NSF Grant No. DAR 78-19044)

Technical Report No. MIT-EL 82-012

PROJECT SUMMARY

The M.I.T. World Oil Project has been developing forecasting methods that integrate the following considerations which influence investment in oil capacity and the level of oil exports: (1) the geology and microeconomics of exploration and production; and (2) macroeconomic and financial effects of oil investment and export sales. The effort is a continuation of previous NSF-sponsored research on the world oil market. Simplified methods of disaggregated analysis of oil exploration and production are being developed, and a country-level model of oil finance has been formulated and tested. This research has proceeded sufficiently well that it appears possible to merge the two into a unified analysis.

This research will contribute to our understanding of oil supply from critical regions of the world; it also should lead to better supply analysis for inclusion in the oil system models maintained by U.S. government agencies, university research and non-profit groups, and private industries.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Project History

The World Oil Project is being conducted by the M.I.T. Energy Laboratory in association with the Sloan School of Management and the Department of Economics. Started in the summer of 1973, the project received support from the National Science Foundation beginning March 1, 1975. The original proposal on "Analysis of the World Oil Market" was for a three-year effort, and the initial NSF funding was for eighteen months: March 1, 1975 to August 31, 1976 (NSF Grant No. SIA75-00739). Subsequently, a continuation proposal was approved, providing a budget for the period September 1, 1976 through February 28, 1978. NSF support was received for the period July 1, 1978 through June 30, 1980 under a project entitled, "Cartel Behavior and Exhaustible Resource Supply: A Case Study of the World Oil Market" (NSF Grant No. DAR78-19044). The current project is an extension of this latter grant for the period of July 1, 1980 through June 30, 1982. Appendix B lists (with abstracts) the publications and working papers from this NSF-sponsored activity over the period March 1975 through December 1981.

This current project is to perform further research on world oil issues. Much has been accomplished under NSF support for this work; yet important research remains to be done, both to improve the analytical apparatus and data resources already developed, and to extend the analysis to new areas. The research here concentrates on world oil supply, and on the development of more adequate methods for forecasting the decisions of key exporters regarding capacity creation and oil production and export.

The work has been led by two co-principal investigators:

M.A. Adelman--Professor of Economics

Henry D. Jacoby--Professor of Management and Director of the Program on International Energy Studies, M.I.T. Energy Laboratory

Over the course of the project several other faculty and M.I.T. staff have contributed. Also, students have played a significant role in the research; during the period covered by this report, approximately six graduate students either have been employed as research assistants, for periods ranging from a semester to the duration of the project, or have written graduate theses on topics associated with the project.

1.2 Recapitulation of Research Objectives

U.S. energy policies are strongly affected by developments in world oil supply and demand, and by movements in the oil price. Events in this market play a dominant role in the consideration of measures to stimulate domestic supply or encourage conservation, and in discussions of oil and natural gas price controls, energy taxation, tariffs and quotas, and the national program of energy R&D and commercialization. Expected market structure and supply patterns also impinge on national security and influence the design and management of crude oil stockpiles, oil sharing agreements, and emergency demand control measures.

The objective of the M.I.T. World Oil Project is to develop improved methods and data--and a better understanding of the characteristics of this market--to aid in the analysis of likely developments over the next few decades. The oil market presents a continually developing challenge to understanding and analysis. Prices and contractual agreements have

undergone radical change in the past few years. The potential capacity for oil production in key areas of the world, and the motivation of governments to produce it, is a matter of considerable uncertainty and dispute. In the future, additional shocks to the system are likely.

From the outset, the Project has been designed to develop models, supporting data bases, and related analysis to assist policy makers and the public as they make decisions in this area. Examples of the types of analysis our work is intended to support include:

- Analysis of the future level and structure of world demand for energy in general, and for oil in particular.
- Analysis of the supply of oil, taking account of geologic potential, cost and problems of access, and government policy.
- Study of the likely future course of the world oil price.
- Research on the effect of oil investment and export decisions on the macroeconomics and finance of producer countries, and of the likely implications for oil capacity creation and total production and export.
- Study of market structure and trade patterns in oil, and the associated implications for national security, international relations, and the oil revenues and foreign balances of key producer states.
- Analysis of international financial and economic growth problems that may be created by changes in oil price and volume.

The intent has been that the models, data, and associated studies developed by the Project be incorporated into the work of government agencies and private groups who are concerned with this market. In addition to the publications and working papers disseminated, methods for achieving this result are discussed in Section 3 below.

2. SUMMARY AND REVIEW OF WORK TO DATE

During the course of this grant we have performed research on a variety of related tasks as outlined in our proposal, and as amended by our letter of May 8, 1980. These tasks are:

Task 1 Supply Model Development

- Subtask 1.1 Integration of Supply Models
- Subtask 1.2 Improved Data Methods

Task 2 Integration of Supply Model and Financial Analysis

- Subtask 2.1 Country Macrofinancial Model Development
- Subtask 2.2 Linkage of Oil Production and Macrofinancial Models

This section describes the results achieved under each task. Most of the effort through December 1981 has been in Subtask 1.1. The text includes citations to the publications and working papers produced during the period of this grant; they are listed in Appendix A.

Task 1 Supply Model Development

Subtask 1.1 Integration of Supply Models

This task involves the linking together of "exploration-discovery" and "production" models into an integrated framework of supply analysis. This development will be a major step beyond the present production model [11],* which presumes homogeneity of costs in any producing region--both across fields and through time. Based on the recent work on field disaggregation, we believe the present production model can be extended to incorporate development cost relationships which are sensitive to the scale of the production unit. The revised model will include additional

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*Numbers in brackets refer to project publications and working papers which are listed, with abstracts, in Appendix A.

parameters which measure this sensitivity. Estimated values of the model parameters can be obtained from cross-sectional analysis of differences in unit costs among regions of varying deposit size. Many of these data are currently in hand, though some new work is needed, as discussed in Subtask 1.2.

A second addition which the "discovery" model will bring to our current oil supply analysis is the explicit drawdown of "proved" reserves from the estimated inventory of "ultimate" reserves. Our present production model subsumes much exploration and discovery activity, and all development, into an aggregate variable which is solely a function of drilling. However, the disaggregated analysis of "discovery" described above will permit specification of likely sequential distribution of field discoveries over time, by size, as a function of exploratory drilling and investment. From these discovered reserves, our current production model can be used to simulate the process by which proved reserves and production capacity are built up and drawn down.

Adapting these two models to work together will require considerable research and analysis. The steps in the process include the following:

(1) The output of the new, simplified discovery model is a sequence of <u>mean</u> field sizes as a function of exploratory drilling effort. For each increment of exploratory effort, however, these means really summarize an underlying distribution of respective field sizes. Moreover, these distributions change systematically as exploratory effort proceeds, conditional on previous discoveries. We will test alternative methods for approximating the partial expectations of discovery size, given an underlying analysis based on the means of size.

(2) Simulated mean discoveries (conditional on preceding finds) can be fed into the production model inventory for present or future development. Obviously, different simulated discovery sequences will have different implications for development effort, particularly for the price-taker. In turn, development efforts and the effect on the developable inventory must feed back into the exploration effort embodied in the discovery model. The principle (for price-takers) is very simple: equate cost at the intensive margin (development) and the extensive margin (discovery). But the simulated discovery sequence and feedback loops are complex relationships, and an algorithm must be developed to coordinate them.

(3) The production model itself must be adapted to work with proved reserves, by reservoir size. The details of the calculations must be coordinated with the efforts to develop better data on capacity, and capacity cost by reservoir size (see Subtask 1.2).

(4) Provision must be made to keep account of both production drilling efforts and drilling effort involved in the exploratory process. These two inputs are close but not complete substitutes.

(5) The investment cost data generated in the analysis must provide the needed inputs on oil sector investment for purposes of the macrofinancial analysis (see Task 2).

(6) The completed model must be calibrated and tested for two or three sample countries.

The fully integrated supply framework should significantly enhance the usefulness of present models, because the response of future supplies

to fluctuations in economic variables (e.g., expected prices and costs) will be treated explicitly, and the dynamic influence of resource depletion will be taken into account as the supply projections are extended into the future. Also, the new framework will give improved estimates of investment requirements, and their distribution over time, for financial analysis.

Most of Step (1) and part of Step (2) have been completed and are in a draft working paper entitled "Regional Modeling of Oil Supply" by James L. Smith. Parts of Steps (2), (3) and (4) have also been completed and are in a draft working paper entitled "Investment Theory and the Development of Exhaustible Resources" by James L. Paddock. Parts of Steps (3), (4) and (5) are related to work under Subtask 1.2 as discussed below.

Two working papers were proposed under this subtask and both are in process as described above.

Subtask 1.2 Improved Data Methods

The main focus of this subtask is the development of concepts and methods which will allow more accurate analysis and measurement of capacity, drilling and costs. Based on this development, a very limited estimation of parameters would be undertaken. The purpose is to support the combined "exploration-production" framework described under Subtask 1.1 above.

Two working papers report the progress of this work. "The M.I.T. World Oil Model: Documentation and Use" by J. Carson, W. Christian and G. Ward [13] presents a summary of the concepts and methods used in the World Oil Models. "The Aggregate Supply Model: Documentation and Use"

by G. Ward [15] presents a detailed discussion of the supply model methodology, data update and parameter estimation. The data work and empirical estimation in this paper was funded by the U.S. Department of Energy under a separate contract No. EX-76-A-01-2295 since our NSF grant did not provide for actual empirical work. The results of this work will then be used in the model integration development work discussed above in Subtask 1.1.

Finally, to aid in completing the data analytic portions of Steps (2), (3), (4) and (5) in Subtask 1.1 another separate contract, No. EX-76-A-01-2295, as extended, has been written jointly with the U.S. Department of Energy and the U.S. Geological Survey. This work is performing empirical estimations of cost and capacity parameters.

These improved data methods, and the updated empirical estimates, have been incorporated into the M.I.T. world oil simulation model, and have formed the basis for a series of presentations and papers by Jacoby and Paddock [3, 9, 14]. The updated supply model, with its interlinked set of analyses of demand and OPEC behavior, is used to define a universe of possible combinations of oil price and world economic conditions over the decade of the 1980s. The resulting "window" of not-unlikely oil prices is quite wide, stretching from $30 to $45 per barrel in 1990 (in 1980 prices), with a most likely value in the range $32 to $35 per barrel.

One working paper was proposed under this subtask. One publication and three working papers have been completed, as described above.

Task 2 Integration of Supply Model and Financial Analysis

Subtask 2.1 Country Macrofinancial Model Development

The main purpose of this task is to modify our existing country

financial model for linkage with the oil production model. The present structure of the financial model reflects well the general macro relationships in an oil-exporter's economy. The primary focus of this structure is the finance sector, including both domestic and foreign aspects. There are equations describing the money base and domestic credit supply, central bank activities, government budget financing, and international capital accounts. However, the flow of funds into and out of the oil sector are subsumed in the current level of aggregation, as is the effect of that sector on real output. Yet these are crucial elements of these countries' economies, and must be modeled explicitly to become subject to analysis.

As yet we have formulated only our approach to performing this work. Further work will follow the completion of Step (5) in Subtask 1.1 above.

Two working papers were proposed under this subtask and one is currently in process.

Subtask 2.2 Linkage of Oil production and Macrofinancial Models

The focus of this subtask is to develop initial approximations to a linkage mechanism for the two models described above in Subtasks 1.1 and 2.1. We have produced one working paper bearing on this subject. It is entitled "Financing Petroleum Development in Developing Countries" by T. Agmon, D. Lessard and J. Paddock [12]. Other portions of the work, however, await the completion of Subtasks 1.1, 1.2 and 2.1 above.

Two working papers were proposed under this subtask and one has been completed as described above.

3. DISSEMINATION OF RESULTS

We have been involved in various activities that were included in the utilization plan of our proposal. The publication of research results during the period of the current grant is shown in the two sections of Appendix A; these two sections are entitled "Publications" and "Working Papers" respectively. Appendix B presents all of the publications and working papers resulting from this NSF project since its inception in March 1975. Appendix C presents a list of meetings, testimony, speeches, and presentations by members of the Project over the period July 1980 through December 1981.

In addition, the MIT Center for Energy Policy Research sponsored two meetings on the world oil situation in November 1980 and May 1981. The substantive basis of data and analysis, and the organization and leadership of these conferences were provided by Adelman, Jacoby, and Paddock along with assistance from Project staff and students. All costs associated with the Conferences themselves were paid by the MIT Center for Energy Policy Research, a privately-funded entity of the M.I.T. Energy Laboratory. These meetings have provided us with extensive contact with a set of outside experts; and therefore we have substituted these activities for the Advisory Committee anticipated in the proposed Organization and Management Plan. These meetings have involved groups of 40 to 80 people. Most of the organizations associated with the Center for Energy Policy Research have participated; this group includes many U.S. and foreign industries, several natural gas and electric utilities, several public interest organizations, a U.S. labor union, and several agencies of foreign governments. In addition, the meetings have included representatives of the U.S. Departments of Energy, Treasury, and State;

the Council of Economic Advisers and the President's Inflation Adviser; the Office of Management and Budget; staff directors of Senate and House committees; officials from the Federal Reserve Bank and the International Monetary Fund; representatives from the banking and investment community; and scholars from other universities. Appendix D contains the schedules of these meetings and lists of the participants for these conferences.

APPENDIX A

Cartel Behavior and Exhaustible Resource Supply:
A Case Study of the World Oil Market
NSF Grant No. DAR78-19044

Publications and Working Papers for the Period
July 1980 through December 1981

PUBLICATIONS

1. Adelman, M.A., "The Clumsy Cartel", in Energy Journal, Vol. I, No. 1. January 1980. Originally distributed as Working Paper MIT-EL 79-036WP.

   The price explosions in the world oil market result from the tardy recognition of the post-1973 consumption slowdown. Such odd results could not happen in a competitive market, but they are not at all strange in the world cartel. Despite stagnant demand and forecasts that it will continue to grow at present rates, OPEC has raised the price toward the optimal, and cut back expansion plans. The cartel is becoming clumsy, however, in its attempt to control the market. Formerly, they set the price, and allocation of output was left to the oil companies. Today, main producing countries set production themselves, independent of consumer demand by type and location. This results in large discrepancies, triggers speculation, and subsequently exaggerates resulting price movements. The Saudis and their neighbors are fine-tuning a cartel with coarse instruments. Supply has to be kept tight despite panic, hoarding, and spot price gyrations, because the controllers fear to lose control. They will avoid the dangerous surplus of supply and so will keep prices under pressure.

2. Adelman, M.A., "Oil in the Eighties", Petroleum Economist, October, 1980.

   Demand will continue weak throughout. The OPEC countries will have considerable difficulty in deepening their cohesion, but the odds favor them.

3. Adelman, M.A., "Energy Markets in the 1980's with Special Attenion to Oil and How to Cope with Them: The Price of Energy with Special Attention to Oil, Ciclo De Conferencieas Sobre Economia, Energeticos Y Desarollo-Compendio, Three Lectures, Institute Mexicano del Petroleo, Mexico, D.E., October 28-30, 1980.

   A series of discussions on the world oil market issues of the 1980s. The focus is on the prospects for the price of oil. Suggestion are made for how various market participants should cope with these issues.

4. Adelman, M.A., "The Realities of the Energy Market, an Agenda for the 1980's: Decisions and Research", in International Energy Options: Agenda for 1980's, ed. Paul Tempest, Oelgeschlager, Gunne Hain Inc., Cambridge, MA, 1980.

   The higher energy prices of 1973 and of 1979 act like a glacial drift--imperceptible in the short run and irresistible in the long run--because they require long temr investment, which incidentally is a drag on productivity and economic growth. Relative to national incomes, energy consumption will keep declining for many years.

   Econometric supply analysis has, unlike demand, been unsuccessful. We have been unable to model the geological-investment interactions. And monopolized markets are intricate and even perverse. High prices and revenues support ever-higher prices.

   Economic research is much needed, and "I would trade all the prognostications about the next century for a little understanding of this decade."

5. Adelman, M.A., "Testimony Before U.S. Senate Committee on Banking, Housing and Urban Affiars", mimeograph, January 1981.

   The world oil market is one big pool, and special deals and special relationships are a harmful illusion. Prices may continue to trend upward, but they will be unstable in any case. Security will continue as a very serious problem, and only a stockpile can mitigate it.

6. Adelman, M.A. and G. Ward, "Estimation of Worldwide Production Costs for Oil and Gas", in J. Moroney (ed.), Advances in the Economics of Energy and Resources, Vol. III, J.A.I. Press, 1980. Originally distributed as Working Paper MIT-EL 79-058WP.

   This paper presents a methodology for estimating drilling and equipping costs of onshore and offshore wells using only the usual data available on such activities: rig time spent drilling and wells completed. The predominant technique used in estimating the various relationships was regression analysis, using less specific published articles and reports as checks.

   A method of incorporating non-drilling production costs such as overhead is also proposed. Finally the cost estimates are applied to obtain dollar requirements per daily barrel of production capacity for major oil producing areas.. Appendices included are: special problems associated with estimating offshore platform and pipeline costs; an examination of recent claims about Saudi Arabian production costs; North Sea production costs calculated using unusually detailed plublished information, and a rough check comparing our calculated production outlays with reported outlays.

7. Jacoby, H.D. and J.L. Paddock, "Supply Instability and Oil Market Behavior", in Energy Systems and Policy, Vol. 3, No. 4 (Winter 1980), pp. 401-423. Originally distributed as Working Paper MIT-EL-79-033WP.

   This paper analyzes the supply disruption in world oil markets in the winter of 1978-1979. The causes of the resultant price rise are explored in the context of spot market behavior and cartel core behavior. In particular, the economic and political roles of excess supply in the Persian Gulf nations are discussed, and conclusions for the likely future are presented. Finally, the implications of these conclusions for U.S. policy are discussed.

8. Jacoby, H.D. and J.L. Paddock, "Combining Analytical Models and Judgment in Oil Price Forecasts," Proceedings of the American Statistical Association, (Business and Economics Statistics Section), American Statistical Association, Washington, D.C., 1981.

A set of interlinked models of world oil supply, demand and market behavior is used to develop an analysis of future oil prices. In exercises of this type, results often involve single-line forecasts of price, perhaps with some range of values calculated with the use of alternative values of key parameters. In the case of the oil market, however, the uncertainty is so great that analytical models need to be used in a way that allows easy input of expert judgment and that fully reflects the range of possible outcomes.

This technique used here is to define a universe of possible combinations of oil price and world economic conditions over the decade of the 1980s, and then to use analytical models and judgment to define the set of points, G, that can be shown to be "unlikely" to occur. The complement of this set, G', then defines a "window" of oil price and growth patterns which are "not-unlikely," and this result is offered as a way of stating the existing level of knowledge, and ignorance, about likely future developments in oil markets.

9. Paddock, J.L., "World Oil Markets: MIT World Oil Project Outlook for the 1980s, " in Proceedings of the American Institute of Chemical Engineers National Meetings: 1980, AIChE, New York, 1980.

Various analytic approaches for forecasting world oil prices and economic growth yield "reference" or point estimates. This paper points out the futility of point forecasts due to the great uncertainties involved in exercises of this type. THE MIT World Oil Project Models are simulated to show the wide range of possible and consistent outcomes.

10. Smith, J.L. and G.L. Ward, "Maximum Likelihood Estimates of the Size Distribution of North Sea Oil Deposits", Proceedings of the American Statistical Association, August 1980, and forthcoming in Journal of the International Association of Mathematical Geologists, 1982.

Estimates of the ultimate resource potential of the North Sea petroleum province are derived from a probabilistic model of the discovery phenomenon. The discovery of individual deposits is treated as sampling without replacement from a target population (the underlying resource base), and with individual discovery probabilities defined in terms of deposit size. Conditional on the underlying resource base, the model specifies the likelihood of all possible sequences of discoveries. Conversely, upon observing a particular discovery sequence, it is possible to identify the underlying resource base that maximizes the likelihood of this event. The present paper examines the sensitivity of such resource estimates to the postulated form of the size distribution of deposts, and to the presumed degree of randomness inherent in the discovery process.

WORKING PAPERS

11. Adelman, M.A. and J.L. Paddock, "An Aggregate Model of Petroleum Production Capacity and Supply Forecasting", MIT-EL 79-005WP, Revised July 1980.

    This paper presents a complete discussion and documentation of the M.I.T. World Oil Project Aggregate Supply Model. First, the theoretical development and methodology are presented. The relationships between geologic and economic characteristics are analyzed and a system of equations representing the inertial process model are discussed. Next, the construction of the data base is described and the data, by country segment, is presented in detail. Methods of bridging the many gaps in the data are discussed. Finally, the simulation forecasts of the model are presented through 1990.

12. Agmon, T., D.R. Lessard and J.L. Paddock, "Financing Petroleum Development in Developing Countries", MIT-EL 81-059WP, September 1981.

    The importance of international finance in energy investment by developing countries is clear. Financing may be the dominant factor determining that investment when enterprises or governments are constrained in their financing options, and hence are unable to fully shift risks or match income and expenditure streams.

    This paper explores one important situation where financing constraints are likely to be binding--that of oil field development by capital-poor developing countries. Our primary analytic focus is those countries which, through foreign borrowing, have the potential to become significant net oil-exporters and for which oil represents a significant portion of their national wealth. We suggest financial instruments and policy interventions that may relax these constraints.

13. Carson, J., W. Christian, and G. Ward, "The MIT World Oil Model: Documentation and Use", MIT-EL 81-027WP, December 1981.

Description of the three separate models used by the World Oil Project. The demand model forecasts energy demand in the OECD countries and aggregates petroleum product demand with crude oil demands from the rest of the world, excluding planned economies. The supply model forecasts possible production scenarios for oil producers throughout the world. The integration model integrates demand and supply forecasts and allocates actual production to producers.

The paper reviews the estimation methodology and database used in constructing the models. The equations are described and the behavior summarized. Policy use of the model is described and limitations of the models are identified. Sample output is presented and the use of the simulation framework is described.

14. Jacoby, H.D. and J.L. Paddock, "World Oil Prices and Economic Growth in the 1980s", Working Paper MIT-EL-81-060WP, December 1981.

A set of interlinked models of world oil supply demand and market behavior is used to develop an analysis of future world oil prices and economic growth. In exercises of this type, results often involve single-line forecasts of price perhaps with some range of values calculated using alternative values of key parameters. In the case of the oil market, however, the uncertainty is so great than analytical models need to be applied in a way that allows easy input of expert judgment and that fully reflects the range of possible outcomes.

The technique used here is to define a universe of possible combinations of oil price and world economic conditions over the decade of the 1980s, and then to use analytical models and judgment to define the set of points, G, than can be shown to be unlikely to occur. The complement of this set, G', then defines a "window" of oil price and growth patterns which are not-unlikely. This result is offered as a way of stating the existing level of knowledge, and ignorance, about likely future developments in world oil markets.

15. Ward, G.L., "The Aggregate Supply Model: Documentation and Use," M.I.T. Energy Laboratory, Working Paper No. MIT-EL 81-038WP, June 1981.

This paper provides documentation of the Aggregate Supply Model, a computer-based model designed to forecast oil production capacity by producing region. The model is an inertial-process type model based on a few simplifying assumptions. These assumptions, plus key terms important for understanding the model, are described in this paper. Data requirements are identified and an example of results from a model simulation is presented. In addition, a technical description of both the model and the data is presented, along with a description of the computer code that implements the model.

APPENDIX B

Cartel Behavior and Exhaustible Resource Supply:
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NSF Grant No. DAR78-19044

Publications and Working Papers for the Period
March 1975 through December 1981

PUBLICATIONS

1. Adelman, M.A., "Constraints on the World Oil Monopoly Price," Resources and Energy, September 1978. A summary appears in Petroleum Economist, September 1977. Originally released as Working Paper MIT-EL 77-038WP, "Producers, Consumers, and Multinationals: Problems in Analyzing a Non-Competitive Market."

   The consuming nations have the power to damage or wreck the world oil monopoly, but prefer cooperation because of their fixed belief that otherwise the market will fail to clear and generate a "gap." Yet they may use the power inadvertently. The monopoly acts essentially as a loose cartel, with a safety net: a large seller (Saudi Arabia) would, if need be, act as the restrictor of last resort. But this would maximize Saudi profits at a much lower price, penalizing the other sellers. The conflict can be held off by ad hoc agreements while raising the price. But the risk of conflict and highly uncertain long run demand and supply make it likely that the cartel will only slowly and gradually approach profit- or wealth-maximization. "Political objectives" coincide with economic objectives and can be neglected.

2. Adelman, M.A., "World Supply and Demand", presented to the Canadian Society of Petroleum Geologists in Calgary, to be published by the CSPG in a Volume of 50th Anniversary Proceedings (forthcoming).

   The energy "gap" or "shortage" is logical nonsense. An oil "price break" upwards is possible, but unlikely. There is an interrelated system of demand; supply potential; monopoly control by the OPEC nations; effects of crude oil price changes on the world economy and on consumer-nations policies.

   Some preliminary results of the M.I.T. World Oil Project are summarized:

(1) slow consumption growth because of lower income growth, the delayed effects of higher prices in 1973-74, and future increases;

(2) complex effects on supply of higher oil prices which, depending on government action, may increase or decrease investment and capacity;

(3) excess capcity and also higher prices through the 1980's, unless the monopoly is destroyed;

(4) great uncertainty must itself be factored into the policies of business and government.

3. Adelman, M.A., "Energy-Income Coefficients: Their Use and Abuse," in Energy Economics, January 1980. Originally distributed as Working Paper MIT-EL 79-024WP.

The right way to estimate and forecast energy demand is to break consumption into rational subgroups, each analyzed to separate out effects of income, price, technology, etc. Two widely quoted relations between aggregate energy consumption and national income are used as a check on such an estimate: the average energy-income coefficient and the incremental energy-income coefficient. The averge coefficient is a valid if imprecise measure, but the incremental coefficient should not be used at all; it mixes up four elements. These four are: the consumption-income relationship, the consumption-price relationship, the time needed to adjust to price change, and the rate of economic growth.

4. Adelman, M.A., "The Clumsy Cartel", in Energy Journal, Vol. 1, No. 1, January 1980. Originally distributed as Working Paper MIT-EL 79-036WP.

The price explosions in the world oil market result from the tardy recognition of the post-1973 consumption slowdown. Such odd results could not happen in a competitive market, but they are not at all strange in the world cartel. Despite stagnant demand and forecasts that it will continue to grow at present rates, OPEC has raised the price toward the optimal, and cut back expansion plans. The cartel is becoming clumsy, however, in its attempt to control the market. Formerly, they set the price, and allocation of output was left to the oil companies. Today, main producing countries set production themselves, independent of consumer demand by type and location. This results in large discrepancies, triggers speculation, and subsequently exaggerates resulting price movements. The Saudis and their neighbors are fine-tuning a cartel with coarse

instruments. Supply has to be kept tight despite panic, hoarding, and spot price gyrations, because the controllers fear to lose control. They will avoid the dangerous surplus of supply and so will keep prices under pressure.

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Demand will continue weak throughout. The OPEC countries will have considerable difficulty in deepening their cohesion, but the odds favor them.

6. Adelman, M.A., "Energy Markets in the 1980's with Special Attenion to Oil and How to Cope with Them: The Price of Energy with Special Attention to Oil, Ciclo De Conferencieas Sobre Economia, Energeticos Y Desarollo-Compendio, Three Lectures, Institute Mexicano del Petroleo, Mexico, D.E., October 28-30, 1980.

A series of discussions on the world oil market issues of the 1980s. The focus is on the prospects for the price of oil. Suggestion are made for how various market participants should cope with these issues.

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Econometric supply analysis has, unlike demand, been uncsuccessful. We have been unable to model the geological-investment interactions. And monopolized markets are intricate and even perverse. High prices and revenues support ever-higher prices.

Economic reasearch is much needed, and "I would trade all the prognostications about the next century for a little understanding of this decade."

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   The world oil market is one big pool, and special deals and special relationships are a harmful illusion. Prices may continue to trend upward, but they will be unstable in any case. Security will continue as a very serious problem, and only a stockpile can mitigate it.

9. Adelman, M.A., and H.D. Jacoby, "Alternative Methods of Oil Supply Forecasting", in R.S. Pindyck (ed.), Advances in the Economics of Energy and Resources, Vol. II, J.A.I. Press, 1979. Originally distributed as Working Paper MIT-EL 77-023WP.

   Analysis of likely developments in the world oil market is ultimately dependent on some method of forecasting oil supply from key regions. Unfortunately, data problems tend to dominate work in this area, and much of the analysis task reduces to making the best use of the limited information that is available. Here we report on two alternative approaches to this forecasting problem, both avowedly data-oriented.

   Petroleum exporters need to be grouped into two rough categories. First, there are what we call price-taker suppliers. Second, there is the "cartel core" -- a small group of nations who are the price-makers. Their groupings are not hard and fast; indeed an exporter would change from one to another camp.

   In this paper our focus is on the price-takers. Our analysis seeks an understanding of the fundamental market forces, and to provide estimates of supply functions for price-taker suppliers and demand functions for importers. These functions are to be incorporated into a simulation model of overall market performance.

10. Adelman, M.A. and G. Ward, "Estimation of Worldwide, Producton Costs for Oil and Gas", in J. Moroney (ed.), Advances in the Economics of Energy and Resources, Vol. III, J.A.I. Press, 1980. Originally distributed as Working Paper MIT-EL 79-058WP.

    This paper presents a methodology for estimating drilling and equipping costs of onshore and offshore wells using only the usual data available on such activities: rig time spent drilling and wells completed. The predominant technique used in estimating the various relationships was regression analysis, using less specific published articles and reports as checks.

A method of incorporating non-drilling production costs such as overhead is also proposed. Finally the cost estimates are applied to obtain dollar requirements per daily barrel of production capacity for major oil producing areas. Appendices included are: special problems associated with estimating offshore platform and pipeline costs; an examination of recent claims about Saudi Arabian production costs; North Sea production costs calculated using unusually detailed published information, and a rough check comparing our calculated production outlays with reported outlays.

11. Agmon, T., D.R. Lessard, and J.L. Paddock, "Financial Markets and the Adjustment to Higher Oil Prices", in R.S. Pindyck (ed.), Advances in the Economics of Energy and Resources, Vol. I, J.A.I. Press, Greenwich, Conn., 1979. Originally distributed as Working Paper MIT-EL 77-039WP.

    This paper explores the linkages between the world energy and financial markets. The role of international financial markets in the adjustment of the real markets for energy is analyzed from both a conceptual and empirical viewpoint. Financial intermediation is found to be an important accommodation mechanism in the market-clearing behavior of price and quantity. Finally we look at the portfolio aspects of producers' "surplus funds," and the implications of stress for world financial markets.

12. Agmon, T., D.R. Lessard and J.L. Paddock, "Financing Petroleum Development in Developing Countries", MIT-EL 81-059WP, September 1981.

    The importance of international finance in energy investment by developing countries is clear. Financing may be the dominant factor determining that investment when enterprises or governments are constrained in their financing options, and hence are unable to fully shift risks or match income and expenditure streams.

    This paper explores one important situation where financing constraints are likely to be binding--that of oil field development by capital-poor developing countries. Our primary analytic focus is those countries which, through foreign borrowing, have the potential to become significant net oil-exporters and for which oil represents a significant portion of their national wealth. We suggest financial instruments and policy interventions that may relax these constraints.

13. Cremer, J. and M.L. Weitzman, "OPEC and the Monopoly Price of World Oil", European Economic Review, Vol. 8, 1976, pp. 155-164. Originally distributed as Working Paper MIT-EL 76-015WP.

    This paper presents a dynamic model of the behavior of OPEC viewed as monopolist sharing the world oil market with a competitive sector. The main conclusion is that the recent increase in the price of oil was a once-and-for-all phenomenon due to the formation of the cartel. The model form used here indicates that real oil prices should remain approximately constant over the next twenty years.

14. Dailami, M. "Inflation, Dollar Depreciation, and OPEC's Purchasing Power", The Journal of Energy and Development, Spring 1979.

    The objective of this paper is to provide some empirical analysis of the impact of the dollar's fluctuation on OPEC's terms of trade over the period 1971-1977, and to assess to what extent the decline in OPEC's terms of trade, after the fourfold oil price increase of late 1973, can be attributed to the falling value of the dollar and to what extent to the high rates of inflation prevailing in the industrial countries. The study is divided: a theoretical analysis of OPEC's terms of trade (the model), the empirical results, and a brief summary with some significant conclusions.

15. Dailami, M. "Financial Influences on the Behavior of Oil Exporters", forthcoming Fall 1980 in Papers and Proceedings of the IAEE/RFF Conference on International Energy Issues: June 1979. Originally distributed as Working Paper MIT-EL 78-035WP.

    This paper discusses the influence of financial considerations on the oil production policies of oil-producing countries. Other factors include technology, politics, and conservation. This study, therefore, should be viewed as only a partial analysis of oil supply determination. However, it has become increasingly clear that the decisions of the oil-producing countries may be more heavily influenced by short-run financial considerations, such as their need for foreign financing, and their apprehension of the impact of changes in oil revenues on their domestic economies.

    After discussing these issues, this paper presents a macrofinancial model of Venezuela. This is a short-run simulation model with econometrically-estimated parameters. The model's structure captures the financial elements described above. The output of the simulation runs show the effects on balance of payments, foreign borrowing, oil production and revenues, and GNP of various exogenously-specified scenarios. Although this model is for Venezuela, it is essentially an open-economy Keynesian-type model which can be applied to other countries.

16. Eckbo, P.L., "A Basin Development Model of Oil Supply", in R.S. Pindyck, (ed.) Advances in the Economics of Energy and Resources, Vol. II, J.A.I. Press, Greenwich, Conn., 1979.

The paper describes a procedure for estimating the supply potential of a region given an exogenously specified time profile for exploratory drilling. The procedure involves analysis of exploration, development, and production of reservoirs. The Basin Development Model relies on a deterministic discovery decline relationship to generate an expected discovery sequence. This discovery decline relationship serves as a first approximation to the joint analysis of the exploration for plays and reservoirs inside a play. The reservoirs found enter into a reservoir model which takes account of costs and expected future prices, and allows detailed consideration of the tax regime. By separating exploration and finding activities from development and production activities, the Basin Development Model allows consideration of the two major aspects of resource depletion, the depletion of producible reservoirs from the population of reservoirs to be found, and the depletion of recoverable reserves from the existing population of producible reservoirs. The price elasticity of the level of ultimate recoverable reserves falls out of the interaction between the exploration and reservoir analysis as demonstrated in the paper.

17. Eckbo, P.L., "Planning and Regulation in the North Sea", Northern Offshore, No. 9, September 1976.

This article discusses the impact on North Sea exploration, production, and reserve levels of Norwegian Government block-allocation and tax policies.

18. Eckbo, P.L., The Future of World Oil, Ballinger Publishing Company, 1976. Originally distributed as Working Paper MIT-EL-017WP.

This paper describes a behavioral model of the international petroleum market and presents the results from it. The purpose of the study is to develop a framework for analysis of the implications of non-competitive behavior in the international petroleum market. The focus is on the market strategies that may be pursued by the world's oil exporters on a joint or an individual basis. The structure of the model is designed to combine features of formal modeling and of informal "story-telling" in a consistent framework. Such a structure requires a simulation type model.

The "stories" that are being told are constructed from cartel theory, from the empirical evidence on previous commodity cartels and from the special characteristics of the individual oil exporters. The model is evolutionary in the sense that each exporter is assumed to behave according to a set of decision rules which may reflect a competitive market structure, a monopolistic market structure or any combination of the two. Changes in the decisions rules being applied provides for the evolution of the market price. An attempt has been made to combine formal competitive and monopoly models with those of the informal story-telling approach.

19. Eckbo, P.L., H.D. Jacoby, and J.L. Smith, "Oil Supply Forecasting: A Disaggregated Process Approach," Bell Journal of Economics, Spring 1978. Originally distributed as Working Paper MIT-EL 77-001.

    Work is under way on a forecasting method that incorporates explicit representations of the steps in the oil supply process: exploration, reservoir development, and production. The discovery history of a region and other geological data are input to a statistical analysis of the exploratory process. The resulting estimate of the size distribution of new reservoirs is combined with an evaluation of reservoir economics--taking account of engineering cost, oil price, and taxes. The model produces a forecast of additions to the productive reserve base and of oil supply. Progress to date is demonstrated in an application to the North Sea.

20. Eckbo, P.L., and J.L. Smith, "Needed Exploration Activity Offshore Norway", Northern Offshore, August 1976.

    This article analyzes the linkages between North Sea Block allocations and their effect on future production. A statistical model is developed to explore the methodology by which Norway influences attainment of its target production rate by allocating blocks to producers.

21. Hnyilicza, E. and R.S. Pindyck, "Pricing Policies For A Two-Part Exhaustible Resource Cartel: The Case of OPEC", European Economic Review, Vol. 8, 1976, pp. 139-154. Originally distributed as Working Paper MIT-EL-76-008WP.

    This paper examines pricing policies for OPEC under the assumption that the cartel is composed of a block of spender countries with large cash needs and a block of saver countries with little immediate need for cash and a lower rate of discount. The decision problem for the two-part cartel is

embodied in a game-theoretic framework and the optimal bargaining solution is computed using results from the theory of cooperative games developed by Nash. The set of feasible bargaining points--and the corresponding Nash solution--is computed under two assumptions on the behavior of output shares: that they are subject to choice and that they are fixed at historical values. The results suggest that, for fixed output shares, there is little room for bargaining and the price path approximates the optimal monopoly price path. If the shares are subject to control, optimal paths depend significantly on the relative bargaining power of each block.

22. Jacoby, H.D., "M.I.T. World Oil Project", in K.C. Hoffman (ed.), Proceedings of the Workshop on World Oil Supply-Demand Analysis (June 1-2, 1977), Brookhaven National Laboratory, October 1978.

    A description of the structure of the project, methods being used, and problems of data and analysis.

23. Jacoby, H.D., "The Oil Price 'Ratchet' and U.S. Energy Policy", Kokusai Shigen (International Resources), Tokyo, Fall 1979.

    This is an analysis and interpretation of events in the world oil market during 1979. OPEC behavior is described in terms of a "ratchet" method of price administration, whereby capacity is held tight, spot prices surge upwards, and official contract prices follow thereafter. The implications for U.S. policy are discussed.

24. Jacoby, H.D. and J.L. Paddock, "Supply Instability and Oil Market Behavior," in International Energy Strategies, J. Dunkerley (ed.), Oelgeschlager, Gunn and Hain, Inc., Cambridge, MA, 1980.

    An analysis of the effect of supply disruptions on oil price behavior. The "price ratchet" effect is introduced and related to an analysis of OPEC oil production capacity.

25. Jacoby, H.D. and J.L. Paddock, "Supply Instability and Oil Market Behavior", in Energy Systems and Policy, Vol. 3, No. 4 (Winter 1980), pp. 401-423. Originally distributed as Working Paper MIT-EL-79-033WP.

    This paper analyzes the supply disruption in world oil markets in the winter of 1978-1979. The causes of the resultant price rise are explored in the context of spot market behavior and cartel core behavior. In particular, the economic and political roles of excess supply in the Persian Gulf nations are discussed, and conclusions for the likely future are presented. Finally, the implications of these conclusions for U.S. policy are discussed.

26. Jacoby, H.D. and J.L. Paddock, "Combining Analytical Models and Judgment in Oil Price Forecasts," Proceedings of the American Statistical Association, (Business and Economics Statistics Section), American Statistical Association, Washington, D.C., 1981.

    A set of interlinked models of world oil supply, demand and market behavior is used to develop an analysis of future oil prices. In exercises of this type, results often involve single-line forecasts of price, perhaps with some range of values calculated with the use of alternative values of key parameters. In the case of the oil market, however, the uncertainty is so great that analytical models need to be used in a way that allows easy input of expert judgment and that fully reflects the range of possible outcomes.

    This technique used here is to define a universe of possible combinations of oil price and world economic conditions over the decade of the 1980s, and then to use analytical models and judgment to define the set of points, G, that can be shown to be "unlikely" to occur. The complement of this set, G', then defines a "window" of oil price and growth patterns which are "not-unlikely," and this result is offered as a way of stating the existing level of knowledge, and ignorance, about likely future developments in oil markets.

27. O'Carroll, F. and J.S. Smith, "Probabilistic Methods for Estimting Undiscovered Petroleum Resources", forthcoming in J. Moroney (ed.) Advances in the Economics of Energy and Resources, Vol. III, J.A.I. Press, 1980. Originally distributed as Working Paper MIT-EL 80-008WP.

The problem studied in this paper is how to estimate and, if possible, set limits to the petroleum resources yet to be discovered in a partly explored area. The approach pursued uses data of the kind normally available in the public domain: historical sequences of fields discovered and their estimated recoverable reserves, and numbers of exploration wells drilled. No use is made of geological data or judgment.

Four models are constructed for detailed study, representing a range of levels of sophistication. The simplest model postulates only that discovery probabilities are proportional to field size, as indexed by millions of barrels of recoverable hydrocarbons. Greater sophistication is then added to obtain other models, by specifying a lognormal distribution of field size, a more general discovery probability law and a link between discovery rate and drilling activity. The performance of these models is examined using data for the Northern North Sea (56 - 62° North).

In some respects, different models and data lead to similar conclusions. All calculations agree that there are no more fields to be discovered in the two largest size-classes and that there are few if any undiscovered fields with recoverable reserves of 500 million barrels or above. They also agree that the majority of undiscovered fields are in the smallest class in the range considered (around 50 million barrels or less). With regard to the total volume of resources in undiscovered fields, however, different approaches give widely different results. The estimated total of hydrocarbon resources in the area, ranges from about 40 to 70 billion barrels of oil and oil equivalent, depending on the model. This is similar to the range of estimates available from various oil industry sources in recent years, using geological data and judgmental methods. These results show that even for a given model and data set, a range of uncertainty surrounds the estimates of total resources which is of the same order of magnitude as the estimate itself.

One lesson is that better results may be obtained with relatively simple models. More ambitious models attempt to improve precision by representing the underlying processes in greater detail. If, however, this representation is incorrect, the net result is to degrade rather than improve the quality of the results obtained.

28. Paddock, J.L., "MIT World Oil Project Outlook," in World Energy Outlook, proceedings of the St. Louis University International Business Conference, St. Louis, 1970.

An analytic forecast of possible combinations of oil prices and economic growth for the world through 1990. The MIT World Oil Project Models are simulated and the results presented.

29. Paddock, J.L., "World Oil Markets: MIT World Oil Project Outlook for the 1980s, " in Proceedings of the American Institute of Chemical Engineers National Meetings: 1980, AIChE, New York, 1980.

Various analytic approaches for forecasting world oil prices and economic growth yield "reference" or point estimates. This paper points out the futility of point forecasts due to the great uncertainties involved in exercises of this type. THE MIT World Oil Project Models are simulated to show the wide range of possible and consistent outcomes.

30. Pindyck, R.S., "Cartel Pricing and the Structure of the World Bauxite Market", March 1977, Bell Journal of Economics, Autumn 1977. Originally distributed as Working Paper MIT-EL 77-005WP.

A cartel is unstable if one or more of its members can earn higher revenues in the long run by undercutting the cartel price and expanding production. In this paper dynamic and static models of the world bauxite market are used to assess the stability of the International Bauxite Association, to suggest possible changes in its configuration, and to determine the likely impact of the cartel on the structure of the bauxite market and the future of bauxite prices.

31. Pindyck, R.S., "Gains to Producers from the Cartelization of Exhaustible Resources", The Review of Economics and Statistics, May 1978. Originally distributed as Working Paper MIT-EL 76-012WP.

The potential gains to produceres from the cartelization of the world petroleum, copper and bauxite markets are calculated under the assumption of optimal dynamic monopoly pricing of an exhaustible resource. Small quantitative models for the markets for each resource are developed that account for short-term resource are measured by calculating optimal price trajectories under competition and under cartelization, and comparing the sums of discounted profits resulting from each.

32. Pindyck, R.S., "OPEC's Threat to the West", Foreign Policy, Spring 1978. Originally distributed as Working Paper MIT-EL 78-001WP.

    This paper examines three important issues in international energy markets, and the implications for American energy and economic policy. First, the paper considers the likely pricing behavior of the OPEC cartel, and argues that OPEC is most likely to set the price of oil at the optimal level, i.e., the level that maximizes the sum of present and future discounted revenues. Some predictions regarding OPEC pricing are offered, and the implications for world energy markets are considered. We argue that the kind of crisis that has been of concern to the CIA, namely a major shortage of oil beginning around 1982, is extremely unlikely to occur, and instead we need to be more concerned with the possiblity of an embargo in the short term. Finally, the implications of higher energy prices for GNP growth, unemployment, and inflation in the industrialized countries is discussed. The paper concludes with a set of energy and economic policy recommendations.

33. Pindyck, R.S., "Optimal Exploration and Production of a Nonrenewable Resource", Journal of Political Economy, October 1978. Originally distributed as Working Paper MIT-EL 77-013WP.

    Most studies of nonrenewable resource production and pricing assume there is a fixed reserve base to be exploited over time, but in fact with economic incentives reserves can be increased. Here we treat the reserve base as the basis for production, and exploratory activity as the means of increasing or maintaining reserves. "Potential reserves" are unlimited, but as depletion ensues, given amounts of exploratory activity result in even smaller discoveries. Given these constraints, resource producers must simultaneously determine their optimal rates of exploratory activity and production. We solve this problem for competitive and monopolistic markets, and show that if the initial reserve endowment is small, the price profit will be U-shaped; at first production will increase as reserves are developed, and later production will decline as both exploratory activity and the discovery rate fall.

34. Pindyck, R.S., "Energy Demand and Energy Policy: What Have We Learned," presented at the International Scientific Forum on an Acceptable World Energy Future, Miami, Florida, November 30, 1978.

    This paper is a survey of about thirty recent econometric studies of energy demand, including the international study of world energy demand done under the M.I.T. World Oil Project. The paper argues that there is much more of a consensus than one might infer from a casual scanning of the recent statistical evidence.

Differences in elasticity estimates by various researchers can in large part be attributed to model structure and to the nature of the data used. We argue that there is no growing evidence that in the long term, price elasticities of demand are significantly larger than we had thought to be the case earlier. The paper also discusses the implications of this point for the formulation of energy policy.

35. Pindyck, R.S., "OPEC's Dilemma: How to Control Production Levels." This is an article that appeared in The Wall Street Journal, December 13, 1978.

    A layman's summary report of an OPEC pricing/production behavior model, focusing on price forecasts.

36. Pindyck, R.S., The Structure of World Energy Demand, M.I.T. Press, March 1979.

    This book provides a detailed description of the work done on world energy demand. The book begins with a discussion of the structure of energy demand, and then describes the specification of alternative demand models for each sector of energy use. Next, a number of methodological issues involved in the estimation of energy demand models are discussed in detial. Statistical results are presented for energy demand models pertaining to each sector of use. Finally, the book discusses the relationship between the price and demand for energy and economic growth, including the implications of our studies for the impact of higher energy prices on economic growth and employment.

37. Pindyck, R.S. "The Cartelization of World Commodity Markets", American Economic Review, May 1979.

    This paper discusses the likelihood of cartels spreading to other commodity markets.

38. Pindyck, R.S., "Interfuel Substitution and the Industrial Demand for Energy: An International Comparison", Review of Economics and Statistics, May 1979. Originally distributed as Working Paper MIT-EL 77-026WP.

    This paper describes the specification and estimation of some alternative models of energy demand for the industrial sectors of a number of industrialized countries. All of the models are based on a two-stage determination of energy expenditures. The first stage of each model determines the fraction of the cost of production allocated to energy, as opposed to other factor inputs such as capital and labor. In the second stage, energy expenditures are allocated to different fuels.

    The most promising results came from the use of a two-stage translog cost function as a description of the production process. The advantage of this translog function is that it is a general approximation to any cost function, and therefore does not a priori impose constraints of homotheticity, or separability on the structure of production. These functions were estimated using pooled data for 10 countries. Other models, including static and dynamic logic models, were also tested. Results from this study seem to indicate that price elasticities for industrial energy demand are larger than had been thought earlier, and that in the long run there may be substitutability between energy and capital. The own price elasticity for total industrial energy demand was estimated to be about -0.8.

39. Pindyck, R.S., "Some Long-Term Problems in OPEC Oil Pricing", in Journal of Energy and Development, Spring 1979. Originally distributed as Working Paper MIT-EL-78-028WP.

    This paper deals with two long term issues in OPEC oil pricing. First, to what extent can a changing allocation of production cutbacks, in which a growing burden is placed on Saudi Arabia and a few other countries while other cartel members behave essentially as price takers, tend to erode the monopoly price over the next twenty years? Second, to what extent would the emergence of Mexico as a significant producer of oil reduce the monopoly power of the cartel and reduce the cartel price? Both of these questions are dealt with using our small monopolistic model of optimal cartel pricing.

40. Pindyck, R.S., "The Characteristics of the Demand for Energy", in John Sawhill (ed.), Energy Conservation and Public Policy, Prentice-Hall, 1979.

This paper discusses the characteristics of energy demand, and the likely impact of changing energy prices on aggregate energy demand and the demands for individual fuels. The paper also provides a survey of statistical studies of energy demand elasticities done over the last few years.

41. Pindyck, R.S., "International Comparisons of the Residential Demand for Energy", in European Economic Review, January, 1980. Originally distributed as Working Paper MIT-EL 77-027WP which is an updated version of MIT-EL 76-923WP.

This paper describes alternative models of energy demand in the residential sectors of a number of industrial countries. The models are based on a two-stage determination of energy expenditures. The first stage of each model determines what fraction of consumers' total budgets will be spent on energy, as opposed to such other consumption categories as food, clothing, etc. In the second stage, energy expenditures are allocated to alternative fuels.

The most promising results came from the use of a two stage indirect translog utility function. the advantage of the translog function is that it is a general approximation to any utility function and therefore does not a priori impose constraints of homotheticity, separability, or additivity on the structure of demand. These functions were estimted using pooled data for nine countries. Other models, including the logit model, were also tested. Results from this study seem to indicate that price elasticities for energy demand are larger than had been thought earlier. The own price elasticity for total energy demand was estimated to be about -.9.

42. Smith, J.L. "A Probabilistic Model of Oil Discovery", forthcoming in Review of Economics and Statistics, Fall 1980. Originally distributed as Working Paper MIT-EL 80-005WP.

This paper presents a discovery model based on the notion that individual reservoirs are discovered randomly, with probability proportional to reservoir size. Our model is an adaptation of Kaufman's original formulation of this problem. The changes we propose are motivated by the need for less computational demands during implementation and reduced sensitivity to data errors which are inherent in reported reserve volumes. The resulting model is applied to the North Sea petroleum province.

Estimates of the total volume of remaining reserves and the size of individual deposits are obtained and compared to estimates provided by the industry. The method of analysis presented here appears to perform well, and constitutes a useful addition to the set of tools available for economic studies of petroleum supply.

43. Smith, J.L. and G.L. Ward, "Maximum Likelihood Estimates of the Size Distribution of North Sea Oil Deposits", Proceedings of the American Statistical Association, August 1980, and forthcoming in Journal of the International Association of Mathematical Geologists, 1982.

Estimates of the ultimate resource potential of the North Sea petroluem province are derived from a probabilistic model of the discovery phenomenon. The discovery of individual deposits is treated as sampling without replacement from a target population (the underlying resource base), and with individual discovery probabilities defined in terms of deposit size. Conditional on the underlying resource base, the model specifies the likelihood of all possible sequences of discoveries. Conversely, upon observing a particular discovery sequence, it is possible to identify the underlying resource base that maximizes the likelihood of this event. The present paper examines the sensitivity of such resource estimates to the postulated form of the size distribution of deposts, and to the presumed degree of randomness inherent in the discovery process.

WORKING PAPERS AND REPORTS

44. Adelman, M.A., "The Political Economy of the Middle East - Changes and Prospects Since 1973," MIT-EL 79-037WP, June 1979.

    Economic relations of the U.S. and the Middle East are dominated by the production and export of petroleum. This paper first looks at our "non-problems", or our belief in certain fictions that prevent us from investigating the real nature of our problems. Among these fictions are: the shortage or "gap" between oil supply and demand and panic about an "energy crisis," the political problem of "access" and "assurance of supply," and the U.S.-Saudi "special relationship." The real problem is price. This is discussed in the context of world oil supply and demand forecasts, world economic growth, communist sector exports, the strategies and problems of the cartel, the world recession-stagnation of 1974-1975, and appropriate options for the U.S.

45. Adelman, M.A. and H.D. Jacoby, "Oil Prices, Gaps, and Economic Growth", MIT-EL 78-008WP, May 1978.

    This paper uses the analytical results from the World Oil Project as a basis for discussion of likely events in the oil market in the 1980's.

46. Adelman, M.A. and J.L. Paddock, "An Aggregate Model of Petroleum Production Capacity and Supply Forecasting", MIT-EL 79-005WP, Revised July 1980.

    This paper presents a complete discussion and documentation of the M.I.T. World Oil Project Aggregate Supply Model. First, the theoretical development and methodology are presented. The relationsips between geologic and economic characteristics are analyzed and a system of equations representing the inertial process model are discussed. Next, the construction of the data base is described and the data, by country segment, is presented in detail. Methods of bridging the many gaps in the data are discussed. Finally, the simulation forecasts of the model are presented through 1990.

47. Agmon, T., D.R. Lessard and J.L. Paddock, "The International Finance Aspects of OPEC: An Informational Note", MIT-EL 76-005WP, March 1976.

The purpose of this paper is to set forth the relevant questions and problems confronted by the world's capital markets due to the structural changes in the world oil market. It presents a summary description of several financial aspects of OPEC, including the organization of relevant information and data into a form useful for subsequent analysis.

First, an analysis of the many forecasts of OPEC accumulated financial surpluses and their estimated investment disposition--with particular focus on the U.S., U.K., and Euromarkets is presented. There follows a brief discussion and extensive source listing of the various financial proposals which arose to deal with these financial surpluses. Concluding sections present a chronology of the major international financial events which led up to the 1973 price rise and thereafter, and a summary of the subsequent changes in U.S. corporate tax policy.

48. Agmon, T., D. R. Lessard and J.L. Paddock, "Accommodation in International Capital Markets: Paying for Oil, Financing Oil and the Recyling of Oil Funds", MIT-EL 76-010WP, April 1976.

This paper focuses on the accommodation role served by the international financial markets in facilitating world oil market equilibration. We analyze the specific roles of primary and secondary recycling of oil funds in the international adjustment process. An extensive empirical study is then conducted using data for 1973, 1974, and early 1975. This study reveals the magnitudes and important interrelationships between flows in the markets for goods and financial assets. We conclude with a general equilibrium model which derives the supply behavior of an oil-producing country.

49. Beall, A.O., "Dynamics of Petroleum Industry Investment in the North Sea", MIT-EL 76-007WP, June 1976.

The purpose of this study is to assess the economic potential of petroleum fields of the North Sea, as reflected in financial flows to the operating companies and host governments. Financial flows include future streams of exploration and development investment expenditures, and sales and tax revenues which accrue in the private and public sectors.

A prerequisite for the economic analysis is an evaluation of current petroleum potential of prospective North Sea Acreage, conducted at a disaggregated (pool) level. This part of the study relies heavily on geological insight and judgemental analysis provided by the author, as well as on published information and formal analytical methods.

The level of cash flows associated with the estimated resource potential is shown to depend on host government tax and investment policies, the world price of crude oil and current industry perceptions of the profitability of individual fields.

50. Bradley, P., "Production of Depleting Resources: A Cost-Curve Approach", MIT-EL 79-040WP, June 1979.

The current energy situation has riveted attention on extractive resources--petroleum, uranium, and coal--and economists have become increasingly concerned with supply analysis for these commodities. Theory cannot ignore salient factors affecting production if observed prices and outputs are to be explained. This paper formulates the analysis of resource production through the use of cost curves to explain firm and industry output. The aim is to retain the desciptive power of this traditional mode of analysis. It is necessary, of course, to modify the calculation of costs to take account of limitations imposed by nature on resource output.

Definitions are presented for long-run average and marginal cost where both production volume and production rate are taken explicitly into account. Corresponding cost curves are illustrated for the simplest situation, uniform output until resource exhaustion. Section III illustrates derivation of cost curves for a more complicated case, declining output over time with shutdown occurring before the resource is entirely used. Section IV uses the cost-curve method of presentation to consider a familiar question in resource development: how does the interest rate affect rate of use? In the concluding section some cautionary notes are raised concerning application of this type of analysis, in particular with respect to the validity of the present-value maximization postulate.

51. Carson, J., "A User's Guide to the World Oil Project Demand Data Base", MIT-EL 78-016WP, August 1978.

A description of all the data used for demand analysis in the World Oil Project. Cites sources used, range of years available, and provides a description of all conversions, aggregations, and other standardization of units. An index of computerized data files, information on how to access the computerized data or

obtain the information in other formats included. Purchasing power parities and issues involving energy unit conversion are discussed.

52. Carson, J., W. Christian, and G. Ward, "The MIT World Oil Model: Documentation and Use", MIT-EL 81-027WP, December 1981.

Description of the three separate models used by the World Oil Project. The demand model forecasts energy demand in the OECD countries and aggregates petroleum product demand with crude oil demands from the rest of the world, excluding planned economies. The supply model forecasts possible production scenarios for oil producers throughout the world. The integration model integrates demand and supply forecasts and allocates actual production to producers.

The paper reviews the estimation methodology and database used in constructing the models. The equations are described and the behavior summarized. Policy use of the model is described and limitations of the models are identified. Sample output is presented and the use of the simulation framework is described.

53. Crandall, M.S., "The Economics of Iranian Oil", MIT-EL 75-003WP, March 1975.

This paper presents an analysis of the production pattern and development cost structure of the Iranian "Consortium" oil fields. Production capacity of exisiting fields under alternative development technologies (e.g., water and gas injection systems) is analyzed first. This includes capacity maintenance and growth plans. The paper then presents a comparative cost study for these fields and derives per-barrel capital costs and present worth of each field.

Next the paper reviews Iran's potential new fields and performs a similar production/cost study based on the published series of "Look Ahead and Capital Development Plans" through 1978 as issued by both the Iranian government (through its National Iranian Oil Company) and the Oil Service Company of Iran (OSCO - a private company owned by the former Consortium companies).

54. Dailami, M., "The Choice of an Optimal Currency for Denominating the Price of Oil", MIT-EL 78-026WP, October, 1978, revised February 1979.

Recently much concern has been expressed about the impact of the dollar depreciation on the real export earning of OPEC and the implications of any protective action taken by OPEC on world economic conditions and the future stability of the dollar. With approximately 80 percent of OPEC imports originating outside the United States and with a predominantly large proportion of OPEC's past accumulated surpluses invested in dollar denominated assets, the loss incurred as the result of dollar depreciation appears to be substantial. Moreover this loss will be heavier in the future if the historical trend of OPEC's trade shares with the strong currency countries such as Japan and Germany, continues its upward momentum.

To protect its export earnings, OPEC can, in principle, either change the dollar price of oil or shift from its existing dollar-oil pricing system to a system based on a currency basket. The objective of this paper is to analyze the impact of the dollar fluctuation on the purchasing power of OPEC's oil revenues and to identify some of the major problems facing OPEC in its attempt to substitute any other currency or a "basket of currencies" for the dollar.

55. Dailami, M., "The Determination and Control of Money Supply in an Oil Exporting Country: The Iranian Experience", MIT-EL 78-027WP, July 1978, revised February 1979.

The impact on the economies of the oil importing nations of the late 1973 oil price increase and its consequent international payment imbalances has been the subject of a great deal of research. But relatively little emphasis has been placed on the severe problems that the resulting capital inflows have created for the economies of oil-exporting counties. Most of these countries have experienced severe inflation and economic disparities since 1974. A better understanding of the role of oil revenues on the domestic economy of these countries can provide useful guidelines for better management of these economies and as a result provide more stability in the world oil market.

In this paper our objective is to analyze the role of oil revenue in the determination and the controllability of money supply in Iran. In particular we will pursue the double objectives of analyzing the degree to which the Central Bank has been able to influence the determination of money supply and the types of monetary instruments used in its effort to control money supply. Any change in oil revenue will change the foreign reserves holding of the Central Bank and at the same time, given the

level of government expenditure, will affect the claims of the Central Bank on the government. This dual feature of oil revenue in Iran seems to us to be a key element in understanding the mechanism of the money base determination, and hence has constituted the core of our theoretical analysis.

56. Dailami, M. "Measuring the Purchasing Power of Major Currencies from OPEC's Viewpoint", MIT-EL 79-022WP, February 1979.

With the price of oil quoted in terms of the U.S. dollar and with the dollar fluctuating differently with respect to different currencies, the question has emerged as how to measure the fluctuation in the value of the dollar which is relevant to OPEC's economic interest and is theoretically meaningful. Related to this is the question of devising an appropriate standard of value for measuring the real rate of return obtained on OPEC's financial surpluses. Concern over these two questions has recently heightened, partly because of the large and continuous depreciation of the dollar since the beginning of 1977, with its implication for the real price of oil, and partly because of the need for some indices of value to be used by oil-producing countries in evaluating their options of choosing between "oil-in-ground and money-in-bank". The problem of comparing these two options is particularly keen to surplus-oil-producing countries such as Saudi Arabia and Kuwait who are compelled to invest a relatively high proportion of their oil revenues in foreign financial assets.

In this paper our objectives are two: First, to present data on the rate of change in the purchasing power of the dollar from OPEC's viewpoint for the period 1971-1977, and to use this to measure the depreciation in OPEC's financial assets. Second, to compare the performance of the dollar with other major currencies from OPEC's point of view over the same period and to see how OPEC would have fared had currencies other than the U.S. dollar been used for oil-pricing purposes.

57. Eckbo, P.L., "OPEC and the Experience of Previous International Commodity Cartels", MIT-EL 75-008WP, August 1975.

This study presents a review and analysis of the available literature of the history of international commodity cartels. Evidence was gathered on 51 cartel agreements in 18 countries. Cartel "success" was defined in terms of the ability of the organization to raise price to at least two times the unit cost of production and distribution. Of the 51 cartel organizations reported in the literature, 19 achieved price controls which raised the level of charges to consumers significantly above what they would have been in the absence of collusive agreements.

The experience of these previous cartels shows that few were able to survive for very long. Those who did succeed in raising prices for four years or more were characterized by markets where the concentration of production was high, the demands inelastic, the cartels market share was high and the membership had cost advantages over outsiders. An additional characteristic of the successful cartels was that governments were not directly involved in their operations. The paper attempts to draw conclusions about the future of OPEC based on its characteristics in comparison to those of successful and unsuccessful cartels in the past.

58. Heide, R., "Log Linear Models of Petroleum Product Demand: An International Study," MIT-EL 79-006WP, February 1979.

This paper provides preliminary results on the estimation of petroleum product demands for major oil consuming countries and final results for several countries whose oil consumption is less significant. More sophisticated models used to analyze the major countries' consumption have been developed elsewhere (Pindyck, etc.). The model specifications were simple log-linear, with right-hand side variables of price of the particular petroleum product, per capita GDP, and lagged per capita consumption of the product.

59. Heide, R., "The Demand for Motor Gasoline: A Multi-Country Stock Adjustment Model", MIT-EL 79-057WP, April 1979.

The demand for motor gasoline is a large component of total demand for oil in industrial countries. This paper describes the development and testing of a dynamic gasoline model using a capital stock model for 11 major countries. The underlying assumption is that gasoline demand is a demand derived from distinct consumer decisions, such as gasoline price, income, and available automobile stock. Automobile stock, distance, and efficiency adjustments are all posited to take more than one period; the dynamics thus arise from this adjustment behavior.

60. Jacoby, H.D., et al., "Energy Policy and the Oil Problem: A Review of Current Issues", MIT-EL 79-046WP, September 1979.

This is a review and evaluation of oil-related energy policy issues under consideration by the U.S. Congress in Fall 1979. It covers oil import controls, security measures, oil decontrol and excess profits taxation, syn-fuels programs, and the energy mobilization board. To set the stage for analysis of specific proposals, there is a discussion of the energy problem and its origins in the world oil market, with a particular focus on security aspects of the oil situation and the likely gains from oil import reduction as compared with other security measures.

The study was sponsored by M.I.T. Center for Energy Policy Research, but made substantial use of data and analysis resulting from the M.I.T. World Oil Project.

61. Jacoby, H.D. and J.L. Paddock, "World Oil Prices and Economic Growth in the 1980s", Working Paper MIT-EL-81-060WP, December 1981.

A set of interlinked models of world oil supply demand and market behavior is used to develop an analysis of future world oil prices and economic growth. In exercises of this type, results often involve single-line forecasts of price perhaps with some range of values calculated using alternative values of key parameters. In the case of the oil market, however, the uncertainty is so great than analytical models need to be applied in a way that allows easy input of expert judgment and that fully reflects the range of possible outcomes.

The technique used here is to define a universe of possible combinations of oil price and world economic conditions over the decade of the 1980s, and then to use analytical models and judgment to define the set of points, G, than can be shown to be unlikely to occur. The complement of this set, G', then defines a "window" of oil price and growth patterns which are not-unlikely. This result is offered as a way of stating the existing level of knowledge, and ignorance, about likely future developments in world oil markets.

62. Members of the M.I.T. World Oil Project, "Progress on Analysis of the World Oil Market," MIT-EL 75-015WP, October 1975.

    This is the 6 month report on the Project. It presents an overview of the research design and the details of work in progress as of Fall, 1975, including the demand analysis, the supply studies, and the various studies of market-clearing processes. It also includes a revised version of the work schedule presented in the original proposal.

63. Members of the M.I.T. World Oil Project, "Progress Report to the National Science Foundation for Project on Cartel Behavior and Exhaustible Resource Supply: A Case Study of the World Oil Market--7/1/78 through 6/30/79," September 1979.

    This report covers the first year of support under NSF Grant No. DAR-78-19044. It describes research on disaggregated methods of analysis of oil supply, including tax and financial aspects, and analysis of cartel behavior. It also reports on the continuing process of documentation and use of analysis methods developed earlier in the project.

64. Owsley, H., "The Effect of Increased National Oil Company Sales on OPEC and the Long Run Structure of the International Petroleum Market", MIT-EL 79-056WP, May 1979.

    The effect of increased national oil company sales on the world petroleum system is examined. These sales cut into the volume of crude handled by the major international companies and will impact upon OPEC's pricing ability.

    The growth of these sales is measured using annual reports and other industry statistics. Their effects on oil company behavior are examined from both a theoretical and an empirical standpoint. The analysis shows that the firms' behavior patterns are indeed changing, as predicted.

    These changes will create pressure on OPEC producers to restrict production. Using supply/demand models developed by the M.I.T. World Oil Project, the output levels of major cartel members are simulated. These results are compared with the countries' economic needs into the late 1980s.

    The simulations indicate that the OPEC core will encounter financial difficulties if current programs are continued. Alternate strategies for the cartel are discussed.

65. Supply Working Group, M.I.T. World Oil Project, "Supply Forecasting Using Disaggregated Pool Analysis", MIT-EL 76-009WP, May 1976.

This study develops and illustrates a methodology for forecasting additions to reserves and production in a relatively young petroleum province. Components of the analytical method include an exploration process submodel which predicts the arrival and size of new discoveries and a reservior development submodel which determines the rate at which discovered resources become available as economic reserves.

Both submodels emphasize the influence which economic variables such as oil price, development costs, and government taxes exert on the rate and pattern of resource exploitation. Consequently, the analytical framework neatly accommodates policy simulations which arise from varied economic scenarios.

Implementaton of the forecast methodology is demonstrated for the North Sea petroleum province. Projection of future additions to reserves and annual production are carried out in detail, so as to reveal both the flexibility and the limitations of the analytical procedure in its present form.

66. Ward, G.L., "The Aggregate Supply Model: Documentation and Use," M.I.T. Energy Laboratory, Working Paper No. MIT-EL 81-038WP, June 1981.

This paper provides documentation of the Aggregate Supply Model, a computer-based model designed to forecast oil production capacity by producing region. The model is an inertial-process type model based on a few simplifying assumptions. These assumptions, plus key terms important for understanding the model, are described in this paper. Data requirements are identified and an example of results from a model simulation is presented. In addition, a technical description of both the model and the data is presented, along with a description of the computer code that implements the model.

APPENDIX C

List of Meetings, Lectures, Conferences, and Testimony by Project Personnel

For the period of July 1, 1980 through December 31, 1981

M.A. Adleman

October 1980	Lectures on energy prices and markets in the 1980's, with special attenion to oil. Presented at the Instituto Mexicano Del Petroleo, Mexico
November 1980	Speaker at Energy Security Conference Yale University, New Haven, Connecticut.
January 1981	Testimony on international energy/oil situation before U.S. Senate Committee on Banking, Housing, and Urban Arrairs.
February 1981	Participant in panel on energy conditions today and tasks for the future at "The History of the U.S. Energy Policy" symposium held at the Lyndon Baines Johnson Library, Austin, Texas.
May 1981	Presented talk on OPEC as a cartel at "The Future of OPEC and the Long Run Price of Oil" conference held at the University of Houston, Houston, Texas.
July 1981	Presented a paper on "North Sea Oil and Gas in the World Market: Perspectives in 1981-2000" at the Center for Policy Studies, London England.
November 1981	Spoke on the security of oil supplies at the IAEE Conference, Houston, Texas.

Henry D. Jacoby

July to December 1980	Member of National Petrolem Council Committee to Prepare Study of Refinery Flexibility.
September 1980 to April 1981	Member of National Petroluem Council Committee on Emergency Preparedness, and of the Coordinating Subcommittee of the Council's study of this topic.
January 1981	Speech on world energy issues, sponsored jointly by M.I.T. Industrial Liason Office and Keidomren (Council of Economic Organizations), Tokyo
January 1981	Speech to the M.I.T. Alumni Council on "International Oil and U.S. Energy Security"
January 1981	Testimony on international energy/oil situation before U.S. Senate Comittee on Banking, Housing, and Urban Affairs.
February 1981	Participlant in panel on energy conditions today and tasks for the future at "The History of the U.S. Energy Policy" symposium held at the Lyndon Baines Johnson Library, Austin, Texas.
May 1981	Presentation on world energy issues to Annual Conference Diversified Business Division, Aetna Life and Casualty Co.
May 1981	Presented talk on OPEC as a cartel at "The Future of OPEC and the Long Run Price of Oil" conference held at the University of Houston, Houston, Texas.
June 1981	Participant in Energy Security Workshop Sponsored by Harvard Kennedy School of Government and Center for Science and International Affairs
July 1981	Presented a paper on "North Sea Oil and Gas in the World Market: Perspectives in 1981-2000" at the Center for Policy Studies, London, England.
November 1981	Speech on the security of oil supplies at the IAEE Conference, Houston, Texas.
November 1981	Speech on world oil conditions to Israel Cultural Centre, Boston.

James L. Paddock

July 1980	Member of the Coordianting Subcommittee of the National Petroleum Council's Study on U.S. Refinery Flexibility." attended meeting in Washington, D.C.
November 1980	Discussant at M.I.T. Center for Energy Policy Research meetings on World Oil Market Developments. Boston, MA.
May 1981	M.I.T. Center for Energy Policy Research meetings. Rapporteur in sessions on future research in: (1) energy and international finance; and (2) world oil supply. Cambridge, MA.
May 1981	Speaker on world oil and international finance at meeting for economic and energy planners from South American countries. Sponsored by U.S. Bureau of Labor Statistics. Cambridge, MA.
June 1981	Meeting on world oil prospects with staff member of U.S. National Security Council. Cambridge, MA.
December 1981	Speaker on world oil market prospects at Stanford University International Energy Workshop. Stanford, CA.

Geoffrey Ward

August 1980	Presented a paper on applying a statistical model for estimation of undiscovered oil reserves at the Business and Economic Statistics Section of the American Statistical Association. Houston, Texas.

APPENDIX D

M.I.T. Center for Energy Policy Research
Conferences on the World Oil Market

Attached are meeting schedules and lists of participants for conferences on the world oil market. All costs of these conferences were paid by the M.I.T. Center for Energy Policy Research (CEPR). The conference's preparation, including discussion memoranda, data analysis results, and discussion leadership, was drawn primarily from research carried out under N.S.F. sponsorship

AGENDA

M.I.T. CENTER FOR ENERGY POLICY RESEARCH

RESEARCH & POLICY ISSUES IN THE CONTEXT OF WORLD OIL MARKET DEVELOPMENTS

November 16-18, 1980

Sunday, November 16

6:00 - 7:00 p.m.		Cocktails
7:00 - 8:00 p.m.		Dinner
8:00 - 9:30 p.m.	*(Blue)*	"Energy Prices, the Economy, the Environment and the Individual: A Research Preview"
		Presentation: David Wood Moderator: Loren Cox

Monday, November 17

7:30 - 8:30 a.m.		Breakfast
8:30 -10:30 a.m.	*(Yellow)*	"Recent Developments in World Oil Markets"
		Presentation: Morris Adelman Thomas Neff Comments: Brice Sachs Lawrence Goldstein Moderator: Loren Cox
10:30 -10:45 a.m.		Coffee Break
10:45 -12:45 p.m.		"The Oil Outlook Beyond the 1980's"
		Presentation: Henry Jacoby Comments: John V. Mitchell Moderator: Loren Cox
12:45 - 1:45 p.m.		Lunch
1:45 - 5:00 p.m.	*(Pink)*	"Energy Legislative and Regulatory Agendas: The Next Two Years"
		Presentation: Loren Cox Comments: Steven Hickok Frank Potter Walter Schroeder Jan Vlcek

Evening Free

Tuesday, November 18

7:30 - 8:15 a.m.		Breakfast
8:15 -12:00 noon	*(Green)*	"Synfuels: Prospects and Problems"
		Presentation: Arthur Wright David White
		Comments: Jim Harlan Daniel Luecke
		Moderator: Loren Cox
12:00 -12:45 p.m.		Luncheon and Departure

List of Participants in Back *(Canary)*

CEPR Meeting November 16-18, 1980

PARTICIPANTS

Morris A. Adelman	Professor of Economics Massachusetts Institute of Technology
Richard Alben	Manager, Technology Evaluation Operation Corporate Research & Development General Electric Company
David J. Atton	Manager, Supply and Transportation Department Manager, Policy & Planning The Standard Oil Company
Eric M. Bodow	Manager of Economic Planning Chem Systems Incorporated
Joan T. Bok	Vice Chairman New England Electric System
James B. Borden	Economics and Policy Manager Energy and Materials Department E.I. DuPont de Nemours & Company
Lawrence Burge	Project Manager of Synfuels E.G.&G., Incorporated
David H. Burns	Special Assistant International Energy Policy Department of State
John G.L. Cabot	Senior Vice President Cabot Corporation
Jacqueline Carson	Sponsored Research Technical Staff Energy Laboratory Massachusetts Institute of Technology
Nazli Choucri	Professor of Political Science Massachusetts Institute of Technology
Maudine Cooper	Assistant Vice President for Public Policy National Urban League
Loren C. Cox	Director Center for Energy Policy Research Energy Laboratory Massachusetts Institute of Technology
William Cummings	Assistant Postmaster General United States Postal Service

John E. Deegan, Jr.	Vice President Consolidated Edison of New York
Fred J. DiLisio	Special Assistant for Energy Conservation United States Postal Service
Maurice C. Ernst	Director, Economic Research Central Intelligence Agency
Anna Lou Fletcher	Staff Economist of Synfuels E.G.&G., Incorporated
F. Harlan Flint	Director, Policy and Planning Government and Public Affairs The Standard Oil Company
Gerald R. Fox	Manager, Energy Systems Evaluation General Electric Company
Hiroshi Fukuda	Counsellor of the Japanese Embassy Washington, D.C.
William J. Gallagher	Purchasing and Materials Caterpillar Tractor Company
Lawrence J. Goldstein	Chief Economist Petroleum Industrial Research Foundation, Inc.
Richard L. Gordon	Professor of Mineral Economics Pennsylvania State University Visiting Economist Massachusetts Institute of Technology
Barnet Groten	Director, Research and Technology Texas Eastern Transmission Corporation
Mariano Gurfinkel	Senior Advisor Commercial Department Petroleos de Venezuela Corporation
Janes W. Hanson	Chief Economist Corporate Planning Department Exxon Corporation
James Harlan	Policy Analyst Office of Policy and Evaluation Department of Energy
Curt Hessler	Assistant Secretary (Economic Policy) Treasury Department

Steven G. Hickok	Minority Staff Director Senate Energy Committee
Robert Higgins	Executive Director John A. Hartford Foundation, Inc.
Takeo Iguchi	Consul-General of Japan Boston, Massachusetts
Henry D. Jacoby	Energy Laboratory Professor, Sloan School of Management Massachusetts Institute of Technology
Lionel S. Johns	Assistant Director Office of Technology Assessment
Ethan Kapstein	Energy Education Director Massachusetts Audubon Society
Michael Karsky	Direction de la Recherche Scientifique et Technique Societe Nationale Elf Acquitaine
Ike C. Kerridge, Jr.	Vice President Stockholder Relations & Economist Hughes Tool Company
William C. King	Director of Policy Analysis Gulf Oil Corporation
Zvi Livne	Visiting Scientist Energy Laboratory Massachusetts Institute of Technology
Geoffrey Lubbock	Senior Business Analyst Energy Group Cabot Corporation
Daniel F. Luecke	Staff Scientist Environmental Defense Fund
Michael C. Lynch	Research Specialist Energy Laboratory Massachusetts Institute of Technology
Jacques Maroni	Energy Planning Director Ford Motor Company
Muriel McCrossen	Associate Economist Research Staff General Electric Company

James A. McNamara	Assistant U.S. Trade Representative for Energy Policy Executive Office of the President
John E. Mitchell	Director of Research Caterpillar Tractor Company
John V. Mitchell	Head, Policy Review Unit British Petroleum, London
W. David Montgomery	Deputy Assistant Secretary for Policy and Evaluation Department of Energy
Thomas L. Neff	Principal Research Scientist Manager, International Energy Studies Program Energy Laboratory Massachusetts Institute of Technology
J. Madison Nelson	Development Manager Energy Materials Department E.I. DuPont de Nemours & Company
Guy W. Nichols	President and Chief Executive Officer New England Electric System
Charles C. Nicholson	Vice President British Petroleum North America, Inc.
Katsumi Oda	Vice-Counsul of Japan Boston, Massachusetts
John L. Olsen	Senior Vice President Government and Industry Affairs Sun Company
James L. Paddock	Research Associate and Lecturer Energy Laboratory Massachusetts Institute of Technology
Len V. Parent	Planning Manager of Corporate Planning Panhandle Eastern Pipe Line Company
Alirio Parra	Director, Commercial Department Petroleos de Venezuela Corporation
Donald H. Peters	Corporate Director of Information Systems E.G.&G., Incorporated

Frank Potter	Staff Director Subcommittee on Energy and Power House Committee on Interstate and Foreign Commerce
Margaret Power	Minority Counsel Subcommittee on Energy Senate Government Affairs Committee
Linda Rathbun	Manager, Market Research Rocky Mountain Energy Company
Tom G. Richards	Project Engineer for Research Caterpillar Tractor Company
John W. Rohrer	Director of Engineering Wheelabrator Frye, Inc.
Brice A. Sachs	Executive Vice President Exxon International
Anthony Scanlon	Economics Advisor British Petroleum, London
Raymond Scheppach	Assistant Director Congressional Budget Office
Walter Schroeder	Director Office of Regulatory Analysis Federal Energy Regulatory Commission
Jack F. Shaner	Economist Caterpillar Tractor Company
Gordon Shearer	Assistant to the Manager Exploration and Production Oil and Gas Division Cabot Corporation
Allen Sheldon	Vice President, Environment and Energy Resources Alcoa Corporation
Melvin K. Simmons	Energy Analyst General Electric Company
J. Edward Smith	Economist Energy Analysis Operation General Electric Company

Kenneth A. Smith	Associate Provost Massachusetts Institute of Technology
John S. Sorice	Energy Planning & Mineral Resources Department Olin Corporation
David Strom	Associate The Conservation Foundation
Michael Telson	Senior Energy Analyst House Budget Committee
Jan B. Vlcek	Attorney at Law Gardner, Carton & Douglas
Geoffrey L. Ward	Sponsored Research Technical Staff Energy Laboratory Massachusetts Institute of Technology
Malcolm A. Weiss	Deputy Director Energy Laboratory Massachusetts Institute of Technology
David C. White	Director, Energy Laboratory Massachusetts Institute of Technology
James C. Wilson	President Rocky Mountain Energy Company
David O. Wood	Associate Director Energy Laboratory Massachusetts Institute of Technology
Arthur W. Wright	Economist Professor & Head of Economics Departmen University of Connecticut Visiting Economist Massachusetts Institute of Technology

AGENDA

CENTER ASSOCIATES PLANNING MEETING

May 20-21, 1981

Hyatt Regency, Cambridge

May 20, 1981 (Wednesday)

6:00 - 7:00 p.m.	Cocktails *William Dawes Room
7:00 - 8:00 p.m.	Dinner *Thomas Paine Room
8:00 - 10:00 p.m.	"The Congressional Energy Agenda - 97th Congress" • Frank Potter, House Committee on Energy & Commerce *Thomas Paine Room

May 21, 1981 (Thursday)

7:00 - 8:00 a.m.	Breakfast *Empress Room (14th Floor)
8:00 - 9:30 a.m.	Review of CEPR Sponsored Research *Thomas Paine Room
9:30 - 10:00 a.m.	Coffee Break
10:00 - 12:00 Noon	Panel Discussion Groups on Two Areas of CEPR Focus • International Energy Markets • Domestic Energy Policy, especially Synthetic Fuels
12:00 - 1:00 p.m.	Lunch *Empress Room (14th Floor)
1:00 - 2:15 p.m.	Reconvene as One Group to Report on Morning Discussion Groups *Thomas Paine Room
2:15 - 3:30 p.m.	Discussion of Changed Policy Landscape
3:30 p.m.	Adjourn

CEPR Meetings May 20-21, 1981

PARTICIPANTS

Morris A. Adelman	Professor of Economics Massachusetts Institute of Technology
Arnold B. Baker	Senior Consultant Policy Analysis & Forecasting Atlantic Richfield Company
Curt Biren	Program Officer The John A. Hartford Foundation, Inc.
James B. Borden	Economics and Policy Manager Energy & Materials Department E.I. DuPont de Nemours & Company
Charles G. Bottomley	Director, Feed Stocks Research E.I. DuPont de Nemours & Company
Edgar N. Brightbill	Director of Planning and Development Division E.I. DuPont de Nemours & Company
John G.L. Cabot	Senior Vice President Cabot Corporation
C. Napier Collyns	Vice President Strategic Planning & Public Affairs Scallop Corporation
Loren C. Cox	Director Center for Energy Policy Research Massachusetts Institute of Technology
William Cummings	Assistant Postmaster General United States Postal Service
John E. Deegan, Jr.	Vice President Consolidated Edison Company of New York, Inc.
E. D. Michael Eades	Technical & Research Liaison Director ICI Americas, Inc.
Theodore R. Eck	Chief Economist Standard Oil Company (Indiana)

Peter Ellis	Research Assistant Sloan School of Management Massachusetts Institute of Technology
Kazuya Fujime	Institute of Energy Economics Tokyo, Japan Visiting Scientist Energy Laboratory Massachusetts Institute of Technology
William J. Gallagher	Purchasing and Materials Caterpillar Tractor Company
Richard L. Gordon	Pennsylvania State University Visiting Economist Center for Energy Policy Research Massachusetts Institute of Technology
Mariano Gurfinkel	Senior Advisor Commercial & Suministro Department Petroleos de Venezuela S.A.
James W. Hanson	Chief Economist Corporate Planning Department Exxon Corporation
Robert Higgins	Executive Director The John A. Hartford Foundation, Inc.
Anton A. Holscher	Planning and Administration Shell Internationale Research Maatschappij B.V.
Dennis J. Ives	Deputy Secretary Department of National Development and Energy Government of Australia
Henry D. Jacoby	Professor, Sloan School of Management Associate Director, Energy Laboratory Massachusetts Institute of Technology
Paul L. Joskow	Professor of Economics Massachusetts Institute of Technology
Ethan Kapstein	Energy Education Director Massachusetts Audubon Society
William C. King	Vice President of Corporate Planning Gulf Oil Corporation

Yoshiaki Kotaki	Consul of Japan Boston, Massachusetts
Zvi Livne	Visiting Scientist Center for Energy Policy Research Massachusetts Institute of Technology
Daniel F. Luecke	Staff Scientist Environmental Defense Fund
Daniel Luria	Research Associate Research Department United Auto Workers
Jacques Maroni	Energy Planning Director Ford Motor Company
Robert McCutchen	Division Manager Research Department Caterpillar Tractor Company
Frank Murphy	Manager of Economic Research General Electric Company
Thomas L. Neff	Program Manager, International Energy Studies Program Energy Laboratory Massachusetts Institute of Technology
Charles C. Nicholson	Vice President British Petroleum N.A., Inc.
James L. Paddock	Research Associate and Lecturer Massachusetts Institute of Technology
Len V. Parent	Planning Manager of Corporate Planning Panhandle Eastern Pipe Line Company
Donald H. Peters	Corporate Director of Information Systems EG & G, Inc.
Frank M. Potter, Jr.	Chief Counsel House Energy & Commerce Committee U.S. House of Representatives
Dorothy K. Powers	Energy Chairperson League of Women Voters of the United States
Linda Rathbun	Manager, Market Research Rocky Mountain Energy Company

Thomas J. Richards	Staff Engineer Caterpillar Tractor Company
John W. Rohrer	Director of Engineering Wheelabrator-Frye Inc.
Cornelius Shields	Vice President, Public Policy Sun Company
Horst Siebert	University of Mannheim Visiting Economist Center for Energy Policy Research Massachusetts Institute of Technology
Jack F. Shaner	Economist Caterpillar Tractor Company
Craig Tedmon	Staff Executive Power Systems, Technology Operation General Electric Company
Malcolm A. Weiss	Deputy Director, Energy Laboratory Massachusetts Institute of Technology
David C. White	Director, Energy Laboratory Massachusetts Institute of Technology
David O. Wood	Program Director Energy Markets, Pricing and Regulation Energy Laboratory Massachusetts Institute of Technology
Arthur W. Wright	University of Connecticut Visiting Economist Center for Energy Policy Research Massachusetts Institute of Technology