

FOR EVENTUAL SUBMISSION FOR
PUBLICATION IN THE CUADERNOS
SERIES IN TWO VOLUMES

ENERGY IN LATIN AMERICA:
THE HISTORICAL RECORD AND FUTURE PERSPECTIVES

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SANTIAGO, CHILE, 1978

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ENERGY IN LATIN AMERICA:
THE HISTORICAL RECORD AND FUTURE PERSPECTIVES

Editor's Note: Purpose and Scope of Paper

This text was originally written as background material for a more broad-ranging study, the Economic and Social Development and External Relations of Latin America.^{1/} This study was submitted at the seventeenth session of the Economic Commission for Latin America (Guatemala City, Guatemala, 25 April-5 May 1977).

The questions addressed by the present text are derived from three prior questions that guided, in large part, the study submitted at the Guatemala City session. These three prior questions were:

First, from a socio-economic point of view, what have been the major developments in Latin America since the fifties?

Second, what are their basic explanations?

Third, what are the prospects for socio-economic development in Latin America over the rest of this century?

The present text is a revised and up-dated version of the original background text. Its overall purpose is to provide a brief description of the pattern of change in Latin America's energy industries in the post-war period and to provide some ideas that may be useful to energy planners in the region's oil-deficit countries as they confront the future price of world oil.

The text deals with five key questions: first, what have been the major features of growth and change in Latin America's energy industries in the post-war period; second, to what degree has the performance of those industries impeded socio-economic growth in the region during the past quarter century; third, what is the most probable level and composition of Latin America's energy requirements at the end of this

^{1/} See CEPAL, The Economic and Social Development and External Relations of Latin America, E/CEPAL/1024, 15 March 1977.

century; fourth, what is the most likely track of world crude oil prices over the rest of this century and what pattern of volatility is inherent in these expected prices for world oil; and fifth, what are the policy options open to Latin America's oil-deficit countries in the light of the expected price structure for internationally traded crude oil during the rest of this century?

A note on dating is in order. The text was completed in November, 1977, and between that time and its publication, changes of consequence have occurred in the world oil industry. The OPEC Meeting in Caracas in December and the subsequent freeze in world emergence oil prices together with the energy legislation at the national level in the United States and the weakening of spot prices in the world oil market are important cases in point. The reader can judge for himself the likely impact of these factors on the predictions of world oil prices presented in this text.

ENERGY IN LATIN AMERICA:
THE HISTORICAL RECORD AND FUTURE PERSPECTIVES

Objectives and Organization

This study deals with the following five questions:

First, what have been the major features of growth and change in Latin America's energy industries since the early fifties?

Second, to what extent has the performance of the domestic component of Latin America's energy industries significantly restricted the process of regional economic growth since the early fifties?

Third, what is the expected pattern of Latin America's energy requirements during the rest of this century?

Fourth, what are the immediate and longer-term prospects for the price of world oil?

Fifth, what energy policies are open to the governments of Latin America's oil-deficit countries for confronting the expected price of world oil?

These five questions constitute the foci of this study, which is divided into two Chapters, the first focussing on the first three questions, while the second focusses on the last two.

Section I of Chapter 1 discusses the economic functions of the energy industries. Section II places Latin America's changing energy profile in international perspective. The wealth of Latin America in energy resources is examined in Section III. The record of growth and change since the early fifties is discussed in Section IV as regards each of Latin America's four basic energy industries: oil, natural gas, coal, and electric power. Section V contains a brief analysis of the degree to which the performance of Latin America's energy industries may have impeded economic growth in the region in the post-war era. Finally, Section VI provides a forecast of total and component modern energy consumption in the year 2000 in Latin America and in its principal energy consuming countries together

/with a

with a forecast of the level of installed generating capacity for that year in the region and in its major power markets. The section closes with a discussion of the basic implications of these forecasts.

Chapter 2 focusses on the price of world oil and its essential implications for energy planners in Latin America's oil-deficit countries. Section I of this chapter identifies the changing structure of world oil prices in the post-war era and offers a basic explanation for that pattern of change. Sections II through IV examine the current structure and prospective changes in the world crude oil industry, on the one hand, and in the complex of energy policies in the industrialized, oil-importing countries on the other. Section V presents a forecast of world crude oil prices for the next two decades. Section VI discusses the range of options open to policy-makers in Latin America's oil-deficit countries as they confront the expected price of world crude oil (as identified in Section V) and closes with a discussion of the security of oil imports in Latin America's oil-deficit countries.

Chapter 1

LATIN AMERICA'S ENERGY INDUSTRIES: THE HISTORICAL RECORD

Section I: The functions of the energy industries

In every nation the energy sector has at least one key economic function: to support socio-economic activity. In some countries, one or more of the energy industries may have a second function: to generate export earnings. In Venezuela, for example, both functions are as obvious as they are economically critical.

Aside from these two functions, the operation of the energy industries has a series of important implications. They present major claims on a nation's scarce investable funds and, in Latin America, particularly on public sector funds. Additionally, they have significant impacts on the pattern of central government revenues and expenditures on current account, in both foreign exchange and local currency. Although the energy industries account for relatively minor fractions of national employment in Latin American economies, they generate substantial claims on certain categories of the region's scarce resources of skilled and semi-skilled manpower. The energy industries obviously have widespread implications for the scale and pattern of environmental damage, both domestically and internationally. The growth of nuclear power generation in Latin America will pose particularly complex and important environmental problems to the societies of the region in this regard. The pricing of energy flows in the domestic economy has important implications for the efficiency with which economic resources are used, not only in the energy sector itself but throughout the domestic and world economies as well. Clearly, then, the energy industries are of prime political importance. The issue of their ownership and control provokes widespread debate and antagonisms not only in Latin America, but throughout the world. Changes in the price of electricity and refined oil products are subjects which political leaders, at both the national and sub-national levels, may ignore only at their peril.

/In discussing

In discussing the role of the energy industries, one must distinguish clearly at the outset between, on the one hand, energy flows as supporters of socio-economic activity in a strictly physical sense, and on the other the implications for economic efficiency and growth of the manner in which that support is extended. The first approach is typically that of the physically-oriented engineering mind, while the second is economic in essence.

An example will suffice to make clear the nature and importance of this simple distinction, which is the source of much confusion in discussions of energy policy. Thus, an engineer might applaud policy-makers in the energy field for the fact that the increasing stock of automobiles, buses, trucks, and other transport media in his country has consistently been serviced with readily available supplies of low-priced motor gasoline and diesel oil, but this applause is irrelevant to the economist, who would ask to what extent the long-term market prices of motor gasoline and diesel oil in that country and the growing stock of transport vehicles made sense economically.

The distinction between the physical support of the growth process provided by the energy industries and the implications for economic efficiency and growth of the manner of providing that support will be discussed subsequently in Section V.

Section II: Latin America and the world energy profile

(a) General comparisons

The level of Latin America's consumption of the modern fuels ^{2/} increased by 6.7 per cent per annum during 1950-1975 and on a per capita basis by 3.8 per cent per annum during this 25-year period.

^{2/} The term "modern fuels" includes coal, oil, natural gas and liquefied natural gas, hydroelectricity, and nuclear fuels. It excludes a wide variety of traditional energy sources, such as human and animal power, direct solar energy, winds, tides, geothermal energy, vegetable fuels and animal wastes. All growth rates presented in this study are compound annual growth rates.

As shown in Exhibit 1, the rate of growth in Latin America's modern energy consumption during 1950-1975, in both absolute and per capita terms, exceeded the corresponding rates for the developed countries and the world as a whole. On the other hand, the average rate of growth of Latin America's modern energy consumption during this period, in both absolute and per capita terms, was less than the average rates recorded in the non-Latin American group of developing countries.

In absolute terms, modern energy consumption in Latin America in 1975 (219×10^6 t.p.e.) was less than one-third the level recorded in that year in all the other developing countries taken collectively (751×10^6 t.p.e.). This fact basically reflects the far larger population of the latter group of countries (2.5 billion) than the former (0.3 billion), however. Thus, when population is taken into account, Latin America's modern energy consumption (682 k.p.e. per capita in 1975 was more than double the comparable figure for the other developing countries (300 k.p.e. per capita), although still far below the level recorded in the developed countries (4,076 k.p.e. per capita).

In terms of per capita modern energy consumption per unit of per capita total real output, many Latin American economies, in both 1950 and 1975, fell between the average levels recorded in the developed countries, on the one hand, and in the impoverished group of developing countries, on the other. This relationship is shown diagrammatically in Diagram 1 and Exhibit 2 for selected countries in 1972.

With regard to changes in the level of energy-intensiveness of production, Latin America consumed about 2.1 kgs of coal equivalent energy per unit of total real output produced in 1965, which put it mid-way between the comparable ratios recorded, in that year, in the developed group of non-centrally-planned economies (2.4 kgs) and in the underdeveloped group of non-centrally-planned economies (1.8 kgs).^{3/}

^{3/} J. Darmstadter et.al., Energy in the World Economy. (Baltimore: The Johns Hopkins Press, 1971), p. 63. A kilogramme of coal equivalent energy is the amount of energy contained in a kilogramme of coal, which, in the present case, is defined as 6,992 kcals.

A preliminary estimate suggests that the level of Latin America's modern energy input per unit of real total output still lies between the levels recorded in the developed and developing economies.

Exhibit 3 presents data on the changing composition of modern energy consumption at the international level. With the exception of the Persian Gulf countries, Latin America has depended on liquid fuels (oil and liquefied gas) to a greater extent, and for a longer period, than any other major world region, and indeed longer than most individual countries or economic country groupings. The substitution of oil and gas for coal was virtually complete in Latin America before this substitution process gained world-wide momentum in the fifties. In short, Latin America's industrial development - a largely post-war phenomenon - has been based on oil and, since 1950, increasingly on natural gas as well. In 1975, these two fuels supplied about four-fifths of Latin America's modern energy requirements. Latin America's economic apparatus is thus outstanding in the degree of its dependence on oil and gas.

The data in Exhibit 3 show that Latin America accounts for relatively minor fractions of world-wide modern energy consumption (both total and component). This reflects the corresponding lack of dominance of Latin America in world production and, to a lesser extent, in world population. Latin America has consistently accounted for relatively minor fractions of world modern energy production, about 7 per cent in 1950 and 6 per cent in 1975 (Exhibit 3).

As shown in Exhibit 3, Latin America is an important source of energy in world markets. The region has constantly been an importer of solid fuels, and its export role is based squarely on oil. In 1975, the region consumed only three-fifths of the volume of modern energy that it produced, a reflection largely of the fact that about one-half of its crude oil production was exported in that year.

(b) Latin America's trade in modern energy sources

Oil has been Latin America's leading export earner in the post-war era, generally accounting for between one-fifth (1950) and about /three-tenths

three-tenths (1975) of total regional export earnings (Exhibit 4). Venezuela has consistently accounted for about nine-tenths of the region's annual oil exports, and oil has provided, in turn, more than nine-tenths of that nation's annual export earnings. Oil exports from Ecuador, Bolivia, and Mexico have increased sharply in value in recent years, but they are still minor in regional and world terms.

The scale and global pattern of Latin America's imports and exports of energy sources has changed substantially during the past three decades. Until the early fifties, Venezuela was the world's second largest crude oil producing region, surpassed only by the United States. Since then, the region's historically dominant position in the world crude oil market has given way to the Middle East and Africa. This displacement has occurred not only in the booming markets for crude oil in North America and Western Europe, but also in the South American and Caribbean crude oil markets (Exhibit 5). Latin America suppliers never gained a foothold in the rapidly expanding crude oil markets of the Far East, largely because of the geographic advantage of Middle East suppliers there.

Latin America's petroleum exports are dominated by crude oil, but the share of refined oil products in total petroleum exports has been increasing over the past quarter century. In 1975 North America accounted for 86 per cent of Latin America's extra-regional exports of crude oil (Exhibit 6), while intra-regional crude oil exports accounted for almost one-half of total Latin American crude oil exports in that year. A major market for South American crude oil is the Caribbean, where a number of large refineries transform it into refined oil products, mainly for export to the North American market. Latin America's exports of refined oil products consist basically of fuel oil (Exhibit 7). This product is exported principally to the United States, where refineries are heavily geared to the production of motor gasoline, using comparatively light crude oils, so that it is necessary to import a significant part of the nation's increasing needs for heavier refined oil products, such as fuel oil. Many of the

/region's oil-

region's oil-deficit countries export relatively small quantities of refined oil products in highly competitive intra-regional and extra-regional circuits, the aim of this trade being to close the gap between domestic market requirements and domestic refinery output in these countries.

Imports of energy sources into Latin America (Exhibit 8) consist of oil, coal, coke and minor volumes of natural gas and electricity. Extra-regional imports of crude oil, largely from the Middle East and to a lesser extent from Africa, have considerably altered the almost complete reliance on intra-regional sources of crude oil which characterized Latin America's oil import pattern in the early post-war era. As indicated in Exhibit 8, in 1975 the Middle East and Africa accounted for roughly 55 per cent and 20 per cent, respectively, of total crude oil imports by Latin American oil-importing countries, while crude oil from regional sources accounted for only one-seventh of these imports. Additionally, the sharp increase in domestic crude oil refining in Latin America since the early fifties has resulted in a strong decline in the volume of imported oil products. These imports are still secured largely through intra-regional trade, although a variety of special products, such as high-grade lubricants and aviation fuels, are secured predominantly from the United States.

Although some Latin American countries have ample resources of indigenous coal, it is comparatively costly to extract and transport and is of relatively low calorific value. Hence, many Latin American countries have turned to imports of higher quality coals and cokes to satisfy the growing requirements for these products, mainly by their metallurgical industries. The bulk of the region's coal and coke imports have come from the United States and, to a lesser extent, from Eastern Europe. Latin America's net imports of natural gas and electricity are quantitatively minor and represent the comparatively small trade in these fuels between Mexico and the United States.

/Section III:

Section III: Latin America's modern energy
resource base

There is a variety of concepts regarding non-renewable and renewable energy resources. With respect to the non-renewable energy resources, the most commonly used (and abused) concept is 'proven reserves'. This is a point estimate of the volume of a non-renewable energy resource contained within conservatively defined limits of known fields which is believed, with a high (and typically unspecified) degree of certainty, to be economically recoverable at prevailing prices and costs.

An estimate of proven reserves should be interpreted in the context of its (unknown) error density function. To say, for example, that on 1 January 1977 the stock of proven reserves of crude oil in a country was x billion barrels really means something like the following: on that date, the estimator of these reserves believed with a subjectively generated level of certitude of, say, 90 per cent that the true level of proven reserves of oil there was, most probably, x billion barrels, so that the actual level of proven reserves there on that date would probably be contained within a subjectively generated limit range of, say, $(x \pm 0.25 x)$ billion barrels.^{4/}

Proven reserves of oil, or any other non-renewable energy resource, constitute a working inventory of that resource, which is the result of the past creation of known reserves from unknown resources, on the one hand, followed by subsequent decisions to produce from these known reserves. Because it is costly to add to proven reserves, neither governments nor private oil companies add to them unrestrainedly.

^{4/} This interpretation is given to put statements of proven reserves in their proper conceptual focus. This does not imply that estimates of proven reserves are built up in such a mathematically rigorous manner. Actually, the estimation of proven reserves is partly an art, partly a science, and the published figures on proven oil reserves, although reflecting much knowledge, also contain much guesswork, outright bias, and more than a little ignorance.

Some international oil companies, for example, might consider that a ratio of proven reserves of oil to anticipated oil production which gave an expected life of, say, ten years an acceptable level of working inventory to carry against the commercial, political, and other risks that they expect to face. Proven reserves of oil, or any other non-renewable energy resource, naturally tend to increase as energy prices rise and as primary, second, and tertiary extraction technology improves. Obviously, proven reserves of oil, or any other non-renewable energy resource, are not a valid gauge of a nation's wealth in that energy resource.

Proven reserves of oil and natural gas in Latin America at the end of 1976 have been estimated at 30 billion barrels and at 90×10^{12} cubic feet respectively, or at 5 per cent and 4 per cent of the estimated volume of the world's proven reserves of these energy resources at that time. As shown in Exhibit 9, the distribution of Latin America's proven reserves of oil and gas is geographically disparate. In the case of oil, nine-tenths of these reserves are located in four Latin American countries: Venezuela (52 per cent), Mexico (24 per cent), Argentina (8 per cent), and Ecuador (6 per cent), while as regards natural gas, five countries accounted for 85 per cent of Latin America's proven reserves at that time: Venezuela (45 per cent), Ecuador (13 per cent), Mexico (13 per cent), Argentina (8 per cent) and Bolivia (6 per cent).

Latin America's proven reserves of crude oil at the end of 1976 represented 18 times the level of crude oil production in the region in that year; the comparable ratio in the case of natural gas was 28.

"Expanded proven reserves" is another non-renewable energy resource concept. It means the sum of the proven reserves at a given point in time, plus the expected addition to these reserves generated by conceptually expanding the conservatively defined limits of known fields employed in estimating the level of proven reserves. Thus, the concept of "expanded proven reserves" has meaning only in a probabilistic sense, insofar as it relates changing stocks of oil

/with changing

with changing levels of certainty associated with statements about the extent of those stocks. The error density function of expanded proven reserves is unknown as it is in the case of proven reserves.

Grossling offers one estimate of the probable extent of expanded proven oil reserves:

"...For most of the non-OPEC developing countries, I can make the following generalization. An additional quantity $\overline{[of\ oil]}$ equal to proven reserves can be obtained with probability 0.8, and another equal additional quantity with probability 0.5. Hence the expected ... $\overline{[volume]}$... of the expanded proven reserves designated here as R_2 would be $(1 + 0.8 + 0.5) R_1$... $= \overline{[Proven\ Reserves]}$... = $2.3 R_1$ ".^{5/}

Excluding Latin American OPEC members' proven reserves of crude oil at the end of 1976 were about 13 billion barrels. The application of Grossling's factor would yield an estimate, with a weighted average certitude of 77 per cent, that expanded proven reserves for this group of Latin American countries would fall in the range of 30 billion barrels plus or minus 8 billion barrels (using an estimated 25 per cent error factor). If Venezuela and Ecuador are included, the resulting level of expanded proven reserves for the region would be 68 billion barrels plus or minus 17 billion barrels (using the same 25 per cent error factor).^{6/} If secondary and tertiary recovery techniques are considered, these estimates might easily be doubled.

Undiscovered reserves is another resource concept. This is the unknown stock of an economically recoverable, non-renewable energy resource that is now lying beneath the surface in unknown places. It

5/ B.F. Grossling, Latin America's Petroleum Prospects in the Energy Crisis, Geological Survey Bulletin 1411 of the United States Department of Interior, 1975, p. 16. Bracketed insertions are not in the original text.

6/ This volume may be compared with Emery's estimate of South America's "Other identified resources" of oil of 74 billion barrels as cited by Grossling, op.cit., p. 35. See: K.O. Emery, Resources of fossil fuels, unpublished report to the U.S. National Research Council, 1973.

is from these stocks that, historically, proven reserves have been created. The sum of undiscovered energy resources plus expanded proven reserves constitutes a country's wealth in a particular non-renewable energy resource. This wealth in a given energy resource plus the volume of its cumulative production in the past defines the ultimate recoverable volume of that energy resource and the country's original endowment with economically exploitable volumes of that energy resource.

Grossling places Latin America's ultimate recoverable reserves of oil at 490-1,225 billion barrels and of natural gas at 2,450-6,370 trillion cubic feet. If we subtract the end-1976 regional cumulative production of each of these energy resources (estimated at about 132 billion barrels and 82 trillion cubic feet, respectively), this gives an estimate of Latin America's reserves of economically exploitable oil and gas still in the ground: between 358-1,093 billion barrels of oil and between 2,368-6,288 trillion cubic feet of natural gas. In the case of oil, this estimate represents 224-683 times the estimated level of regional oil production in 1976 and between 358-1,093 times the estimated level of regional oil consumption in 1975. The estimated economically exploitable reserves of natural gas represent between 740 and 1,965 years of regional production in 1976 and between 1,691 and 4,491 years of regional consumption at the 1975 rate of annual consumption (i.e., 1.4 trillion cubic feet).

Grossling's estimates of ultimate recoverable reserves in Latin America are based on benchmark figures for oil and gas reserves per unit of prospective producing area. The figures he employed for Latin America were derived from analysis of data for three areas.^{7/} Grossling's estimates of Latin America's ultimate recoverable reserves of oil and gas have a downward bias, which he underscores in his statement that the estimates "... do not include any allowance for the occurrence of giant-size accumulations like the Middle East.

^{7/} Cotarminous United States, the Soviet Union, and the Middle East.

/These cannot

These cannot be excluded; moreover, I suspect that the Caribbean area and the Argentine continental shelf are two regions where they could occur".^{8/}

Identified reserves is a concept that is often used in discussions of energy resources other than oil. It is a measure of the stock of an energy resource known to exist and capable of being extracted profitably at given prices and costs. This term is usually employed in discussions of non-fuel mineral resources. It is comparable to the concept of expanded proven reserves used in discussion of oil and gas reserves. The concept of identified reserves excludes undiscovered recoverable reserves.

The potential yield from Latin America's identified reserves of oil shale, located largely in Brazil, has been estimated at 800 billion barrels, while the potential yield from undiscovered oil shale reserves in the region is thought to be of the order of 41,200 billion barrels.^{9/} Identified resources of oil in tar sands in the region, concentrated in Venezuela, are thought to be of the order of 1,200 billion barrels, no estimate being available for undiscovered stocks of this energy resource.^{10/} For purposes of comparison, in 1973 the Latin American economies consumed a total of about 882 million barrels of oil products.

Latin America's stock of identified coal resources has been reckoned at 20 billion metric tons and undiscovered coal resources at 10 billion metric tons.^{11/} By way of comparison, coal consumption in Latin America in 1972 was about 16 million metric tons.

^{8/} Grossling, op. cit., p. 30

^{9/} Both estimates are taken from Grossling, op. cit., p. 35, citing W.C. Culberston and J.K. Pitman Oil Shale, 1973, in D.A. Brobst and W.P. Pratt (eds.), "United States Mineral Resources", U.S. Geological Survey. Prof. Paper 820, p. 501.

^{10/} Grossling, op. cit., p. 16.

^{11/} Grossling, op. cit., p. 35, citing P. Averitt, "Coal", 1973, in op. cit., p. 140.

Identified uranium reserves in Latin America have been estimated at 11.4×10^3 metric tons of U_3O_8 .^{12/} No estimate is available for the stock of undiscovered uranium resources in the region.

An estimate of Latin America's hydroelectricity potential requires a different definitional approach from that used in discussing non-renewable energy resources because the energy resource involved in this case is renewable (i.e., falling water). The measuring concept employed is the flow of hydroelectricity that could be generated in the region if all economically exploitable hydropower sites were developed and operated on the basis of average expected water run-off conditions. In 1966, CEPAL estimated that, for Latin America, this volume of hydroelectricity was of the order of $2,835 \times 10^3$ Gwh.^{13/} By way of comparison, the actual level of hydrogeneration in the region in 1975 was about 131×10^3 Gwh.

Since the CEPAL estimate of hydroelectricity potential was made in 1965, world energy prices have, of course, sharply increased, rendering the estimate clearly out-of-date. The level of potential hydrogeneration in the region today is probably much higher than that estimated by CEPAL in 1965, but its true extent is simply not known today with anything even approaching acceptable precision.

The estimates presented above underscore the large scale and diversity of Latin America's wealth in modern energy resources. However, they obscure the widely disparate geographic distribution of these resources among the more than two dozen countries that constitute Latin America. Moreover, they provide no insight into the long-term economic competitiveness of these individual energy resources, either intra-regionally or internationally, while the estimates are so rough empirically that they have little operational usefulness, especially as they have not been

^{12/} Grossling op.cit., p. 46, citing P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, Energy Resources of the United States, U.S. Geological Survey Circular 650, 1972, p. 27

^{13/} Economic Bulletin for Latin America, May 1967, pp. 56-63.

corrected for the effects of the sharp increase in world energy prices since 1973. Finally, the various estimates of energy reserves and resources discussed above are regional aggregates, and while a regional focus is useful for some purposes, in questions of energy resources and policy the key unit is typically the nation, not the region, and so discussions of the region's wealth in energy resources are often beside the point. This is the case in this study, which deals in Chapter II with energy policy at the sub-regional level for the oil-deficit countries.

Section IV. Growth and change in Latin America's energy industries since the fifties

(a) Total energy

Latin America's consumption of modern fuels and vegetable fuels increased by 5.3 per cent per annum during 1950-1975. As shown in Exhibit 10, vegetable fuels were consumed in every Latin American country in both years, although the region's overall dependence on this type of fuel declined sharply during this 25-year period: from 40 per cent of total regional energy consumption in 1950 to 16 per cent in 1975.

Nevertheless, vegetable fuels still constitute a major source of energy supplies in most Latin American countries. In 1975, for example, they constituted more than one-fifth of total energy supplies in seven Latin American economies and more than two-fifths of those supplies in another eight countries.

The data in Exhibit 10 indicate that Latin America drew on all the modern fuels in satisfying its modern energy requirements in both 1950 and 1975.^{14/} Oil and natural gas increased their share in the region's modern energy consumption from 74 per cent (i.e., 67 per cent and 7 per cent, respectively), in 1950 to 77 per cent (62 per cent and 15 per cent, respectively) in 1975. The share of coal declined

^{14/} With the exception of nuclear fuels in 1950.

from 13 per cent to 5 per cent over this period, while that of hydropower was 14 per cent in 1950 and 18 per cent in 1975. Nuclear power was introduced into the region's energy base by Argentina in 1974, but the volume involved in that year was minuscule vis-à-vis the volume of regional energy consumption.

Latin America's overall pattern of reliance on a diversity of modern fuels is not typical of each individual Latin American country. In both 1950 and 1975, for example, only seven 15/ of the twenty-six countries shown in Exhibit 10 produced and consumed the four basic modern energy sources (coal, oil, natural gas, and hydropower), and it would be misleading to suggest that even these countries' modern energy structures were broadly based. In 1975, for example, 75 per cent of modern energy consumption in these seven countries came from oil and gas alone.

Of the remaining nineteen countries listed in Exhibit 10, three (i.e., Bolivia, Ecuador and Trinidad and Tobago) produce oil and natural gas. Bolivia and Ecuador also produce hydropower, but vegetable fuels are important in both economies. In 1975, they supplied 43 per cent of Bolivia's total energy requirements and 38 per cent of Ecuador's. In both Bolivia and Ecuador, oil is clearly the backbone of the energy system. It constituted 73 per cent of Bolivia's modern energy consumption in 1975 and 89 per cent of Ecuador's. In meeting its modern energy requirements, the economy of Trinidad and Tobago is dependent on oil and gas in roughly equal proportions. Other modern fuels are not produced there, and vegetable fuels are comparatively minor in terms of Trinidad and Tobago's total energy requirements (i.e., 6 per cent in 1975).

Few of the remaining sixteen countries listed in Exhibit 10 produced any modern fuel on a significant scale in either 1950 or 1975, and all of them were critically reliant on imported oil throughout this extended period. In four countries - Bahamas, Barbados, Grenada and

15/ Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela.

/Guyana - the

Guyana - the supply of indigenous fuels in 1975 was limited exclusively to vegetable sources, so that the energy supplies in these four countries, in 1975, came entirely from vegetable fuels and from imported refined oil products.

In twelve of these sixteen countries, modern energy production in 1975 was limited to one fuel.^{16/} In Cuba, it was limited to minor volumes of crude oil and hydropower,^{17/} and, in the other eleven countries it was limited to hydropower. Moreover, in all twelve countries hydropower only supplied an average of 5 per cent of total energy requirements in 1975, the remaining 95 per cent being supplied from imported oil (59 per cent), vegetable fuels (35 per cent) and coal (1 per cent). Taken as a whole, these twelve Latin American countries relied on imported oil for roughly nine-tenths of their modern energy requirements in 1975.

(b) The oil industry

(i) Introduction. The oil industry consists of several segments: first, crude oil exploration, development and production; second, crude oil refining; and, third, oil marketing (including both the import and export of crude oil and refined products and the domestic marketing of refined oil products). These segments of the oil industry, and the transport links between them, make possible the ultimate application of refined oil products in production. The pattern of growth and change in these three basic segments of the region's oil industry in the post-war era is discussed below.

^{16/} These countries are: Costa Rica, Cuba (which produces small volumes of oil and hydropower), El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, the Dominican Republic and Uruguay.

^{17/} Crude oil production in 1975 in Cuba was roughly 3 per cent of the volume of refined oil product consumption in that year. Oil constituted 98 per cent of Cuba's modern energy base in 1975, while vegetable wastes supplied 35 per cent of Cuba's total energy consumption in that year (see Exhibit 10).

(ii) Indigenous oil production and domestic oil consumption. The eleven Latin American countries producing crude oil in 1975 were the same as those which produced it in 1950 (Exhibit 11). Oil supplies in the remaining fifteen countries in the region were entirely imported in both 1950 and 1975.

Within this group of eleven crude oil producing countries, however, there have been substantial changes in the degree to which increasing requirements for refined oil products in the domestic economy have permitted the export of indigenously produced oil (Exhibit 12). Venezuela, of course, has been, and will continue to be, a major crude oil exporter. Ecuador, following recent oil discoveries, has moved quickly since 1972 to increase its oil exports. In 1950, Ecuador's crude oil production was around 50 per cent greater than the volume of its internal refined product requirements, but by 1975 such production was 3.9 times the volume of refined oil products consumed domestically (Exhibit 12).

Mexico's crude oil surplus of the early fifties was erased by 1973, only to be reestablished in 1975. Recent developments in the Mexican oil industry promise a resumption of crude oil exports on a significant scale in the future.^{18/} Current plans are to develop an oil export capacity by 1982 of 1,188 thousand barrels per day, fifteen per cent of which will be in the form of refined products; present oil exports are about 200 thousand barrels per day, including about 20 thousand barrels per day of motor gasoline.^{19/}

Argentina was heavily dependent on imported crude in the early fifties, but by 1975 it was producing a volume of crude oil more or less

^{18/} In 1974, a major United States oil company estimated that oil reserves located in Chiapas-Tabasco could amount to 10-20 billion barrels. See: International Petroleum Encyclopedia, 1976 issue, p. 190.

^{19/} See: "Mexico Plans Push on Exports of Gas as well as Oil", Petroleum Intelligence Weekly, June 6, 1977, p. 5.

equal to its domestic consumption of refined oil products.^{20/} Here again, the recent discovery at Puerto Rojas, near Mendoza, is a promising sign for the future. Major efforts in oil exploration and development will surely be called for, however, if Argentina is to remain free of reliance on imported oil in the future.

Peru, a minor crude oil exporter in 1950, supplied roughly three-fifths of its internal refined product requirements from indigenous crude oil in 1975. Self-sufficiency in oil supplies could be achieved and export status recovered with the completion of the Concordia-Bayovar crude oil pipeline.^{21/}

In Trinidad and Tobago, a major crude oil exporter in the region in the fifties, the ratio of crude oil production to domestic oil consumption declined from 16.3 in 1950 to 8.5 in 1975. Crude oil production in Trinidad and Tobago increased only slowly during the sixties, averaging 1.9 per cent per annum, but since 1970 it has increased more rapidly with the development work centered in Trinidad and Tobago's eastern offshore areas.

Colombia was a major Latin American crude oil exporter in the fifties and sixties, but its crude oil export position deteriorated sharply in the seventies. This occurred largely as a result of the pressure of rising domestic requirements for refined oil products in the face of more slowly rising domestic crude oil production, a

^{20/} The comparison is misleading in that Argentina's indigenous crude oil production in 1950 was lower than might otherwise have been possible at that time since the private oil companies were reducing crude oil output, all new oil exploration and development activity having been reserved for YPF by law in 1935. See: Gertrude G. Edwards, "The Frondizzi Contracts and Petroleum Self-Sufficiency in Argentina", R.F.M. Miksell, et.al., Foreign Investments in the Petroleum and Minerals Industries, (Baltimore, Md., 1971), p. 161.

^{21/} This pipeline is 557 miles in length. It has a 200,000 b/d initial capacity (with expansion capacity to 500,000 b/d). The pipeline crosses the Amazon jungle, the Andes, and Sechura desert, reaching Bayovar at the Pacific coast. It went operational in July, 1977.

phenomenon, in turn, largely explained by the comparatively low prices for crude oil and refined oil products set by the State. Recent changes in this policy could bring about a resurgence of indigenous crude oil supplies in Colombia.22/

The reverse took place in this period in Bolivia. In 1950, indigenous crude oil supplied about two-thirds of Bolivia's domestic market for refined products, but in 1975 crude oil production in Bolivia was 2.4 times the volume of refined oil products consumed domestically. YPF's ambitious five-year oil development programme promises a resurgence in Bolivia's participation in the world oil market over the next decade.23/

The remaining three of the region's eleven crude oil producing countries produced substantially less than their volume of internal refined product consumption in both 1950 and 1975. Cuba's crude oil production was negligible in both years, the major change during the period being the shift in import reliance from the United States (and, to a lesser extent, Venezuela) to the Soviet Bloc.24/ Although crude oil production in Brazil and Chile, the two remaining crude oil producers in the region, has increased rapidly since 1950, both produce substantially less crude oil than the volume of their domestic demand for refined oil products.25/ In each country, however, local crude oil production has increased significantly since the early fifties,

22/ See: "Petroleum Intelligence Weekly", August 18, 1975, p. 10; and: International Petroleum Encyclopedia, (The Petroleum Publishing Company, Tulsa, 1975), p. 183.

23/ See: International Petroleum Encyclopedia, (The Petroleum Publishing Company, Tulsa, 1975), p. 178.

24/ The Soviet Union has assumed the role of Cuba's major crude oil supplier in recent years, but to save transport costs the crude oil being landed in Cuba is often the result of swaps of Soviet for non-Soviet bloc oil, and is, therefore, not necessarily Soviet bloc oil in a physical sense.

25/ This statement should not be construed as implying that self-sufficiency in crude oil supplies is a priori an economically defensible or desirable goal.

and Brazil and Chile, by 1975, were supplying volumes of indigenous crude oil that represented about one-quarter (Brazil) and three-tenths (Chile) of their internal refined product consumption. Their strong emphasis on increasing indigenous oil supplies and the development of newly found reserves 26/ could reduce the degree of dependence of both countries on imported oil in the relatively near future.

The total consumption of refined oil products in the remaining group of fifteen Latin American countries which do not produce crude oil (Exhibit 10), constituted less than 10 per cent of total regional consumption in both 1950 and 1975. Obviously, this reflects in part the relatively minor proportions of regional production and population in these countries. The absence of a crude oil producing industry in each of these fifteen countries constitutes a serious constraint on the options open to their energy planners in their design of energy policies to confront the currently high price of imported oil.

Although Latin America as a whole has consistently exported crude oil surplus to regional refined oil requirements, the picture changes substantially when the region's oil-surplus countries are excluded from the regional totals. Thus, in 1950, 3.9 tons of oil were produced in the region for each ton of refined products consumed, and by 1975 this ratio had declined to 1.8. If only the region's oil-deficit countries are considered, however, the figures in Exhibit 12 show that indigenous crude oil production in the region was only about one-quarter of the level of refined product consumption in both 1950 and 1975.

26/ In the case of Brazil, one estimate, based on preliminary data, is that the Garoupa field discovered in 1974 in the Compos Basin, contains about 600 million barrels of oil. This offshore field is located relatively close to the large concentration of refineries in the States of Minas Gerais, Sao Paulo, and Rio de Janeiro. Planned production from Garoupa is set at 200,000 b/d in comparison with Brazil's total crude oil production of about 172 thousand b/d in 1974.

(iii) Exploration and development.^{27/} Many more Latin American countries have explored for oil in their countries than those which have established a crude oil production capability. Exhibit 13 presents data on two decades of petroleum exploration activity in Latin America. Roughly 13 per cent of all wells drilled in the region during this period were exploratory wells, and 35 per cent of these exploratory wells were successful.^{28/} Examination of the data shows that the success rate was particularly high in many South American countries and in Mexico, Trinidad and Tobago and Barbados. Exploration wells in the remaining countries of Central America and in the Caribbean were notably unsuccessful.

Historically, the ratio of wells drilled per unit of potentially oil-bearing land in Latin America has been relatively low. The number of wells drilled per square mile in Latin America (.02) is about 2 per cent of the comparable ratio for the United States (1.17), and is roughly 13 per cent of that for the Soviet Union.^{29/} Additionally,

^{27/} In Latin America, the bulk of exploration and development wells are drilled to find oil, not natural gas. Gas is found largely in association with oil in the region, and it is, therefore, a by-product of finding oil. Available statistics on exploration, development, and production expenditures in Latin America are not disaggregated for oil and gas, and so, this subject will be discussed here jointly for both oil and gas.

^{28/} This is an extraordinarily high success ratio for exploratory wells, and it suggests that many outpost wells are being included in the total for exploratory wells (i.e., the total probably does not include only true wildcat wells).

^{29/} Actually, there is a strong upward bias in the United States ratio due to the stimulation of well drilling there as a result of the oil prorating system. The figures above were calculated from data presented in: B.F. Grossling, "Latin America's Petroleum Prospects in the Energy Crisis", Geological Survey Bulletin 1411, (United States Government Printing Office, Washington, 1975), p. 27.

/Latin America's

Latin America's drilling record has been relatively poor by international standards from the point of view of the volume of oil and gas found per unit of land area drilled. In short, much of Latin America's potential oil and gas-bearing areas remain unexplored, which suggests, in turn, that the bulk of Latin America's wealth in oil and gas reserves is still in the ground, waiting to be found. It is quite possible that, in a matter of decades, Latin America may take its place once again as a leading source of world oil.^{30/}

Exhibit 14 presents the pattern of expenditures on oil and gas exploration and development in Venezuela and the rest of Latin America since the late fifties. Exploration expenditures in Latin America excluding Venezuela peaked in 1959 and subsequently remained at relatively low levels during the sixties. The level (in current dollars) of exploration expenditures by this group of countries was the same in 1969 as it was in 1960, signifying a strong decline in the volume of real resources committed in support of oil and gas exploration activities in this group of countries during this period. Exploration expenditures by these countries continued to stagnate during 1970-1973, but they doubled to 150 million dollars in 1974 and remained at this level in 1975.

A similar trend is evident in the pattern of expenditures by Latin America, excluding Venezuela, on oil and gas development and production. These expenditures increased steadily to a peak of 485 million dollars in 1960, but thereafter they declined, falling to 360 million dollars by 1970. Since then, development and production expenditures by this group of countries have been increasing, and with particular vigour since 1973.

The basic explanation for these diverse trends lies in the changing structure (actual and expected) of world crude oil prices, on the one hand, and in the structure of the expected marginal costs of supplying indigenous crude oil in this group of countries, on the

^{30/} This subject is discussed more intensively in Chapter 2 (Section IV (iv)).

other. More specifically, world crude oil prices during 1950-1957 remained high relative to supply costs, not only in most of the leading oil exporting countries at that time, but in many Latin American oil-deficit/oil-producing countries as well. This fact provided a stimulus to develop more crude oil reserves and to produce from them and/or to explore for cheaper oil. This incentive was reinforced because the structure of world oil prices at that time was being taken as a predictor of future oil prices and because import substitution strategies were being pursued aggressively, as a matter of national policy, by oil-deficit countries in Latin America. On the other hand, this tendency was restrained by the fact that decreases in the unit cost of international oil transport were reducing the expected landed cost of imported crude oil during this period.

The price (in current dollars) of internationally traded crude oil peaked in 1958 and then declined until 1970. Since 1970, the trend in world oil prices has been sharply upward, particularly since 1973. The decline in exploration expenditures during the sixties in Latin America (excluding Venezuela) reflects, inter alia, widespread decisions at that time against investment in oil and gas exploration programmes in the face of what was probably the prevailing expectation at that time that future landed prices of world oil would be significantly lower than then current prices. Additionally, while continuing development and production expenditures did support an increasing level of crude oil output, the expectation of declining real prices for world oil evidently restrained many oil companies and governments in the region from undertaking not only exploration but also major oil development programmes.

An upward revision of the level of actual (and expected) world crude oil prices in the seventies is undoubtedly the major force behind the upswing in the level of oil exploration, development, and production expenditures in Latin America excluding Venezuela during the present decade.

/Changes in

Changes in the pattern of expenditures in Venezuela on oil and gas exploration, development, and production must be examined separately from those of other Latin American countries. In 1943, the Venezuelan Government agreed to the extension up to 1983 of the concessions of the foreign oil companies operating there, in return for increased taxes. In the early fifties, oil production increased sharply in Venezuela during a period of burgeoning world oil consumption, while Venezuela's proven reserves of crude oil increased only sluggishly (Exhibit 15). Despite a sharp increase in the drilling of exploratory and development wells, Venezuela's reserve production ratio showed no appreciable change during 1950-1955.

Departing from previous policy, the Venezuelan Government extended new concessions to foreign oil companies in 1956 and 1957, and investments in oil and gas exploration and development increased through 1958. Since then, new concessions have not been extended to foreign oil companies, and these companies have shifted their investment focus progressively to the Middle East and Africa. Crude oils from these regions have increasingly displaced Venezuelan crude oil, and this retarding effect was compounded by the United States crude oil import quota system that was imposed in 1959 on announced grounds of "national security".

The data in Exhibit 14 underscore the sharp decline since 1958 in the number of new wells commissioned in Venezuela, not only in exploration but in development and production as well. Given the declining volume of real resources committed to developing crude oil reserves, the result, once again, was that Venezuela's reserve production ratio began to decline, falling to 11.2 in 1969 and 1970. Since then, however, the strong increase in real crude oil prices in the world market has been a windfall to Venezuela in terms of the extent of its proven crude oil reserves. Gains on this account, taken in conjunction with declining levels of crude oil production since 1970, have been the major forces behind the strong increase in recent years in Venezuela's reserve production ratio, which reached 21.5

/in 1975.

in 1975. Nevertheless, the long-term need to build up crude oil reserves is being increasingly stressed in Venezuela, and the stage seems set for striking increases in investment for this purpose.^{31/}

Since 1970, the increased price of world oil has been accompanied by reductions in the level of Venezuelan crude oil production (Exhibit 15) and de facto increases in Venezuela's economically exploitable reserves of crude oil. Venezuela's exploration and development expenditures have increased since 1970, but exploration expenditures, although increasing, still remain at relatively low levels (Exhibit 14). Crude oil reserve management in Venezuela in the recent past has been focused basically on the task of drawing from proven and extended proven reserves, with little emphasis on the identification of new fields by wildcat drilling.

(iv) Oil refining. Since the fifties, Latin America has substituted domestically refined for imported refined oil products on a major scale. In 1950, the region's oil-importing countries were heavily reliant on the international market for their supplies of refined oil products (Exhibit 16). Since then, however, substitution has proceeded to such a point that, by 1970, imports of refined oil products were still only about the same (i.e., 13 million cubic metres) as had been recorded twenty years earlier. Refined oil products imported into region today are basically the result of the need to rectify relatively minor discrepancies between domestic market requirements for and refinery yields of individual refined oil products, together with the need for some specialty products which it is more economic to import than to produce locally.

The basic factors promoting the expansion of local refining capacity in the Latin American countries since the fifties have been the increasing scale and diversity of the requirements for refined oil products in them and the strong declines in the cost of transporting

^{31/} See: "Venezuelan oil sector runs into political problems", Latin America Economic Report, 1 July, 1977, Vol. V, No 25.

oil internationally. These pressures have been operating on a world scale, the result being a massive shift from resource-oriented to market-oriented refineries in the post-war era. In Latin America, as elsewhere, the pressure to secure reductions in the transport costs of oil imports through local refining was reinforced by central governments favouring import substitution and projects designed to save foreign exchange. Other perceived advantages were probably at work as well, such as increasing the diversity of energy suppliers and the pursuit of prestige projects. As will be discussed subsequently, this shift to the domestic refining of imported crude oil rather than importing refined oil products was accompanied in Latin America by a tightening of control by central governments over the domestic refining industry and, more generally, over the domestic energy industries. Finally, as will also be discussed later, many of the quantitative increases in Latin America's crude oil refining capacity since the fifties have been export-oriented, built to satisfy the growing market for refined products in North and South America and, to a lesser extent, in Western Europe.

The substitution of domestically refined for imported oil products has been accompanied by an increased regional reliance on imported rather than indigenous crude oil (Exhibit 17). In 1975, this dependence was total in many Central American and Caribbean economies as well as in Paraguay and Uruguay, and in the same year imported crude oil was the major source of crude oil used in the refinery systems of Cuba (97 per cent), Brazil (76 per cent), Chile (66 per cent) and, to a lesser extent, Trinidad and Tobago (57 per cent) and Peru (38 per cent). In Argentina, however, imported oil represented only 10 per cent of refinery runs in 1975. The remaining crude oil producing countries in the region ^{32/} operated their refineries on indigenous crude oil in both 1950 and 1975.

^{32/} Namely, Venezuela, Bolivia, Colombia, Ecuador and Mexico.

The expansion in Latin America's refining capacity since the fifties (Exhibit 18) has been accompanied by three other trends: first, an increase in the average size of crude oil refining units; second, the installation of more catalytic cracking and reforming capacity;^{33/} and, third, an increase in the number of large-scale, export-oriented refineries in the region, these being located in Venezuela and in the Caribbean.

Between 1957 and 1976, installed refining capacity in Latin America increased from 2,644 to 7,690 thousand barrels per day (TBD), while the scale of the average oil refinery ^{34/} increased from 37 to 85 TBD (Exhibit 19). Much of the increase in regional refinery capacity recorded during this period was accounted for by the installation of large-scale (i.e., more than 100 TBD capacity) export-oriented refineries in the Caribbean and in Venezuela. A similar concentration of increasing refinery capacity in units of over 100 TBD was observed in South America excluding Venezuela. This shift to larger-scale refineries was seen in Argentina, Brazil and Colombia, and it allowed each of these countries to increase their refining capacity between 1957 and 1976 while reducing the number of refineries. In the remaining countries of South America, during the same period, one refinery was built in the 31-50 TBD range (in Ecuador); three were built in the 51-100 TBD range (two in Chile and one in Peru); and there was an increase in both the number and capacity of small scale (i.e., less than 30 TBD) refineries, in the remaining small oil markets of South America.

^{33/} Catalytic cracking is the act of breaking down relatively large oil molecules into smaller and lower boiling molecules. The more stable of these molecules are then collected largely in the form of cracked gasoline, the remaining reactive molecules polymerizing into tar and coke. Reforming refers to the cracking of naphtha to yield more volatile fractions of higher octanes. Reforming differs from catalytic cracking essentially in that a more volatile charge stock is used in reforming than in catalytic cracking, but each process has as its main purpose the production of more motor gasoline.

^{34/} Average refining capacity is total crude oil refining capacity divided by the number of refineries constituting that capacity.

In Central America, the new refineries installed during 1957-1976 tended to be small in scale, reflecting the size of internal markets there. Mexico, in contrast reduced the number of its refineries during 1957-1976 while increasing national refining capacity by 316 TBD. This was achieved basically by the installation of three refineries, each with a capacity of more than 100 TBD.

This increase in average refinery size in the region has been accompanied by an increase in reforming capacity and, in the non-oil-exporting countries of the region, in catalytic cracking capacity as well. (Exhibit 18). Thus, the growth in distillate refining capacity and in catalytic and reforming capacity in the region has been sufficient to reduce imports of gasoline from about 68,000 barrels per day in 1950 to about 40,000 barrels per day by 1975, despite a five-fold expansion in the consumption of gasoline in these countries during this 25-year period.

Refining operations in Latin America are of two basic types: first, there is the typical country case of the refining system oriented to the domestic market; and second, there are the relatively large, export-oriented refinery systems which transform crude oil into fuel oil and other refined products for export, largely to the markets of North and South America and Western Europe.

In Venezuela the export-oriented refineries operate on indigenous crude oil, but in Trinidad and Tobago they are heavily dependent on imported crude oil. In 1975, indigenous crude oil constituted only about one-half of Trinidad and Tobago's total crude requirements, the remaining crude oil requirements being supplied largely from the Middle East (65 per cent) and Indonesia (32 per cent).^{35/}

The other export-oriented refineries located in the Caribbean run exclusively on imported crude oil. In 1975, crude oil imports into Aruba and Curaçao, for example, came largely from Venezuela

^{35/} The United Nations, World Energy Supplies, 1971-1975, Series J, No 20, 1977, p. 76.

(70 per cent) and to a lesser extent from the Middle East (11 per cent) and North Africa (12 per cent). In Puerto Rico, the major suppliers of imported crude oil in 1975 were the Middle East (60 per cent) and Venezuela (35 per cent). Export refinery operations in the Bahamas were heavily dependent, in 1975, on crude oil imported from Africa (51 per cent) and from the Middle East (40 per cent).^{36/}

Map 1 shows the location in Latin America of petroleum fields, refineries, tanker-receiving ports, pipelines, rivers with river - and ocean - going traffic, and major concentrations of population. The bulk of the refining capacity in Central and South America is located in or near large coastal cities. Basically, this spatial pattern of refinery location reflects two facts: first, the bulk of this capacity runs on imported crude oil; and second, the large coastal cities, where these refineries are located, also constitute the major domestic markets for refined oil products.

Concentrations of population and industrial activity outside these major port cities are typically too small to merit the installation of crude oil pipelines from coastal crude oil receiving terminals to the inland refineries that would have to be built to service these small inland markets. Generally, they are supplied by moving refined oil products from seaboard refineries by truck, train, and barge, while the other quantitatively minor coastal markets are supplied by moving refined products by sea from the large coastal refineries. Refined product pipelines do not abound in the region, and the relatively minor mileage of such pipelines is concentrated in Argentina, Bolivia, Chile, Colombia and Mexico.

There are, however, exceptions to the general spatial pattern of refinery concentration in or nearby major coastal cities. The several thousand miles of crude oil trunk pipelines used for this purpose are located largely in Argentina, Bolivia, Brazil, Colombia, Mexico and Venezuela, where there are relatively large markets for a

^{36/} Ibid, pp. 74-77

diversity of refined oil products (e.g., Mexico City). The bulk of the crude oil pipeline capacity in the region, however, has been installed to move crude oil from producing areas to the coast for direct export and/or local refining for the domestic and/or the export market.

(v) Latin America's international oil trade. In this section, a brief discussion is provided of two topics: first, the scale, country composition, and geographic destination of Latin America's exports of crude oil and refined oil products; and second, the scale and geographic source of crude oil imports into Latin America's oil-deficit countries.

The figures in Exhibit 20 underscore the continuing importance of Venezuela in regional exports of both crude and refined oil products. In 1950, Venezuela accounted for 90 per cent of crude oil exports and 20 per cent of refined oil exports from Latin America. The comparable shares in 1975 were 77 per cent and 43 per cent, respectively. The increasing percentage share of Venezuela in the export of refined products during this period was won largely at the expense of Aruba and Curaçao, whose share in the region's refined product exports declined from 76 per cent in 1950 to 34 per cent in 1975. Moreover, the share of refined oil products in the mix of Venezuela's total oil exports has increased from 13 per cent in 1950 to 29 per cent in 1975. In this regard, Venezuela, which is a relatively high-cost crude oil supplier (compared with many Middle Eastern and African countries), has been concentrating increasingly on the export of refined products (largely fuel oil) to the North American and Latin American markets in contrast with its earlier and relatively more pronounced specialization in the world crude oil market.

The data in Exhibit 20 show the decline that took place in the fifties and sixties in crude oil exports from Colombia, Peru and Mexico, while at the same time they underscore the rapid growth that has occurred in the seventies in the volume of such exports from Bolivia, Ecuador, and Mexico. In 1975 these latter three countries, together with Venezuela, accounted for 90 per cent of Latin America's crude oil exports.

/A similar

A similar pattern of country concentration is evident in the case of Latin America's exports of refined oil products. In 1975, three countries accounted for over nine-tenths of these exports: Aruba and Curaçao (34 per cent), Venezuela (43 per cent), and Trinidad and Tobago (14 per cent).^{37/}

Exhibit 21 presents data on the destination of Venezuela's exports of crude oil and fuel oil. The figures on the volume of crude oil exports underscore Venezuela's heavy reliance on sales to the export refinery operations at Aruba and Curaçao and to the United States and Canada. In 1975 these three markets accounted for seven-tenths of Venezuela's crude oil exports, while in combination with sales to Latin America and Western Europe they accounted for all but 7 per cent of Venezuela's total volume of crude exports.

During the fifties and sixties, Venezuela's exports of crude oil to Aruba and Curaçao stagnated. This was largely the result of a corresponding stagnation in refined product exports from Aruba and Curaçao caused, in turn, by the worldwide shift to domestic refining operations that took place at that time. Increased competition from other large-scale export-oriented refineries, including of course those in Venezuela itself, also contributed to this pattern (Exhibit 20). These forces, together with the depressing influence of the higher prices on refined product consumption throughout the world since 1973, largely account for the fact that Venezuela's exports of crude oil to Aruba and Curaçao in 1975 were only one-half the level recorded in 1950.

The steadily declining costs of moving oil internationally have made Middle Eastern and African oils increasingly competitive with Venezuelan oils in major world markets in the post-war era.

^{37/} The figures in Exhibit 20 exclude exports of refined oil products from the Bahamas and Puerto Rico and to this extent overstate the dominance of Venezuela, Aruba and Curaçao, and Trinidad and Tobago in this export market.

/Additionally, the

Additionally, the imposition of mandatory oil import controls by the United States Government in 1959 was a major factor in eroding Venezuela's subsequent penetration of this market for crude oil and promoting Venezuela's strategic concentration on the export of fuel oil to that country.

Fuel oil accounted for seven-tenths of Venezuela's total exports of refined products in both 1950 and 1975. Exports of fuel oil from Venezuela are heavily concentrated in the United States market and, more specifically, in the market for boiler fuels in the eastern United States. In 1974, for example, about seven-tenths of Venezuela's fuel oil exports went to this market, but the strong decline in fuel oil imports by the United States from Venezuela reduced this share to 53 per cent in 1975.

Venezuela's Latin American and European fuel oil markets have been eroded since the fifties due to the expansion of domestic refining facilities in these markets (drawing largely on Middle Eastern and African crude oils) and the competition of other export refineries in or oriented towards the European market. New markets for Venezuelan fuel oil have been created since the fifties in Aruba and Curaçao, in Puerto Rico, and in the expanding ships' bunker market in Panama. Up to 1974, however, growth in fuel oil sales to these three expanding markets had only just about offset Venezuelan's losses in its Latin American, European and other traditional fuel oil markets, with the result that net growth in Venezuela's fuel oil exports from the fifties to 1974 was largely due to growth in the volume of exports of this refined product to the United States. With the strong decline in fuel oil imports by all of Venezuela's key customers in 1975 (except Aruba and Curaçao), the volume of fuel oil exports in that year was reduced to what it had been about fifteen years earlier. For the most part, the strong decline in the volume of Venezuela's exports of fuel oils in 1975 was the result of the corresponding decline in United States fuel oil imports, compounded

/by the

by the relative displacement of Venezuelan fuel oils by those exported to the United States from refineries in the Caribbean islands, particularly from the Netherlands Antilles and from the Amerada Hess refinery in the Virgin Islands.^{38/}

The increased prices received for Venezuela's exports of crude oil and refined oil products since 1973, however, have more than compensated for reduced sales volumes since that time. Thus, between 1973-1975 the volume of Venezuela's crude oil and refined product exports declined by 30 per cent and 40 per cent, respectively, but the value of Venezuela's oil exports increased from 4.5 billion dollars to 9.9 billion dollars (Exhibits 21 and 22).

^{38/} The basic quantitative changes underlying the strong decline in Venezuela's exports of fuel oils to the United States market during 1974-1975 are summarized below (in millions of metric tons per year):

	Apparent United States consumption of fuel oils	United States refinery output			United States imports of fuel oils						
		Total	Distillates	Residuals	Total	Venezuela	Virgin Islands	Netherlands Antilles	Bahamas	Trinidad and Tobago	Puerto Rico
1974	284	616	135	59	102	33	18*	20	8	8	2*
1975	262	627	134	68	74	15	17*	17	7	5	2*
1974-75	(22)	11	(1)	9	(28)	(18)	(1)	(3)	(1)	(3)	-

Source: United Nations, World Energy Supplies, 1971-1975, Statistical Papers, Series J, No 20, pp. 140-141, and United States Department of Commerce, Bureau of the Census, United States General Imports Schedule A, Commodities by Country (FT 135, December, 1974), pp. 2-128 and pp. 2-130; and Ibid (1975), pp. 2-124 and pp. 2-125. Statistics given in these two sources in barrels were converted to metric tons using a conversion factor of 1 barrel = 0.149 metric tons.

For a discussion of the discriminatory impact of United States government programmes on Venezuela's fuel oil exports to the United States East Coast and the competitive advantage accorded to refiners in the United States and in the United States Virgin Islands during 1975, refer to: "United States Policy Review Might Ease Woes of Caribbean Refiners", Petroleum Intelligence Weekly, January 12, 1976, p. 1; and "United States Plans to Ease Market Barriers to Imported Oil", op. cit., February 16, 1976, p. 1.

* Estimated figure, taking total exports of fuel oils given in World Energy Supplies as equal to fuel oil exports to the United States.

Crude oil imports by Latin American countries increased by about 10 per cent per annum during 1955-1970 (Exhibit 23). During this period, almost every oil-deficit Latin American country sharply reduced its dependence on crude oil supplied from within the region, so that the share of regional supplies in Latin America's total crude oil imports declined from 69 per cent in 1955 to 42 per cent in 1970. Since 1970, the decline in intra-regional dependence on crude imports has been particularly marked. By 1975, 85 per cent of the crude imported by Latin America's oil-deficit countries came from outside the region, mostly from the Middle East (51 per cent) and Africa (12 per cent). In 1975, reliance on regional crude oil supplies was only one per cent and 12 per cent in the case of Trinidad and Tobago and Uruguay, respectively, and in Brazil, Latin America's major crude oil importer, the ratio was only 2 per cent in that year. The ratios were still relatively high in 1975 in the case of Chile (39 per cent) and Argentina (34 per cent).

(vi) Latin America's consumption of refined oil products. The bulk of Latin America's consumption of refined oil products is accounted for by a few countries. Thus, eight of the twenty-four countries listed in Exhibit 24 accounted for nine-tenths of regional consumption of these products in 1975: Brazil (27 per cent), Mexico (23 per cent), Argentina (15 per cent), Venezuela (7 per cent), Colombia and Cuba (5 per cent), Peru (4 per cent), and Chile (3 per cent). Although the consumption of refined oil products in the remaining sixteen countries has grown rapidly since the fifties, they still constitute small oil markets. On average, refined product consumption in this group of sixteen countries was roughly 18 thousand barrels per day in 1975, and in many of them the level of average daily oil consumption was substantially below even this relatively low figure.

The growth rate of Latin America's consumption of refined oil products declined from 7.7 per cent during 1950-1960 to 5.8 per cent during 1960-1970. This decline was observed in 18 of the 24 countries /listed in

listed in Exhibit 25.^{39/} The reasons for it are diverse, but - generalizing for the region as a whole - the major forces at work were probably a concomitant deceleration in the pace of growth in the relatively energy-intensive industries and in the mechanization of work processes between the fifties and sixties, together with a speeding-up of the substitution of natural gas for fuel oil. At the regional level, the forces promoting the deceleration in refined product consumption seem to have offset the effects of the acceleration in the rate of growth of Latin America's total real output and the more-or-less steady rate of growth in regional population during 1950-1960/1960-1970.^{40/}

The average rate of growth of regional refined product consumption during 1970-1973 was 7.4 per cent (Exhibit 24), the increase in world oil prices in those years providing no significant brake on Latin America's oil consumption. During 1973-1974, the period of sharpest increase in world oil prices, however, a strong deceleration occurred in the growth rate of refined product consumption in Latin America, so that growth in 1973-1974 was limited to 4.1 per cent despite a 6.9 per cent increase in real regional output ^{41/} (as against 6.8 per cent during 1970-1973).^{42/}

^{39/} In Brazil and Chile, these rates of growth were approximately equal for the periods 1950-1960 and 1960-1970. In the remaining four countries, i.e., Costa Rica, El Salvador, Barbados and Trinidad and Tobago there was an acceleration in the growth rate of refined product consumption. These four countries are of only minor quantitative importance in terms of defining trends in regional oil consumption, however, and together they accounted for only about 2 per cent of the volume of regional oil product consumption in 1970.

^{40/} The growth rate of regional total real output accelerated from 5.1 per cent during 1950-1960 to 5.6 per cent annum during 1960-1970. Regional population growth averaged 2.8 per cent in both periods.

^{41/} CEPAL, "La Economía Latinoamericana en 1976 (I)", Notas sobre la economía y el desarrollo de América Latina, Nº 250, August, 1977, p. 1.

^{42/} CEPAL, Statistical Division.

During 1974-1975, the slowing-down of the growth rate for refined product consumption was further intensified: growth was limited to 0.9 per cent, despite an increase in real regional output of 2.6 per cent during 1974-1975. Significantly, the absolute level of refined product consumption in the group of 18 oil-deficit countries noted in Exhibit 24 declined during 1974-1975, the growth rate in refined product consumption of this group of countries declining from 1.9 per cent (1973-1974) to -1.1 per cent (1974-1975). Four of the eighteen countries in this group had lower levels of refined product consumption in 1975 than in 1970.

To sum up, the figures in Exhibit 24 suggest that the sharply increased world oil prices in the seventies, and particularly since 1973, eventually acted as a brake on the growth rate of the consumption of refined oil products in almost all Latin American countries, although country-by-country examination shows that the extent and timing of this braking effect varied widely among them. The braking effect was particularly pronounced during 1974-1975 in the region's oil-deficit countries. In many countries, of course, this effect was compounded by a slowing of the growth rate of total real output, particularly during 1974-1975: a phenomenon which, in its turn, was casually linked, in part, to the increased price of world oil in the first place.

The changes recorded in the structure of consumption of refined oil products in Latin America during 1950-1974 are detailed in Exhibit 25. Basically, there were two major kinds of change:

First, since 1950 gasoline and diesel oil, the region's key transport (and stationary engine) fuels, have been displacing fuel oil, the region's prime boiler fuel. The combined share of gasoline and diesel oil in total refined product consumption increased from about two-fifths in 1950 to one-half in 1975. These two refined products accounted for 57 per cent (i.e., 31 per cent and 26 per cent, respectively) of the total increase in refined oil product consumption recorded in Latin America during 1950-1975.

/By way

By way of comparison, fuel oil's share in the volume of refined product consumption in the region declined from 50 per cent in 1950 to 31 per cent by 1975. Taken as a whole, the increasing share of gasoline and diesel oil reflects the fact that the mechanization and growth of transportation activities was proceeding at higher rates during 1950-1975 than the growth of consumption of fuel oil, which was already widely in use as early as 1950 as a boiler fuel in industry and power plants. It should be noted, however, that this pattern of change has taken place within the context of rapidly increasing volumes of consumption of fuel oil, gasoline, and diesel oil since the fifties.

Second, the share of these three leading oil products in Latin America's total refined product consumption has declined since the fifties from 91 per cent in 1950 to 84 per cent in 1975. This broadening of the base of refined oil products consumed in energy applications in the region is due to the growth in the use of liquefied petroleum gas, principally as a household fuel, from 1 per cent of total oil products consumed in the region in 1950 to 8 per cent in 1975. By way of contrast, kerosene, although increasing rapidly in terms of volumes consumed during this period, recorded the same market share (8 per cent) in oil product consumption in 1975 as it did in 1950.

(vii) Ownership and control of Latin America's oil industries. Exhibit 26 presents data up to 1976 on the extent of public ownership of various segments of the oil and gas industries in eleven Latin American countries. In 1975, the eleven countries listed in Exhibit 26 accounted for about 95 per cent of Latin America's oil production; 92 per cent of crude oil exports; about one-half of both refined product exports and regional crude oil refining capacity; and 93 per cent of the volume of refined oil products consumed in Latin America.

/The figures

The figures in Exhibit 26 underscore the widespread, high, and generally increasing level of public ownership of Latin America's oil industry. When account is taken of the fact that, throughout Latin America, central governments also play critical roles in the pricing, transport, importing and exporting of oil and in the investment decisions of the oil industry, it is readily apparent that the Latin American oil and gas industries are tightly controlled by governments throughout the region, even though they may not be owned by the government in a specific country.

Exhibit 27 presents more detailed data on the structure of refinery ownership in Latin America. The eight major integrated world oil companies accounted for about 64 per cent of Latin America's refining capacity in 1957, but only 21 per cent in 1976, this strong decline being due largely to the nationalization of the Venezuelan oil industry on 1 January 1976.

In 1957, about nine-tenths of the ownership by the majors was concentrated in refining facilities in Venezuela, Aruba, Curaçao and Trinidad and Tobago. In 1976, however, full foreign ownership by one or more of the eight majors was restricted to the export refineries at Trinidad and Tobago and at Aruba and Curaçao, and to a few small, domestically-oriented refineries in Central America and the Caribbean. Partial ownership by one or more of the eight majors in 1976 was restricted to Argentina (32 per cent), Colombia (5 per cent), Ecuador (21 per cent), El Salvador (82 per cent), and Puerto Rico (13 per cent).

The nationalization of the Venezuelan oil industry in 1976 calls for comment at this point. Nationalization extended to all assets of the foreign oil companies in Venezuela, and compensation was calculated on the basis of the net book value of each company's assets. Altogether, the foreign companies received 1.28 billion dollars for these assets.^{43/} A Venezuelan commission was set up, and arrangements were made between each foreign oil company and the counterpart Venezuelan company created to deal with such arrangements. Under official policy, direct participation by foreign oil companies in the Venezuelan

^{43/} International Petroleum Encyclopedia, 1976, (The Petroleum Publishing Co., 1976), p. 194.

oil industry was rejected in favour of operating contracts, negotiated on a company-by-company basis. Under this approach, the foreign oil company is paid a fee in return for specified services such as producing and refining crude oil. Obviously, however, the resulting net acquisition cost of Venezuelan oil to the companies must be sufficiently competitive to induce them to continue purchasing Venezuelan oil, since these companies also have access to oil elsewhere.^{44/}

(c) Natural Gas

In Latin America, indigenous production of natural gas is limited to ten countries (Exhibit 28), most of the reserves being located in four countries which in 1975 accounted for 84 per cent of total regional gas supplies: Venezuela (41 per cent), Mexico (24 per cent), Argentina (11 per cent) and Chile (8 per cent).

In 1975, natural gas accounted for about two-fifths of the modern energy sources consumed in Venezuela and Trinidad and Tobago (Exhibit 10), while it supplied major shares of modern energy consumption in Mexico (25 per cent), Argentina (22 per cent), Colombia (12 per cent), and Chile (14 per cent). It accounts for between 2 and 6 per cent of modern energy requirements in Bolivia, Ecuador, and Peru, while in Brazil natural gas forms less than one per cent of the volume of modern energy sources consumed.

^{44/} In January, 1976, Exxon reportedly received 24.5 ¢ per barrel from the Venezuelan government for "technical services" rendered in that month, which was higher than the 22 ¢ margin widely reported in the case of many Middle East producing countries at that time. Exxon was paid a service fee of 15 ¢ per barrel of crude oil produced and another 15 ¢ for each barrel refined, which for January, 1976, amounted to about 24.5 ¢ per barrel of crude oil production. For details, see "Petroleum Intelligence Weekly", March 1, 1976, p. 5.

The discovery of natural gas reserves in Latin America is a by-product of exploring for oil, since the two are usually found together and the objective of wildcat drilling in the region is typically to find oil, not gas. Few wildcat projects have been undertaken historically in the region in search of natural gas simply because the stock of proven gas reserves has usually been far more than that required to satisfy final energy markets. In the past, governments have preferred to invest scarce capital in the search for and development of oil deposits (or in other sectors of the economy) rather than in the development of the costly systems of gas transmission and distribution needed to release gas reserves for consumption.

Latin America's natural gas distribution pipeline systems are largely intra-national (Map 1). These lines transport natural gas from the producing fields to the usually far-away processing facilities at urban coastal sites for ultimate delivery to domestic consumers. Latin America's international trade in natural gas is limited to minor volumes of gas exports from Bolivia and Chile to Argentina ^{45/} and to small volumes of two-way exchanges of this fuel between Mexico and the United States. ^{46/} The pipelines supporting this trade are shown on Map 1.

The major pipeline project now planned in Latin America is the projected Bolivian-Brazilian gas transmission line. ^{47/} Mexico's planned

^{45/} In 1974, Bolivia exported 1,546 billion cubic meters of natural gas to Argentina via the pipeline which extends from the fields near Santa Cruz and Chuquisaca to the Argentina border at Yacuiba and then down to major processing and consuming centres along the Rio de la Plata. This 150 billion cfd, 330 mile pipeline went operational in 1972. Between July and December, 1976, Chile sold 357 million cubic meters of natural gas to Argentina.

^{46/} In 1974, Mexico exported 12 million cubic meters of natural gas to the United States, from which it imported 376 million cubic meters in return. Mexico's exports are to the Brownsville, Texas area, while its imports, secured from the area of Laredo, Texas, are obtained via the pipeline to Nueva Rosala.

^{47/} A pipeline project is planned to carry gas from Bolivia's gas fields in the Santa Cruz area all the way to Brazil's Sao Paulo industrial centre, some 1,200 miles distant. The project's cost is estimated at 3 billion dollars and it will supply Brazil with 400 billion cfd of natural gas.

gas pipeline project is shown in Map 1. Interest has been shown in the economic feasibility of shipping liquefied gas from the southern gas fields to central and northern centres of energy consumption in Chile, as a substitute for the imported oil on which these centres are now heavily reliant. The high price of oil in world markets could also increase interest in transporting natural gas from Peru's large fields, located east of the Andes, to Lima. In general, the sharp increase in the price of imported oil promises a widespread review of the potential for exploiting Latin America's wealth in natural gas as well as in other energy sources such as coal and hydropower.

As in the case of refined oil products, data on the end-use applications of natural gas in Latin America are too fragmentary for substantive analysis. Exhibit 29 presents data on the volumes of gas produced and marketed in selected countries since the mid-fifties. These figures underscore the low ratio of gas actually marketed to the volumes of gas produced. Much of the difference is explained by the use of gas to maintain reservoir pressures and thus stave off otherwise physically unavoidable increases in the unit cost of crude oil production due to declines in well pressure over time. Sizeable volumes of natural gas produced in Latin America have also been flared off, however, as shown in Exhibit 29. The increased cost of world oil has increased pressure to reduce these volumes of flared gas in the future.

Although supporting data are not available, the major uses of the natural gas marketed in the region appear to be as a boiler fuel in thermal power stations (particularly in Venezuela, Mexico and Argentina) and as a feedstock for industrial chemicals (e.g., methanol) and fertilizers. Relatively minor volumes are also marketed for household use for cooking and space heating.

Exhibit 26 presents data on the extent of central government direct ownership of most of the domestic natural gas industries in Latin America. As in the case of the oil industries of these countries, ownership of Latin America's natural gas industries is concentrated heavily in the hands of central governments.

(d) Coal

Coal's share in Latin America's consumption of modern fuels declined from 13 per cent in 1950 to 5 per cent in 1975. In 1975, coal was produced in only seven Latin American countries, four of which accounted for more than nine-tenths of the region's coal production: Mexico (39 per cent), Colombia (24 per cent), Brazil (20 per cent), and Chile (12 per cent). Argentina, Peru and Venezuela also produced coal in 1975, but on decidedly minor scales (Exhibit 30).

Exhibit 30 shows the volumes of coal produced, imported, exported, and consumed in various Latin American countries in selected years since 1950. During 1960-1975, three countries accounted for the bulk of increased coal production in the region: Brazil, Colombia, and Mexico. In Colombia and Mexico, local coals are suitable for producing coke for the steel and other metallurgical industries, and this, plus the stimulus to conserve oil in the seventies, is one of the reasons for the increased coal production in these two countries. This has enabled both Colombia and Mexico to support increased volumes of metal production with relatively little marginal need to import higher grades of coal or coke.

By way of contrast, Brazil's indigenous coal is relatively poor in quality, and this has made necessary greater reliance on imports of coking coal and coke for blending purposes in order to satisfy the technical requirements for coke in Brazil's expanding metals industry.

At the same time technical progress since the fifties in the region's steel industry has reduced the volume of coke required per unit of steel output. This progress has constituted a brake on the rate of growth of Latin America's requirements for indigenously supplied coking coal and for imported coals and coke as well. This downward pressure on the growth in coal requirements has been most important in

/those countries

those countries where the steel industry has accounted historically for high fractions of total coal sales.^{48/}

Apart from steel, the other major market for indigenous coal in the region has been the electric power industry. Coal deliveries to this industry have provided a hedge in some Latin American countries against big losses to oil in traditional markets for local coal.^{49/}

In Colombia, and in some locations in Mexico, where the quality of indigenous coal and its location to markets are relatively more favourable, the loss of markets for coal to oil and gas has been moderate. Nevertheless, in almost every major coal-producing country in the region, coal's share in domestic energy consumption declined during 1950-1975.^{50/}

Generally speaking, in those Latin American countries which produce both coal and oil, oil has eroded coal's position most severely where the quality of indigenous coal has been relatively poor and where it is costly to extract and then to transport to domestic consumers, as in the cases of Argentina, Chile, and Venezuela. This comment aside, however, it is obvious that competition from oil has been the major force explaining the lack of dynamism in Latin America's coal industry in the post-war era. Despite the increased incentive in the seventies to replace oil with coal, coal's share in Latin America's modern energy consumption was lower in 1975 (i.e., 5.0 per cent) than it was in 1970 (i.e., 5.3 per cent).

^{48/} In 1972, these functions were as follows: Argentina (44 per cent), Brazil (62 per cent), Mexico (68 per cent), Chile (27 per cent), Colombia (18 per cent), Peru (58 per cent), and Venezuela (93 per cent). See: R. Suárez, "El Carbón Latinoamericano y sus perspectivas", Annex I, pp. 259-286, published in: Comisión Económica para América Latina, América Latina y los Problemas Actuales de la Energía, published by the Fondo de Cultura Económica, Mexico, 1975.

^{49/} In 1972, the electric power industry accounted for the following percentage share of coal deliveries: Argentina (19), Brazil (35), Chile (35), Colombia (13), and Mexico (3). See: R. Suárez, El Carbón Latinoamericano y sus perspectivas, op.cit., Annex I, pp. 259-286.

^{50/} The only coal consuming countries in the region which recorded an increase in this ratio during the period were Mexico (from 6.6 per cent to 7.2 per cent) and Venezuela (from 0.5 per cent to 1.0 per cent).

Exhibit 31 presents one estimate, published in 1972, of the extent of measured and potential reserves of coal in Latin America and in other countries and country groupings. Also indicated is the volume of coal produced in these areas in 1975. These figures show the huge size of the identified physical stocks of coal compared with coal consumption. As in the case of natural gas, the major problem in Latin America is not to add to the stock of identified coal reserves but rather to develop and produce more coal from already identified stocks in response to the higher prices of world energy sources since 1970.

Foreign capital has never played an important role in Latin America's coal industry. Typically, the State has protected the indigenous coal industry from collapse under the pressure of competition from oil and imported coal. Detailed discussion of the protection of the region's indigenous coal industry in the post-war period, however, is blocked by lack of data.

(e) Electric power

(i) Electricity consumption. The electric power industry consists of three segments: generation, transmission, and distribution. Base load and peak power requirements are met by power stations drawing potentially on a wide variety of energy sources, including hydropower, refined oil products, natural gas, coal, vegetable fuels, and, more recently, nuclear materials. Electric energy is then transported in huge amounts and at very high voltages to locations nearer to consumers, often far from the site of generation, by way of transmission lines or interlinked grid networks. The power is then physically transformed and distributed to power consumers in the quantities and voltages required by each of them for the various productive applications.

Since 1950, Latin America's consumption of electric power has doubled, on average, every eight years. The 8.8 per cent annual average growth rate of the region's output of electric energy since 1950 puts electric power, together with oil refining, among Latin America's leading growth industries during the past quarter century.

/The categories

The categories of demand supporting this growth are readily identified by the potential uses for electric energy: heat, mechanical power, light, and chemical energy. Given the region's pattern of industrial growth in the post-war era, the data in Exhibit 32 suggest the relative importance of these end-uses in specific national markets.

Manufacturing and mining industries have accounted for about one-half of the growth in regional power consumption since 1950. Growth not only in the relatively electricity-intensive industries, but also in manufacturing output in general, together with the progressive mechanization of work processes and the spread of electric lighting, have been the pivotal forces supporting increased electric power consumption in Latin America since World War II. Much of the growth recorded by Latin America's secondary sector industries since the 1950s would simply not have been physically possible without access to increasing supplies of electricity to sustain high intensity flows of mechanical work, on the one hand, and to support output gains in the electro-chemical and electro-metallurgical industries, on the other hand.

Households and commercial establishments account for about another one-third of the growth recorded in Latin America's power consumption since 1950. In urban centres, electric lighting has become a commonplace in homes, offices, and factories, which was not the case in the region in the 1940s. Indeed, the use of electric power as a source of heat may have been overstimulated from an economic point of view in some markets by the low prices set for electricity at some times by public power authorities. Increases in real family income throughout Latin America since World War II have stimulated the growth in the region's household power market. Volumetrically, this process has been most important in the large and more affluent countries of the region, such as Argentina, Brazil, Mexico and Venezuela.

In rural Latin America, the growth of electricity use has been decidedly less impressive than in urban and suburban areas. Public power authorities in Latin America did not really focus seriously on
/the development

the development of rural markets until the 1960s. Prior to that time, the scarce capital that was available to these authorities was allocated, for the most part, to the development of urban and suburban power markets, expansion in power flows in rural areas being supported by less dramatic additions to private and public sector electric generating and supply capacity. The data in Exhibit 33 indicate that the consumption of electricity is still a limited phenomenon in rural Latin America, where it is used largely as a source of artificial lighting and as a power source for relatively low capacity electric motors. These motors are used in a multiplicity of ways on farms and in rural households and commercial establishments, and to a large extent they have been the means by which capital has been substituted for the low-intensity power flows historically supplied by human and animal labour.

It should be underscored, however, that the sectoral pattern of growth in the consumption of electric energy in specific Latin American countries, as shown in Exhibit 32, shows wide variation between countries. Additionally, the regional pattern is heavily weighted, in a statistical sense, by a handful of countries such as Argentina, Brazil, Mexico and Venezuela. Bearing this in mind, the data in Exhibit 32 show that in some Latin American countries the major sources of growth in the power market since 1950 have been households and commerce, not manufacturing and mining.

The statistics provided in Exhibit 32 on the consumption of electric energy give no hint of the considerable gains achieved throughout Latin America in the post-war period in the quality of power service: i.e., the regularity with which power companies supply electricity in the volumes (i.e., kWh), forms (i.e., voltage, cycles), and at the times required by consumers willing and able to pay for it. The widespread and notable improvement in the quality of power service in the region since the 1950s is evidenced by the steady decline in the frequency of blackouts and brown-outs. It is also partially

/reflected in

reflected in the declining quantitative importance of power supplies produced by establishments other than power companies for their own use and often for sale on a small scale to others in their immediate area.^{51/} Improvements in the quality of the service rendered by electric power industries in the region should be recognized as one of their major accomplishments in the post-war era, quite apart from the impressive record of strictly physical output gains which they have also achieved during this period.

The declining quantitative importance of these self-suppliers warrants additional comment at this point. In 1950, they accounted for 23 per cent of the electric energy generated in Latin America, although this ratio varied widely among individual countries in the region (Exhibit 34). By 1975, however, they accounted for only 12 per cent of regional power generation, again with a wide pattern of country-by-country variation. Chief among the factors promoting the decline in the quantitative role of these self-suppliers has been the rapid growth in the integration of power networks serviced by the large power companies, particularly those in the public sector, and also the increased reliability of power supplies sold by these companies.

Rapid though it has been, however, the growth in the consumption of electric energy in Latin America since 1950 has not been outstanding by international standards. World power consumption during 1950-1975 expanded by 8.3 per cent per annum, while in Latin America electric power consumption grew at 8.8 per cent per annum (Exhibit 35). The consumption of electricity in the developed countries during 1950-1974 increased at the somewhat slower rate of 8.1 per cent annually, but this slower growth proceeded from a 1950 level that was about thirty times the comparable Latin American level in that year. Thus, despite the high rate of growth in Latin America's power generation since the 1950s, the region still remains far behind the developed countries

^{51/} Such small-scale power producers are labelled "self-suppliers".

in terms of electric power generated, absolutely and per capita, as well as in terms of power generated per unit of total real output. Exhibit 36 presents detailed information on these three aspects of electric power generation in twenty-seven Latin American countries in the post-war era.

(ii) Installed capacity, generation and efficiency. Exhibits 34 and 37 present data on the post-war growth pattern of Latin America's electric power generation and installed generating capacity. Both exhibits reveal the dominance of a handful of countries in the regional totals. In 1975, for example, five countries (i.e., Argentina, Brazil, Colombia, Mexico and Venezuela) accounted for about four-fifths of regional power generation and generating capacity. This pattern is, of course, what one would expect, given the heavy weight of these countries in Latin America's industrial output and population.

The impressive rate of expansion in Latin America's electric generating capacity since the 1950s was financially facilitated, to a significant extent, by the access of many Latin American countries to long-term capital from a variety of foreign institutions specializing, inter alia, in long-term power equipment and power project financing. The data presented in Exhibit 38 show that the cumulative flow of long-term power project financing from three such institutions during 1946-1975 totalled 5.8 billion dollars. The share of long-term loan financing from such institutions as these in the total financial requirements of a power project varies widely, depending on a variety of factors such as the type and scale of project and the host country and financial institutions involved. Historically, however, long-term debt financing by institutions such as the IBRD and IDB have probably accounted for between one-fifth and one-quarter of the total project value of the power schemes receiving such support.^{52/} To this extent,

^{52/} Between 1961 and 1974 the IDB granted 72 long-term loans for financing power projects in Latin America. The aggregate value of these loans was 1.6 billion dollars, or 28 per cent of the 5.8 billion dollars total cost of the 72 projects.

/they have

they have provided considerable support for the physical expansion of the region's electric power supply capacity in the post-war era.

In addition to this direct financial support, institutions such as the IBRD and IDB have also served as valuable conduits for the transfer of a broad range of technologies to Latin America's public power authorities. This has involved not only the promotion of technical engineering-type knowledge, in which equipment-supplying companies play the dominant role, but also the promotion of many other kinds of knowledge of the power industry as well: power tariff policy, system control and planning, financial and economic project evaluation, personnel planning and training, contracting and cost control, debt management, and so on. Clearly, promotion of knowledge in these and related areas of business and institutional management was also aided in these countries through other corporate, national and international channels, but the contributory role of institutions such as the IBRD and IDB to this increased stock of knowledge has certainly been a notable one.

The data in Exhibit 34 show that the share of hydropower in Latin America's generation of electric power has increased slowly over the past quarter century, from 51 per cent in 1950 to 57 per cent in 1975.

Countries depart widely, however, from this regional pattern of hydropower generation. Thus for example, five of the twenty-seven countries listed in Exhibit 34 did not generate hydroelectricity in 1975, while at the other extreme, in three Latin American countries hydropower accounted for more than four-fifths of domestic power supplies in that year. Between these extremes, the country-by-country pattern of reliance on hydropower in 1975 varied markedly.

It might seem strange, at first sight, that a region so richly endowed in economically exploitable hydropower potential as Latin America has not achieved an even higher degree of reliance on hydropower than that revealed by the data in Exhibit 34. However, a number of practical considerations have combined to restrain the extent of this

/reliance. Chief

reliance. Chief among these factors have been the following: the comparatively higher capital requirements for generation and transmission associated with hydro projects vis-à-vis thermal power projects; the comparatively high social opportunity cost of capital in Latin America, which gives rise to a more powerful bias against the typically more capital-intensive hydropower option than against the (non-nuclear) thermal power option; the secular decline in the (real) price (CIF) of imported oil during much of the post-war period; the growing concentration of population and power markets in large coastal cities with easy access to locally refined and imported oil products; and the need to increase thermal generating capacity, in part, simply as insurance against the vagaries of future conditions of water availability.

The slow secular decline in the quantitative share of thermal stations in the regional generation of electric energy has been accompanied by increasing reliance on oil and, to a lesser degree, on natural gas as the thermal power industry's leading fuels (Exhibit 39). Power plants fired by vegetable fuels have now lost their earlier quantitative significance. A milestone event in Latin America's power industry was the introduction of nuclear power in 1974.^{53/}

The overall pattern of fuel-use in Latin America's electric power industry may be summarized as follows. Within integrated power systems, hydropower and nuclear power, when available, are used to the maximum extent possible. Fuel oil typically supplies the bulk of remaining base load generating requirements, but coal-fired plants are used for this purpose in some countries. Peaking power is widely supplied from relatively small and high cost diesel plants, although in some countries natural gas has been displacing diesel oil for this purpose.

^{53/} In 1974 the 319 megawatt nuclear power plant of Atucha, Argentina went operational.

The pattern of fuel-use in isolated power systems also varies widely. When the scale of power consumption is relatively large, power requirements are often met using fuel oil, although depending on the local pattern of resource endowment, hydropower or coal might be employed to meet power needs in these larger systems. The more typical case, however, is the small isolated power system, reliant on old, comparatively high-cost diesel plants or, in rare cases, on vegetable fuels.

The application of technical change has promoted greater efficiency in fuel-use in Latin America's thermal power industry in the post-war era (Exhibit 40). During 1960-1974, the average heat rate of Latin America's public sector thermal stations declined from 3,700 to 3,200 kilocalories per kWh generated, or, on the average by 1.0 per cent per annum during this 14-year period. By way of comparison, however, the average heat rate of central power plants in the OECD countries in 1973 was about 2,500 kilocalories/kWh.

A large part of these thermal efficiency gains are quantitatively explained by progress in a few countries, such as Argentina and Mexico, for example (Exhibit 40). These countries are dominant in public sector thermal power generation in the region, and they have also recorded significant improvements in thermal efficiency.

Progress in the post-war period in the physical efficiency of fuel-use in Latin America's thermal power industry has been the result largely of meeting increasing volumes of power demand by substituting larger and thermally more efficient power plants for older vintage plants to serve integrated networks that themselves have been expanding through interconnexions. In Argentina and Mexico, for example, the scale of market requirements has supported the introduction of thermal plants in the 300-350 MW range. Such plants have heat rates of the order of 2,000 kcals/kWh when operating at design capacity. The use of thermal power plants such as these to meet base load requirements has made it possible in some Latin American countries to put thermally

/less efficient

less efficient plants into reserve or to scrap them, but the introduction of thermal power plants of this size has simply not been economically feasible in many Latin American countries, given the small scale of their power markets. In these countries, the relatively small size of the market has been a major impediment to realizing thermal efficiency gains in the thermal electric power industry.

Thermal power generation in Latin America has increased at a more or less steady rate, averaging 8.2 per cent per annum during 1950-1975. The rate of growth in thermal efficiency in the region's central thermal stations has been much slower, however, and it has shown strong deceleration in recent years. In the power industry of Chile and in the public power systems of other Latin American countries (e.g., Argentina, El Salvador, and Guatemala), average heat rates have actually increased during the 1970s (Exhibit 40). The more rapid rate of increase in thermal generation than in thermal efficiency gains has exerted upward pressure on fuel consumption in the region's thermal power industry, as it has on the index of energy input per unit of real output at the national level. The relative rate of growth of these two variables will play an important role in determining the volume of oil and modern energy consumption in the future.

The other major contribution to the decline in the heat rate of Latin American power systems was been the interconnexion of electrical systems, a phenomenon that has been stimulated by advances in transmission technology in the developed countries. In 1950, electric power could be transported economically up to a limit of about 450 kilometers, in contrast with today's range of about 2,000 kilometers. This capability to transport electric energy economically over longer distances has made it possible not only to substitute hydropower for thermal power in Latin America, but also, given the pattern of system generating capacity, to substitute lower-cost for higher-cost power flows in the region's many thermal power systems as well.

/At the

At the regional level, interconnexion of electric power systems across national frontiers is an area of considerable promise for thermal efficiency gains and for socio-economic progress in general in Latin America. So far, however, these gains remain largely untapped. The only international interconnexion schemes now operational in the region are those providing for one-way power flows from Paraguay to Brazil and Argentina, plus three others providing for two-way exchanges of power on a comparatively small scale between Uruguay and Brazil; between Colombia and Venezuela; and between Ecuador and Colombia. There is also an interconnexion which enables Mexico to import power, again on a relatively modest scale, from the United States.

Technical progress in Latin America's power industry has also been laggard in the area of line loss reduction. Such reductions generate direct savings in fuel inputs into thermal power systems, and they are a source of efficiency gains in the use of capital. In power systems that are short of spare generating capacity, line loss reductions also make it possible to improve the quality of service to power consumers.

The data in Exhibit 32 show that the ratio of transmission and distribution losses (including theft) to electric power consumed (i.e., the line loss ratio) has declined slowly in the region since the 1950s. This ratio was 15 per cent in 1950, and by 1976 it had declined to 12 per cent.

In many Latin American power systems, line loss ratios are much higher than the regional average would suggest. In 1975, for example, particularly high ratios were recorded in El Salvador (31 per cent), the Dominican Republic (29 per cent), Costa Rica (25 per cent), and Haiti (25 per cent). On the other hand, they have been reduced to relatively low levels in Brazil (9.5 per cent) and Chile (9.1 per cent). By way of comparison, line loss ratios in the developed countries are around 10 per cent or so. Given the strong increase recorded in the cost of world energy supplies since 1973, the reduction of line losses now constitutes an even more promising area than in the past for cost-reducing investments in the power systems of many Latin American countries.

/Changes in

Changes in plant factor ratios 54/ in Latin America's electric power industries in the post-war period warrant comment at this point. The average plant factor for Latin America's electric power industry has increased from 3,517 hours in 1950 to 3,774 hours in 1975. There is much dispersion about these average figures, however. In countries with relatively high levels of industrial demand for power and/or with comparatively well-integrated power networks (e.g., Brazil and Venezuela), plant factors tend to be higher than in countries where the household component of power demand is dominant. On the one hand, a low plant factor may simply reflect an excess of installed generating capacity. On the other hand, a rate of growth in the consumption of electric energy that, over time, is outdistancing the rate of growth in generating capacity would put an upward pressure on the plant factor. Clearly, the diversity of factors impinging on a nation's plant factor suggest caution in interpreting changes in it.

Developed countries, with high levels of industrial power demand and comparatively well-integrated power networks, have plant factors usually well in excess of 4,000 hours.55/ The plant factors of power systems in many of the underdeveloped countries outside Latin America fall in the range of 1,500-2,000 hours, whereas those for Latin America are concentrated in the 3,000-4,000 hour range. With due respect for the diversity of factors underlying this international pattern, a comparison of the plant factors and power markets of Latin America and the developed countries would suggest that there are three kinds of change that would promote desirable increases in Latin America's plant factors in the future: first, continued growth in the base load component of electric power consumption, especially by industrial power consumers; second, progressive integration of electric grid systems; and, third, improvements in the area of peak power management.

54/ The plant factor ratio is the volume of electricity generated in a given power system divided by the installed in-service generating capacity.

55/ In 1973, for example, the following plant factors were recorded: United States, 4,252 hours; Japan, 4,905; Canada, 4,823; West Germany, 4,819; Soviet Union, 4,677; East Germany, 5,378; Poland, 4,755.

A comment is in order at this point on the degree of progress made in the area of cycle standardization in post-war Latin America. In the early post-war period, there was a pronounced absence of cycle standardization in many national power markets of the region (Exhibit 41). In general, however, this did not constitute an inordinately pressing problem from the point of view of system operation because, at that time, the degree of grid integration was relatively primitive. As the goal of grid integration became more widespread in the region, however, the lack of cycle standardization became a more serious problem. By and large, this problem has now been resolved.

In Brazil, for example, up to the 1960s some service areas were supplied with power of 50 Hertz, others with 60 Hertz. In 1964, however, 60 Hertz was established as the national standard, and by the early 1970s, Brazil had fully converted to this standard.

In Venezuela, 60 Hertz was also adopted in the early 1960s as the national standard, and work began on the task of cycle conversion, which was finally achieved in the early 1970s.

Power supplies in Mexico had long been generated using two cycles, and in 1950, they were about equally split between 50 and 60 Hertz. In the late 1960s, however, 60 Hertz was adopted as the national standard, and by the early 1970s cycle standardization in Mexico was nearing completion.

By 1975, the situation with respect to cycle standardization in continental Latin America was the following: Argentina, Bolivia, Chile, Paraguay and Uruguay generate on 50 Hertz, while the remaining countries in the region are in various stages of the process of cycle standardization, and when their conversion programmes are completed they will be generating exclusively on 60 Hertz. Generalizing for the region as a whole, therefore, cycle standardization at the national level is now virtually completed (Exhibit 41). The fact that two cycles are in use in the region can constitute at times an obstacle to intra-regional trade in electricity and especially to the joint

/development of

development of water resources for the production of hydroelectric power. Nevertheless, technical progress in the area of cycle standardization has contributed, in no small part, to increase efficiency in the use of fuels and capital in Latin America's electric power industry in the post-war era.

(iii) Ownership. One of the most striking changes in Latin America's power industry since the 1950s has been the rise of State ownership. Exhibit 42 shows that, in 1950, public power authorities in Latin America accounted for only 10 per cent of the power supplied by generating companies (i.e., including self-suppliers). By 1975, this ratio had increased to 78 per cent. In effect, during 1950-1975, the State has changed its role in regional power generation from one of a quantitatively minor supplier among established electric power companies to a virtual monopolist.

A similar rise to dominance is evident in the distribution segment of the region's electric power industry (Exhibit 43). Generally speaking, the transmission segment of the electric power industry in Latin America has traditionally been a public sector undertaking, since historically private power companies in the region have avoided investment in costly transmission facilities, concentrating their investments in the thermal generation segment of the industry.

For the most part, the transition from private to public sector ownership was achieved through the purchase of assets by the State. The reasons underlying increased State ownership of the domestic power industry vary widely, of course, depending on the country involved, but generally speaking, in most cases they probably involved one or more of the following considerations: First, the State could acquire the assets of domestic generating and distribution companies on favourable terms. Second, the fact of a major foreign presence in the domestic generating segment of some power industries in the region probably provoked considerable popular pressure for State takeover. Third, in countries

/where power

where power prices were being kept below supply costs by the State, public ownership may have been chosen as a way to ensure increasing power supplies without extending politically embarrassing subsidies to private power producers. Finally, in some cases, the State may have been convinced, for one of a variety of reasons, that the attainment of its goals required a rate of expansion of the domestic power industry that was simply not consistent with private ownership of that industry.

Section V - performance of the Latin American
energy sector since the 1950s

The previous sections of this study have presented the essential features of growth and change in Latin America's energy industries. In this section, the emphasis shifts to the question of the overall performance of the region's energy sector in the post-war period.

As noted earlier, in discussing the performance of the energy sector it is important to distinguish between its performance in a strictly physical sense, on the one hand, and its performance from the point of view of economic efficiency and growth, on the other.^{56/}

It is impossible to discuss the performance of a nation's energy sector until one specifies the objectives pursued in its operation. In Section I it was argued that in all countries the energy sector always has one basic function: to support the process of socio-economic activity or - stated in a different and less precise way for present purposes - to support economic growth. In some countries, such as Venezuela, for example, the energy sector may have another related and basic function: to generate foreign exchange on a large scale. In this section, the performance of the energy sector is discussed only with reference to the first of these two objectives, since that objective is shared by all Latin American countries, and it is clearly of paramount importance to all of them.

^{56/} See the discussion of this subject in Section I of Chapter 1.

From a methodological point of view, a serious evaluation of the performance of the region's various energy industries since the 1950s from a strictly physically approach would suggest the evaluation of the following null hypothesis: the physical pattern of energy supplies from the region's energy sector has never been a bottleneck to the physical growth of regional output on any significant scale since the war.^{57/} This null hypothesis was proposed and evaluated in an unpublished study, prepared by CEPAL's Division of Natural Resources and the Environment, entitled "Evaluación de la acción física del sector energético sobre el desarrollo económico latinoamericano en el período de post-guerra". In this section the basic methodology and conclusions of this report will be presented.

The study begins with the observation that it is obviously impossible to evaluate this hypothesis with precision. The "region" consists of more than two dozen nations, each with its own energy industry. The term "energy sector", depending on the country, could include such sub-sector industries as oil, coal, natural gas, electric power, fuelwood, and so on. The "oil" industry itself covers a variety of specific fuels, such as motor gasoline, fuel oil, jet fuel, diesel oil, etc. The "post-war period" covers more than a quarter of a century during which time, for the most part, the statistics on energy supplies and economic growth in the region are woefully inadequate. When the difficulties posed by these considerations are recognized, it becomes obvious that firstly, simplification is required in order to evaluate this hypothesis and secondly it can only be evaluated in a very rough way.

^{57/} Excluded here, by definition, is the growth-reducing effect of the misallocation of fuel, capital and other resources stemming from distortions in the relative prices of these inputs of the electric power industry over time. In other words, the point of view is a strictly physical one, and it is to this extent of limited usefulness analytically. At a later point, however, the growth-reducing effect of economically inefficient resource allocation in the region's power industry will be covered explicitly.

/Following these

Following these observations, the field of inquiry was restricted by energy industry and by country. With respect to the limitation by energy industries, analysis was limited to electric power and oil, and in the case of the oil industry, the field was limited to the following refined oil products: motor gasoline, kerosene, fuel oil, and diesel oil. These restrictions were based on the observation that electric power and oil are the most critical energy industries of the region in terms of the scale of resources involved and their role in supporting process of economic growth.

With respect to the restriction by country, the study limited the evaluation of the supply of electric power and refined oil products to the following seven countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. In both 1950 and 1974, these countries accounted for about nine-tenths of both total regional output and commercial energy consumption in Latin America, and they also account for the bulk of electric power and oil consumed in Latin America.

The study proposed a variety of specific criteria for evaluating the adequacy of the physical supply of electric power and refined oil products in these seven countries.^{58/} Following the discussion of these criteria, they were applied with the purpose of generating specific information for evaluating the null hypothesis. The results of this exercise were the following: first with regard to the electric power industry, it was concluded that power supplies did constitute a physical bottleneck to economic growth in the region from 1950 up to roughly the mid-1960s. On the other hand, the study also concluded that this threat to economic growth was not of a particularly large order of magnitude, and since then the study found that there have not been any compelling grounds for arguing that power supplies have constituted a significant physical bottleneck to economic growth in the region.^{59/}

^{58/} See: "Evaluación de la acción del sector energético sobre el desarrollo económico Latinoamericano en el período post-guerra", an unpublished paper prepared by the Division of Natural Resources and the Environment of the Economic Commission for Latin America, Santiago, Chile. These criteria are presented, discussed, and evaluated in detail for electric power in Section III (1: A, B, and C) and for refined oil products in Section IV (1: A, B, and C).

^{59/} Ibid, III (2 A and 2 B).

/Second, with

Second, with respect to the supply of refined oil products, it was concluded that there was no compelling case for arguing that the physical supply of refined oil products has significantly restricted the process of regional economic growth since the 1950s. True, there have been cases where disruption of physical supplies of refined oil products did constitute an obstacle to production and consumption in specific countries at specific times, but these instances were of relatively short duration. At the regional level, they were aberrations, both spatially and temporally.^{60/}

Returning to the null hypothesis specified previously, then, the overall conclusion of the study was that it should not be rejected. The major qualification involved here was the electric power industry up to the mid-1960s. Even here, however, the problems of physical supply posed by this industry during that time cannot be judged as grave in terms of the threat to regional economic growth. Within this context, it is concluded that, from a strictly physical point of view, the energy sector has not constituted a significant bottleneck to regional economic growth since the 1950s.

The previous analysis focused on the issue of the physical support rendered by the energy sector to the process of physical growth of output. The economic efficiency characterizing that pattern of support is a different and more important issue, however. For example, it might be observed that electric power supplies have consistently been available in a given country during a certain period of time and that, in a strictly physical sense, power supplies did not constitute a significant bottleneck to physical growth in that country during that period, but if it were also observed that these supplies were provided to consumers at prices far below cost, then it would have to be concluded that, from the point of view of economic efficiency, criticism would certainly be appropriate. If this condition of economic inefficiency in resource use in the electric power industry did exist, then it would also have to be concluded that economic growth was throttled as well, on the assumption that these inefficiently allocated resources could have been employed profitably elsewhere.

^{60/} Ibid, IV (2 A and 2 B).

Given that the energy sector has, in very general terms, met its basic objective of physically supporting growth in the region since the 1950s, what can be said about the degree of economic efficiency with which this support was provided during that period?

Obviously, this question cannot be answered with any degree of precision. From a methodological point of view, it is even more difficult to approach than the question of physical support. It is, nevertheless, a question of prime importance.

No attempt is made in this brief study to answer this question in a rigorous manner. It is a question which, if taken seriously, would require a degree of study that is simply beyond the limits of the resources available for present purposes. Therefore, rather than undertaking a serious investigation of the implications of the performance of the region's energy sector since the 1950s from the point of view of economic efficiency and, hence, economic growth, this section will close with two general observations bearing on this subject.

First of all, as indicated in Section IV of this study, the prices of many energy flows in Latin America have been controlled by the State throughout the post-war period. Generally speaking, these prices have not been set with respect to the opportunity cost of using those energy resources between domestic and foreign markets in Latin America in that period. In the electric power industry, the prices of electricity have often been set by public power authorities far below the costs of supplying it. This was the case especially in the earlier part of the post-war era. The same comment is relevant in the case of many refined oil products, for example. From an economic point of view, inefficiency in the use of fuels and other resources would undoubtedly be associated with the fact, and over time the magnitude of losses due to this would be substantial. This being the case, there undoubtedly would have been a cost in economic growth, since badly allocated capital (and other) resources could have been applied elsewhere in the economy.

/Second, in

Second, in all probability the quality of economic analyses supporting the introduction of many energy projects in the region has often been inadequate, particularly in the earlier portion of the post-war period. To the extent that this was the case, it certainly would suggest economic inefficiency in the pattern of physical support given by the energy sector to the process of regional economic growth in the post-war period, and the scale of this inefficiency would surely be impressive.

Section VI - Latin America's modern energy consumption
in the year 2000

Exhibit 44 presents forecasts for the year 2000 of total regional modern energy consumption by type of modern fuel and selected fuel-consuming countries and coal consumption in the region's iron and steel industry, while Exhibit 45 shows total installed generating capacity in Latin America by type of fuel employed, in selected countries.

In this section, discussion is restricted to the most important quantitative features of the forecasts, which are the following:

1. As shown in Exhibit 44, in the year 2000 petroleum and, to a lesser extent, natural gas will still be the backbone of Latin America's energy system. Petroleum's share in the region's commercial energy consumption is expected to decline from 61 per cent in 1975 to 46 per cent in 2000, while the share of natural gas is forecast to be the same as in 1975 (i.e., 15 per cent).
2. The figures in Exhibit 44 show that the shares of hydropower and coal in regional energy consumption are expected to be about 18 per cent and 8 per cent respectively in the year 2000.
3. Nuclear power is expected to penetrate rapidly into Latin America's energy base during the next quarter of a century.

/Increasing from

Increasing from insignificant levels in 1975, nuclear power should constitute about four-fifths of thermal power generation and about two-fifths of total power generation in Latin America by the year 2000. Nuclear generation facilities in the year 2000 will be concentrated in Argentina, Brazil and Mexico. Minor levels of nuclear generating capacity are forecast for Chile, Cuba, Peru and Uruguay.

4. The share of fuels consumed in Latin America's electric power industry in total regional energy consumption is expected to be about 21 per cent in the year 2000, or more or less the currently prevailing level. One of the critical assumptions underlying this expectation is that the average heat rate in Latin America's thermal power plants will decline to 2,500 kcals/kWh by the year 2000 from the 1975 level of 3,219 kcals/kWh. This implies an average compound rate of decline in the average thermal heat rate in the region of about 1.0 per cent per annum during 1975-2000.^{61/} Should this assumption prove overly optimistic, then the level of fuel consumption in the region's electric power industry would have to be adjusted upward as would, of course, the forecast volume of regional energy consumption as well.
5. The elasticity of modern energy consumption with respect to total real output in Latin America is expected to decline from 1.3 during 1950-1974 to 0.9 during 1974-2000.

These forecasts are, of course, no more defensible than the assumptions and methodology used in generating them. Even taking into account the wide margin of error which is undoubtedly contained in them, however, one conclusion seems beyond doubt: oil will continue to be the key energy resource used to support Latin America's economic growth during the rest of this century. This conclusion is the entry point for Chapter 2, which focuses squarely on the price of internationally traded crude oil over the next quarter century and on the formulation of energy policies in Latin America's oil-deficit countries.

^{61/} See, Section IV (e, ii) of this study for a discussion of the record of change in the heat rate of the region's thermal electric power industry.

Chapter 2

THE PRICE OF WORLD OIL: PROSPECTS AND IMPLICATIONS FOR ENERGY PLANNERS IN LATIN AMERICA'S OIL-DEFICIT COUNTRIES

Introduction

Chapter I described the quantitative record of growth and change in Latin America's modern energy industries: oil, gas, coal, and electric power. The performance of the region's energy sector was discussed in the context of its main function: that of supporting socio-economic activity. A forecast was made of commercial energy consumption in Latin America and in its principal energy markets in the year 2000.

Chapter 2 considers two broad topics: future prices for world crude oil and energy policy in Latin American oil-deficit countries.

Section I of Chapter 2 identifies and explains the pattern of world crude oil prices in the post-war era. It considers the relative importance of three factors in explaining changes in world crude oil prices during this period: the pressure of increasing demand on the supply cost of world crude oil, the organization of the world oil industry, and energy policies in the industrialized, oil-deficit countries.

Section II provides an analysis of the structure of today's world crude oil market from the point of view of its relevance for price formation.

Section III provides a summary of the current pattern of energy policies in the industrialized, oil-importing countries.

Section IV focuses on price forecasting. It opens with a rough estimate of the maximum level of the long-run marginal cost of supplying world oil over the next two decades. This cost constitutes the floor below which the price of world oil over the next two decades may not fall without jeopardizing its supply. An estimate is then

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made of the minimum long-run incremental cost of supply of synthetic oil. After this, there is a discussion of the most likely developments in the world crude oil producing industry, on the one hand, and in the energy policies of the industrialized, oil-importing countries, on the other. These materials constitute the background material for the price forecast, which is then presented.

Section V develops some ideas that might be helpful in the future to designers of energy policies in Latin America's oil-deficit countries, given the forecast of world oil prices. The discussion is conducted on the geographically abstract level of the region's oil-deficit countries.

This discussion of energy policy is conducted along two lines: the first considers the formulation of policies that have a direct impact on the demand for energy in oil-deficit economies, while the second concentrates on the formulation of policies designed to reduce the unit supply cost of energy consumed in these economies. In each line of discussion, a distinction is made between those policy options that require international agreement for their realization and those which do not.

Chapter 2 concludes with a brief discussion of the problem of the security of imported oil supplies for Latin America's oil-deficit countries.

Section I: The record of world oil prices in the post-war era

(i) Introduction

This chapter presents a survey of world crude oil price formation during the post-war period. It does not dwell on the dynamics of this process for its own sake. Instead, the objective is to provide information that will be useful in identifying factors that will be critical in shaping world crude oil prices in the future. A knowledge of these factors as they operated in the past is a necessary condition for a reasoned position about them in the future. Continuing ignorance guarantees predictive error.

/(ii) World

(ii) World crude oil prices: 1945-1977

(a) 1945-1949

At the end of the Second World War, seven large, vertically integrated companies 62/ dominated the world oil industry (Exhibit 46). From then until 1948, internationally traded crude oil, regardless of the site of its production, was priced on the basis of its (actual or equivalent) acquisition cost (FOB., Texas Gulf) in the United States plus insurance and freight to the importer's port.

Most of crude oil entering international trade in the early post-war years was exported from Venezuela and, to a lesser extent, from the United States. Almost all of this trade was accounted for by transfers between the producing and refining affiliates of the major international oil companies and by exchanges of crude oil and refined products between them. In the early post-war period, most oil exports were in the form of crude oil, but a considerable part of internationally traded oil consisted of refined oil products.63/ World refining capacity was overwhelmingly owned by the major international oil companies.

Crude oil prices posted at the United States Gulf Coast increased from the end of World War II to 1948 (Exhibit 47). The reasons for these increases remain conjectural, but they did not involve any accompanying increase in the prospective, long-run incremental costs of world oil under the pressure of increasing demand: the huge fields in Kuwait and Saudi Arabia were just being brought into world supply.

62/ Exxon, Mobil, Shell, Socal, Texaco, Gulf, British Petroleum. Compagnie Française des Pétroles is often included in the group of eight major international oil companies.

63/ In 1950, for example, world imports of crude oil and refined oil products were 145 and 94 million tons of coal equivalent. J. Darmstadter, et.al., Energy in the World Economy, published for Resources for the Future by the J. Hopkins Press, (Baltimore, Md.: 1971) p. 303.

at prospectively lower incremental costs 64/ than those required to develop and produce more oil in many fields in Venezuela and the United States. Had this not been the case, the Middle East fields would not have been developed by the international oil companies which had producing rights in both hemispheres.

The explanation of the increases in posted prices during 1945-1948 is to be found in the exercise of market power 65/ by the major oil companies with the tacit acquiescence of many governments of industrialized countries seeking to protect their coal, oil, and gas industries and, in some cases, their vested interests in the world oil industry as well. With the price of world oil far above its incremental supply cost and the major oil companies firmly in control of world oil production, marketing and refining, any downward movement in world oil prices could only result from price-cutting on oil sales by the major oil companies themselves - a temptation which they resisted until 1948. Not only did they resist that temptation, but they maintained their unity as higher prices were posted for world oil during 1945-1948. The governments of the industrialized countries, and most importantly at that time the United States, gave passive assent to those price increases.

The first arms-length sale of Middle Eastern crude oil occurred in 1948 and at a discount.66/ In that year, Eastern Hemisphere pricing was introduced, so that prices of crude oil from the United States

64/ Adelman estimates that, in the early fifties, the cost of developing more crude oil in the Persian Gulf was about 0.39 dollars per barrel. See: M. Adelman, The World Petroleum Market, published for Resources for the Future by the Johns Hopkins Press, (Baltimore, Md.: 1972), p. 145. By way of comparison, during 1950-1952, the posted price of Saudi Arabian light crude oil was 1.71 dollars per barrel, FOB., Ras Tanura (Exhibit 47). More oil reserves could have been developed in the Persian Gulf at that time on a large scale and rapidly.

65/ By this term is meant the ability to control the supply of crude oil destined for sale in the world oil market and, hence, the ability to effect its price in that market.

66/ Adelman, op.cit., p. 134.

Gulf were equalized in London with Middle Eastern oil supplies. In 1949, the formal link between United States Gulf/Caribbean and Persian Gulf prices was cut. A buyer of Western or Eastern Hemisphere oil paid the FOB price posted at either the United States Gulf or at the Persian Gulf, as the case might be, at the date of contract. As a result, oil supplies were available on an FOB basis at the United States Gulf/Caribbean and at the Persian Gulf, and independent buyers were free to choose between them on their competitive merits. With the price watershed for world oil pegged initially at London, Middle Eastern oil penetrated rapidly into European and Asian markets. Latin America remained largely dependent at that early date on Western Hemisphere supplies.

The price of Persian Gulf crude oil declined during 1948 and 1949, while the posted prices of United States and Caribbean crude oils stayed constant (Exhibit 47). These declines were probably the result of two forces: first, the pressure exerted on the major oil companies by the Mutual Security Administration for reduced prices on oil supplies being moved into Western Europe under the Marshall Plan,^{67/} and second, spontaneous price-cutting by the major oil companies. This latter development was, in turn, a partial, but far from total, adjustment to the lower supply costs of Persian Gulf crude oils.

The decline in the relative prices of Persian Gulf and United States/Caribbean crude oil during 1948-1949 and the accompanying drop in international freight rates moved the point of parity between these supplies from London to New York City by late 1949.^{68/} Even at that early date, the United States market was clearly at the point of massive penetration by Middle Eastern oil.

^{67/} For a discussion of this subject, see Ibid., pp. 138-139.

^{68/} Ibid., p. 140.

To sum up, then, crude oil prices during the late forties show a disparate pattern. They increased during 1945-1948, but then, during 1948 and 1949, Persian Gulf prices declined while United States/Caribbean crude oil prices remained constant. In neither case did the impact of increasing world oil demand on the supply costs of world oil constitute an explanation, although the decline in world oil prices during 1948-1949 can be explained partially in terms of a slow, competitive adjustment to the expectation of sharply reduced incremental costs of Middle Eastern oil compared with Venezuelan and United States supplies.

One reason for the price reductions on Persian Gulf crude oil sales in 1948-1949 was the outbreak of competition between the major oil companies, which they had resisted earlier. The other reason was the pressure for lower prices successfully exerted by the Mutual Security Administration. There is no evidence of strong pressure by oil-importing industrialized countries at the time for lower world oil prices. They apparently calculated that their interests lay elsewhere: in the protection of their domestic coal, oil, and gas industries and, in some cases, in the protection of their stake in the world oil industry. This was particularly the case with respect to the United States, which at that time was by far the main force in world energy markets.

(b) 1950-1957

The price of world crude oil was frozen during 1950-1952. It then increased, in an uneven manner, from 1953 until the end of the Suez Crisis in 1957 (Exhibit 47). Major price increases for world oil were posted in 1953 and 1957. Worldwide inflation and declining international freight rates offset some of the increased money cost of world oil between 1949-1957, but on an FOB basis the price in current dollars of internationally traded crude oil increased by about 25 per cent during 1953-1957, while worldwide inflation was of the

/order of

order of 11 per cent.^{69/} In real terms, therefore, the increase in the price of world oil averaged about 3.3 per cent per annum during 1953-1957.

An explanation of these developments in world crude oil prices can initially be found in a study of the oil market of the United States. By late 1949 it was clear that, if not impeded, Middle Eastern crude oils would quickly penetrate the United States market on a major scale, since their low incremental cost made them more competitive than the crude oils produced in many fields in the United States and in the Caribbean. The oil prorationing system ^{70/} in the United States allocated production rights to wells in more or less inverse proportion to their supply costs, and this system encouraged imports by assigning preferential production rights to crude oils in the United States that were more costly than Persian Gulf crude oils, (i.e., to stripper wells). Refiners in the United States (and elsewhere) were eager to import cheaper Middle Eastern supplies, and the major oil companies with producing interests in the Persian Gulf stood to profit immensely by the export of these crude oils to the large United States market.^{71/}

^{69/} The index of world consumer prices (1970=100) increased from 51.9 in 1953 to 57.4, in 1957 or by 10.6 per cent. International Financial Statistics, The International Monetary Fund, Washington, D.C., May, 1976.

^{70/} Prorationing is a system of collective control exercised by regulatory agencies in the United States over crude oil production there with the objective, inter alia, of price maintenance. See W.F. Lovejoy and P.T. Homan, Economic Aspects of Oil Conservation Regulation, published for Resources for the Future by the Johns Hopkins Press (Baltimore, 1967); and S.L. Mc Donald, Petroleum Conservation in the United States, An Economic Analysis, published for Resources for the Future by the Johns Hopkins Press (Baltimore, 1971).

^{71/} On this last point, see the calculations presented in Adelman, op.cit., p. 149.

The threat of Middle Eastern oil to United States domestic interests was recognized at an early date. The eighty-first Congress conducted three investigations on the potential harm of increased oil imports into the United States. The Federal Trade Commission launched a study of the international oil cartel, and the Small Business Committee of the House of Representatives undertook a study of the extent of the potential damage of oil imports to United States oil-producing interests. The message for the oil companies of these investigations and studies was clear: "... if they did not keep imports down to a very low figure, legislative action would be taken".^{72/}

The message was understood: price cutting on Middle Eastern crude oils stopped during 1950-1952, and crude oil imports to the United States East coast froze during 1950-1951.^{73/}

Then in 1951, with planned imports of crude oil into the United States on the increase once again, the Texas Railroad Commission ^{74/} exerted its influence, and imports of crude oil into East Coast refineries slowed down during 1952-1953. Shortly afterwards, however, oil imports from the Middle East began to increase rapidly once again, and a special United States Cabinet committee was formed in July 1954 to study the question of oil imports.

The President was empowered to restrict oil imports into the United States in 1955. Voluntary restraint by United States oil companies on oil imports was called for in 1957, but this approach

^{72/} Ibid., p. 150.

^{73/} Imports of crude oil to the United States East Coast increased as follows, in TFD (years in parenthesis): 467 (1950), 469 (1951), 524 (1952), 552 (1953), 601 (1954), 678 (1955), 718 (1956):
Ibid., p. 151

^{74/} The Texas Railroad Commission is an institution that plays a critical role in determining the rate and geographic pattern of crude oil production in the State of Texas. Because of the importance of Texas in the United States oil industry, the Commission, therefore, exercises a powerful influence on the pattern of price and output in the United States oil industry as a whole.

/was ineffective

was ineffective in halting the growth in such imports. The oil prorationing system still remained in jeopardy in 1958 because of the threat of imported oil, especially from the Middle East, by both the major oil companies and by independent refiners.^{75/}

With this background in mind, the fundamental reasons for the freeze (1950-1952) and subsequent increases (1953-1957) in the price of internationally traded crude oil can be identified. The strong pressures exerted within the legislative, executive, and some agency components of the United States government to restrict oil imports into the country limited the inclination of the major oil companies to cut the prices of Middle Eastern oil as a means of penetrating the United States market. If they had tried to enter this market on a large scale they would certainly have been expelled. Similar pressures were being exerted in European countries and in Japan ^{76/} to protect their domestic energy industries from imported oil.

These pressures appear to have induced the major oil companies to initiate and then sustain the freeze in world oil prices during 1950-1952. When they were reasonably sure that oil imports into the United States would not reach disruptive proportions, United States producers maintained their solidarity as the price for United States crude oil was increased in 1953. Accepting the de facto closure of the United States oil market to imported oil on an increasing large scale, the prices of Middle Eastern and Caribbean crude oils were increased in 1953, following the United States lead.

In a competitive market for internationally traded crude oil, the temporary slow-down in the rhythm of the United States' imports of world oil in the early fifties (i.e., a deceleration in the rate of rightward shift in the demand curve for internationally traded crude oil) would imply a deceleration in the rate of increase in the

^{75/} Imports of oil from Canada provided a similar threat to the United States prorationing system at this time. See Adelman, op.cit., p. 154 for a discussion of this threat.

^{76/} For a discussion of the Japanese case, see J.W. Mullen, Energy in the Japanese Economy (1876-1964), an unpublished doctoral thesis, New York University, 1972.

price for it in equilibrium, assuming no significant change in the positively sloped world crude oil supply function. But it was precisely the competitive condition that was lacking at that time. Price did not increase from a lower to a higher equilibrium level as an erroneous use of the competitive model would have predicted. Nor did price move downward toward new equilibrium levels along now decelerated rates of rightward shifts in the demand curve for internationally traded crude oil. In fact, price increased in 1953 from a level that was far above the equilibrium level to begin with. In short, the competitive model, while useful for gauging the direction and degree of pressure on price at that time and now (i.e., downward and intense), was an irrelevancy in a predictive sense. The price increase that did occur in 1953 was made possible, on the one hand, by the major companies' control over world crude oil production, marketing, and refining operations and, on the other hand, by the passive reactions of the major oil-importing governments to the increased price of world oil.

With the disruption of oil flows at the time of the Suez Crisis (1956-1957), world oil supplies became tight. Nevertheless, in 1957 the Texas Railroad Commission refused to grant higher oil production allowables to compensate for stagnating supplies of Middle Eastern oil in world markets during the crisis.^{77/}

^{77/} As the data below show, increased exports of crude oil and fuel oil from Venezuela (in million barrels/year) during the Suez Crisis (1956 and 1957) provided some measure of relief in the world oil market from the stagnation in Middle Eastern and United States oil supplies (in million metric tons/year):

Middle East exports

<u>to world:</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>
Crude oil	136.9	143.3	143.4	174.6
Refined oil (energy) products	23.1	26.2	28.3	28.8
<u>United States crude oil production</u>	335.7	353.7	353.6	331.0

(cont.)

/The price

The price of United States crude oil was increased again in 1957 and, as in 1953, the prices of Middle Eastern and Caribbean crude oils followed it upward. Neither the price freeze of 1950-1952 nor the upward trend in world crude oil prices to 1957 would have occurred under competitive market conditions. Under competition, world oil prices, which were far above incremental supply costs, would have moved down to reflect the lower expected incremental costs of supplying oil from the immense, low-cost fields in the Persian Gulf.

To sum up, two basic forces underlie the trends in world oil prices during 1950-1957: first, the success of the threats and actions taken in the United States, Western Europe and Japan to block the import of cheaper oil so as to protect their indigenous oil, coal, and gas industries, and second, the restriction of world oil supplies, which was made possible by the concentrated and integrated structure of the world oil industry at that time. The strongly increasing demand for world oil during 1953-1957 did not imply higher prices for it at that time because, at the margin, Middle Eastern oils could be supplied on a major scale at only a fraction of the long-run incremental supply costs of the other oils moving in international trade during that period. Under conditions of free competition,

<u>77/ (concl.)</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>
<u>Venezuela:</u>				
<u>Exports of crude oil:</u>				
To the world	314.8	393.7	495.6	456.2
To the United States	140.4	163.3	196.4	163.9
<u>Exports of fuel oil:</u>				
To the world	94.8	112.4	115.2	130.1
To the United States	52.8	59.0	73.1	84.9

Sources: "Industria Petrolera Venezolana", Ministerio de Minas e Hidrocarburos, División de Economía Petrolera, Caracas, December 1965, p. 14 and p. 18. Data on Middle Eastern oil exports taken from: World Energy Supplies, 1950-1974, United Nations, 1976, Statistical Papers, Series I, No 19, p. 269 and p. 309. Data on United States crude oil taken from Ibid., p. 201.

/these cheaper

these cheaper Middle Eastern crude oils would have displaced the higher priced crude oils moving in international trade, putting the whole price structure for world oil under strong downward pressure. The fact that this did not happen bears witness to the strong block to competition that existed in the world oil market during 1953-1957.

With the United States market effectively sealed off, suppliers of Middle Eastern and Caribbean crude oils followed the United States lead in raising crude oil prices in 1953 and 1957. One strategic alternative for the international oil companies at that time was to cut prices on sales in leading markets outside the United States (i.e., in Western Europe and in Japan). However, the major oil companies recognized that any price cuts made by one of them in these markets would be matched by other companies, and so they all opted for and secured higher prices on their international oil sales. This development is indicative of the relative lack of competition in the world crude oil market at that time, a situation rooted in the control of world crude oil production, marketing and refining by the major oil companies and fortified by the protectionist energy policies of the governments of many industrialized countries at that time.

(c) 1958-1970

The upward pressure on world crude oil prices during the Suez Crisis continued into early 1958. Thereafter, the market price of internationally traded crude oil declined up to the end of 1970. Exhibit 48 shows the development of posted prices, market prices (in current dollars), tax paid costs, and government revenue per barrel on sales of Saudi Arabian light crude oil (34°API) during 1955-1974. This was the crude oil which, by the sixties, had become the world's point of reference for international pricing purposes.

The market price of Saudi Arabian light crude oil declined by 3.1 per cent a year between 1958-1970, while worldwide inflation averaged about 4.4 per cent a year.^{78/} The real price of this key crude

^{78/} During 1958-1970, the world consumer price index increased from 60.0 in 1958 to 100.0 in 1970, or by 66.7 per cent. See: International Financial Statistics, International Monetary Fund, Washington, D.C., May 1976.

oil declined from 4.89 to 2.02 dollars of 1975 per barrel during this period (Exhibit 58, Column 3).

The Suez Crisis of 1956-1957 did not eliminate the threat of imported crude oil to the United States oil prorationing system. It merely put off the day of reckoning. Under the pressure of rising oil imports, the United States market was insulated de jure from the world market in 1959 by the imposition of mandatory oil import quotas. Moreover, the international price leadership role exercised by United States producers of crude oil in 1953 and again in 1957 was not repeated after the United States market was legally sealed off from competition with imported crude oil in 1959. The market price of Saudi Arabian light crude oil started falling in 1958, while the posted prices for United States (Texas Gulf) crude oil remained constant. Sealed off legally from competition with world oil, the market price of United States crude oils increased during the sixties while the price of internationally traded crude oil declined.^{79/} The linkage between the United States and world crude oil markets was to remain broken until the seventies.

The declining price of internationally traded crude oil during 1958-1970 was a slow adjustment, in an increasingly competitive world crude oil market, to the lower incremental costs of Persian Gulf and African oil supplies. This decline reflected the loosening control of the major oil companies over world crude oil production, refining and marketing, but at the same time the relative slowness of this decline showed how high this level of control continued to be.

In 1959 the market price of Saudi Arabian light crude oil, FOB Ras Tanura, was about 1.70 dollars per barrel (Exhibit 48). The incremental supply costs of this crude oil were probably less than 0.40 dollars per barrel at that time.^{80/} This gap between the price and

^{79/} For example, the average posted wellhead price for United States' crude oils increased from 2.90 dollars per barrel in 1959 to 3.18 dollars per barrel in 1970, while the estimated market price of Saudi Arabian light crude oil (34QAPI) declined from 1.70 dollars to 1.26 dollars per barrel (FOB, Ras Tanura).

^{80/} Ibid., p. 145.

the cost of supplying crude oil for the world market drew a variety of entrants into the world crude oil producing business: State and quasi-State oil entities; consortia of domestic business interests, such as the Japanese group which struck oil in the Middle East; and a large number of international oil companies of widely varying sizes and degrees of integration which were independent of the major oil companies. Host governments granted concessions to these new entrants for the development of areas that, in many cases, had been returned to them by the majors.

The price-cost gap in world oil also induced some host governments to sell on their own account crude oil obtained through their interests in the producing business located in their countries, although the host governments continued to market the bulk of their oil through the networks of the major companies. The gap also encouraged the Soviet Union to step up its role as a competitive seller in the world oil market in the fifties and during the sixties.

The development of new oil supplies in the late fifties and during the sixties was not limited to the Persian Gulf. Large-scale, competitive world oil supplies were also developed in Africa (e.g., Libya, Algeria, and Nigeria). Many of these new sources of world oil were developed with the participation of relatively small international oil companies, as was the case in Libya, for example. In that country, these smaller companies developed oil supplies rapidly and on a large scale, and they brought this oil to market in a competitive fashion by cutting prices.

The entry of many relatively small crude oil producers into the world oil market in response to the price-cost gap was paralleled by the growth in the number of large independent refiners. This later development was part of the worldwide shift from resource to market-oriented refineries, and its speed was enhanced by the rapid growth in the consumption of refined oil products during the fifties and sixties. The growth in the number of large independent refineries, on the one hand, and the increase in the number of independent sellers of international crude oil, on the other, increased the competitive

/margin of

margin of the world crude oil market. Adelman estimates that sales of crude oil in the arms-length component of this market increased from 6.9 per cent in 1950 to 17.6 per cent by 1957 and 20.7 per cent by 1968.^{81/} He also estimates that the share of the eight major international oil companies in world refinery runs (excluding those in the United States and in the centrally planned economies) declined from 67.4 per cent in 1957 to 61.6 per cent in 1966.^{82/} Jacoby estimates that during 1953-1972 more than 300 private and 50 State-controlled companies either made their entrance into the international oil business or significantly increased their operations in it. He also notes that between 1953-1972 a minimum of fifty new integrated international oil companies entered the world oil business.^{83/}

The entry of newcomers into the world crude oil producing business and the growth in the number of independent refiners and integrated international oil companies increased the supply of world oil and put its price under pressure in markets outside the United States.^{84/} Price-cutting by new entrants ricocheted back on the international oil companies, compelling them to lower their prices where, otherwise, they might not have done so, or at least not as rapidly.^{85/} The scale of the price-cost gap put the major companies

^{81/} Ibid., p. 90.

^{82/} Ibid., p. 95.

^{83/} N.H. Jacoby, Multinational Oil, (New York: The Macmillan Publishing Co., 1974), p. 294.

^{84/} In Latin America, the role of Brazil and Argentina in bringing down world crude oil prices was especially important. They were able to do this because of the large volume of contacts for imported crude oil that they could offer to sellers of world oil.

^{85/} A large, established oil company is understandably more reluctant to cut prices than a newcomer. When the former cuts price, it does so over the whole range of its sales base, while the newcomer's sales base is, by definition, smaller and his incremental sales, in the case of world crude oil, can be quite large. Hence, the newcomer often has less of a financial inhibition against price-cutting than the large, established company. This was the case of the small independents in Libya, who added rapidly to their export sales by price-cutting.

under pressure to shave prices even without the stimulus provided by the independent companies. The attraction for the major companies to cut prices had long been present, and they had not always resisted it in the past.

The reduced price of international oil posed a threat to indigenous coal, crude oil, and natural gas industries. From a political point of view, the threat posed by imported oil to domestic coal was especially worrying to oil-importing governments because of the large number of workers and businesses with vested interests in protecting this industry. At the same time, various industrialized countries with international oil and gas producing interests looked forward to balance of payments benefits from higher prices for international oil and gas. The mix and intensity of these various interests differed widely among the oil-deficit industrialized countries, but one conclusion seems clear: not all of them welcomed the declining price of world oil. This lack of enthusiasm was also noticeable in some countries which, as well as having domestic energy industries to protect, had made substantial energy investments abroad and sought to protect those investments through propping up the price of world oil.

By and large, the governments of the oil-deficit countries opted for the protection of their local energy industries (and foreign energy investments). Protection of local energy industries was extended by using a variety of instruments, in varying degrees of intensity depending on the country and the time: price controls, tariffs, subsidies, quotas, direct purchases for resale, and the establishment of captive markets for local fuels. The aim was to prop up the price of fuel oil in domestic markets to levels higher than would prevail under competition and, by so doing, to protect coal and other local energy industries (and international interests, as the case might be).

If governments wanted the price of fuel oil to follow the lead of indigenous coal, the international oil companies could be relied upon to co-operate to the extent possible, given the degree of their declining control over the supply of world oil and also the extent

/of their

of their day-to-day ability to maintain ranks and restrain price cutting. One major difficulty here was the competitive action of independent sellers of world crude oil, independent domestic refiners, and various buyers of fuel oil (manufacturers, power companies, fuel oil wholesalers, etc.) in the oil-importing countries. If the governments of the oil-deficit countries did not restrain competition between these buyers and sellers of fuel oil and coal in the domestic energy market, the major international oil companies had no choice, realistically, but to follow the downward trend in oil prices that was bound to emerge from competitive trading.

The pressure on governments to intervene was intensified at that time by the fact that the incremental supply costs of coal were on the increase in many oil-importing countries while world oil prices were under sharp downward pressure. The strong increases in refinery runs in the oil-deficit countries were rapidly increasing the physical supply of fuel oil as a joint product of the refining process, which was heavily geared to gasoline production, thus putting the price of fuel oil, in turn, under strong downward pressure. The rapidly increasing supply of fuel oil eventually led to declines in its price relative to coal, and all over the world indigenous coal industries in oil-deficit countries progressively lost ground to oil (Exhibit 49).

By way of summary, then, during 1958-1970 the real price of internationally traded crude oil declined by about 7.1 per cent per annum compounded (Exhibit 58, Column 3). The link between United States and world crude oil prices was formally broken in 1959 and remained so until the seventies. Moreover, during the sixties the growth in the arms-length component of the world crude oil producing industry and the increasing importance of independent sellers and buyers (especially in Western Europe and Japan) eroded the control of the major companies over the supply of world oil and widened the competitive margin of the international crude oil market. However, the grip of the major companies, though slackening, was still significant, and this continuing control explains, in part, the maintenance of a sizeable price-cost gap in world oil /during this

during this period. The protective energy policies of many governments of industrialized oil-importing countries supported this situation. Nevertheless, the real price of world oil did decline during 1958-1970, and this fact must be judged as a competitively induced adjustment to the lower levels of long-run incremental costs of supplying world oil from the Persian Gulf and Africa. By way of comparison, this process of adjustment was briefly observable in 1948-1949, but it had remained blocked from 1950 to early 1958.

(d) 1971-1977

The downward trend in the price of world oil, in evidence since 1958, stopped in 1970 and was then reversed. The explanation of this reversal does not lie in any fundamental change in the pattern of the long-run incremental supply costs of world oil as measured, at a maximum, by the levelized cost per barrel of developing more reserves in existing fields, producing from them, and then transporting that crude oil to seaboard loading facilities. The supplies needed to meet much of the world's oil demand up to the end of 1985 were available in the major producing countries of the Persian Gulf in the early seventies at a cost in 1968 prices of no more than 0.10-0.20 dollars/barrel.^{86/} By comparison, the market price of Saudi Arabian light crude oil in 1970 was on the order of 1.26 dollars per barrel, FOB ... Ras Tanura, or about 1.09 dollars per barrel in prices of 1968.

In 1970, as throughout the entire post-war period, more oil could be produced for world markets than was in demand at current prices. In short, in the seventies, as in the fifties and sixties, the explanation of the evolution of world oil prices is to be found, not in the competitive interaction of world oil supply and demand, but in the structure of the world oil industry, on the one hand, and the complex of energy policies of the industrialized countries, on the other.

^{86/} Adelman, op.cit., p. 76.

In 1970, a number of factors placed the OPEC governments in a strong position to extract higher unit revenue on exports of oil produced in their countries. As shown in Exhibit 50, crude oil production for and proven reserves available to the world oil market remained heavily concentrated in OPEC member countries and in four Persian Gulf OPEC countries in particular, whereas the benefits of the market power arising from this concentration were still largely being reaped by the international oil companies. The forces of nationalism and profit-seeking, however, were continuously working to increase unity among OPEC member countries to shift the benefits of this power from the companies to them. By 1970, with prices at low and prospectively lower levels, it was probably clear to all host oil countries that the most viable route to higher income on oil export account for them was to wrest control of the supply of world oil from the international majors, who themselves were clearly losing that control due to increasing competition in the world oil market.

In May 1970, the Trans-Arabian pipeline 87/ was closed and the Trans-Israeli pipeline was not used to help offset the resulting shortage of world oil. The United States demand for imported oil was rising sharply in response to several factors: increased economic activity, domestic shortages of natural gas and low sulphur oils, the prospect of halting United States crude oil production, and the sluggish expansion in nuclear power capacity. Oil imports into Western Europe and Japan were also increasing rapidly due to the revival of economic activity in these markets and their almost complete reliance at the margin on imported oil from OPEC sources to satisfy domestic energy requirements.

87/ The Trans-Arabian Pipeline (tapline) came into service in 1950. A crude oil pipeline 1,200 miles in length, it was constructed to transport crude oil from Saudi Arabia to the Mediterranean at Sidon, Lebanon, for subsequent transshipment to Europe. It was closed in May, 1970 after an accident, and Syria blocked its reopening. Lack of access to its 500,000 barrels per day crude oil carrying capacity increased the demand, especially in European markets, for Libyan crude oil, and to that extent strengthened Libya's bargaining power at that time vis-a-vis the oil companies and the oil-importing countries over the division of economic rent in crude oil production there.

The soaring demand for world oil, in the face of the then prevailing tanker shortage, drove up oil tanker rates sharply, increasing the profits of the oil companies, especially on oil exports from North Africa to West European markets. Shortly after the closure of the Trans-Arabian pipeline, the Libyan Government began cutting back production quotas of the oil companies operating there in support of its demand for higher revenues per barrel. The Libyan cutbacks in production allowables, coming on top of the closure of Tapline, burgeoning world oil demand, and the entry of the United States as a potentially large-scale importer of world oil, put Libya in a good position tactically to strike for more revenue per barrel exported. Libya's strategy was successful, and its success induced a leap-frogging of demands for increased revenue per barrel by the member governments of OPEC. Company-host government negotiations ensued, with behind-the-scenes participation of the oil-importing industrialized countries.

The Teheran agreement of February 1971, and the agreements supplemental to it, were hailed by the governments of the oil-importing industrial countries as ushering in a five-year period of predictable and acceptable increases in the price of world oil.88/

88/ The Teheran agreement came into force on 15 February 1971. It was an accord between the oil companies and the governments of Iran, Iraq, Saudi Arabia, Kuwait, Abu Dhabi, and Qatar. It covered crude oil exports from the Persian Gulf only, but associated agreements came into force on 20 March 1971, covering exports from North Africa, Nigeria, and East Mediterranean ports. These agreements resulted in an increase in posted prices of about 21 per cent over the level on January 1975 and an increase in consolidated tax rates from 50 per cent to 55 per cent. An inflation adjustment of 2.5 per cent a year was also included. The Teheran and associated agreements were viewed by many governments of oil-importing countries as a final settlement and the basis to be used for calculating the companies' increasing tax liabilities to host governments to the end of 1975 and also for assessing the trend in world oil prices up to the end of 1975.

/The apparently

The apparently widespread belief in this prophecy, combined with the considerable vested interests in moderately higher oil price in the case of some industrialized countries, explains the widespread support for the Teheran agreement among the governments of many industrialized oil-deficit countries.

When the Teheran and related agreements took effect, the price of world oil was increased to cover the higher level of tax-paid cost, plus some profit for the oil companies. The governments of the OPEC countries had clearly triumphed, and gained an increase in revenue received per barrel of oil exported from their countries. The governments of the industrialized, oil-importing countries believed that these increased payments were acceptable, and applauded their own statesman-like role in engineering the agreements. The oil companies increased prices, with a premium. And the consumer, as usual, was the loser.

The financial details of the Teheran agreements were expressed in United States dollars. The devaluation of the dollar in August 1971 and then again in February 1973 led to a series of new agreements on world oil - the Geneva (and supplemental) agreements - which identified the basis for compensating host governments for international currency realignments. These agreements provided for an 8.5 per cent increase in posted prices in January 1972 and then for a 6 per cent increase in April 1973. Subsequent negotiations led to the revision of the index used for compensating host governments for devaluations. The Geneva II agreement of June 1973 provided a new basis for compensating host governments for devaluations. This agreement supported an increase in posted prices of about 12 per cent over the level prevailing on 1 January 1973, with revision, up or down, to be made subsequently on a monthly basis.

The pattern of world oil prices and government revenues per barrel between 1970 (i.e., prior to the Teheran agreement) and October 1973 shows that although the host countries increased their total
/receipts per

receipts per barrel substantially during this period, oil company margins increased even more rapidly. Taking Saudi Arabian light crude oil as an example, between 1970 (average) and 1 October 1973, host government receipts increased by about 0.85 dollars per barrel, while company margin (i.e., price FOB less tax-paid cost per barrel) increased by about 0.89 dollars per barrel. On 1 October 1973, the level of company margin on this crude oil, at 1.12 dollars (3.00 dollars - 1.88 dollars) per barrel, was at an all-time high, as was its market price of 3.00 dollars per barrel, compared with 1.26 dollars per barrel in 1970 (Exhibit 48).

The fact that the company margin per barrel increased more than the government revenue per barrel between 1970 and 1 October 1973 was largely due to the strong growth in the demand for world oil during this period and to the ability of the oil companies to pass on to consumers the increased payments they had to make to host governments, plus a margin for themselves. However, the strongly nationalistic and profit-minded host governments could hardly fail to be offended by the fact that the companies' margin had increased more than theirs.

The record of company-government negotiations from 1970 to October 1973 shows a clear lack of opposition on the part of the governments of industrialized, oil-importing countries to the prospect and subsequent fact of increases in the price of world oil. Highly placed public officials in these countries were, in fact, welcoming higher oil prices on a variety of grounds. In effect, sellers were being applauded for raising their prices, and the division of economic rent between the companies, the host governments, and the importing countries was implicitly being hailed as equitable, an implicit position hardly shared by the host oil governments. One can search in vain for any reference by a high public official in the oil-importing industrialized countries at that time to the simple economic fact that the long-run incremental cost of supplying oil from the Persian Gulf was only about 5 per cent of its price in early October 1973 (using Saudi Arabian light crude oil for measurement purposes).

/These observations

These observations were not lost on the member governments of OPEC, who clearly desired a transfer from the companies to themselves of a larger share of the economic rent generated in the world crude oil industry.^{89/} In September 1973 the fourth Egyptian-Israeli war broke out, and expectations about the price and tax-paid cost of world crude oil became chaotic. The governments of six Persian Gulf countries met in Kuwait in October 1973,^{90/} and using Saudi Arabian light crude oil as a yardstick, they fixed the tax-paid cost of this crude oil at 3.15 dollars per barrel on 16 October compared with the level of 1.88 dollars which had been set on 1 October 1973. The market price of Saudi Arabian light increased from 3.00 dollars to 3.65 dollars per barrel, with the oil company margin declining to about 0.50 dollars per barrel from its 1 October 1973 level of 1.12 dollars per barrel (Exhibit 48).

In December 1973 the governments of the same six Persian Gulf countries made a truly shattering announcement. Effective 1 January 1974, the posted price and government take on Saudi Arabian light crude oil was to be fixed at 11.65 dollars and 7.00 dollars per barrel,

^{89/} For example, in August 1973 the estimated company margin on the sale of Saudi Arabian light crude oil was about 0.94 dollars per barrel (versus 0.23 dollars per barrel in 1970), while the government take per barrel in August, 1973 was about 1.76 dollars per barrel (versus 0.88 dollars per barrel in 1970). See Exhibit 48.

^{90/} This meeting was convened, without the companies, after the breakdown of company-country negotiations in Vienna on the issue of the adjustment of world oil prices to take into account worldwide inflation. The participating Persian Gulf countries (i.e., Iran, Saudi Arabia, Kuwait, Abu Dhabi, Qatar and Iraq) unilaterally abrogated all standing agreements with the oil companies on such essential matters as price and government revenue per barrel and substituted instead the provisions of the Kuwait meeting. So much for the predictions of many senior statesmen in the industrialized countries that the Teheran agreement would usher in a five-year period of limited and predictable increases in the price of world oil.

/respectively. Officials

respectively. Officials in the industrialized countries protested, but no significant action was taken. The new level of prices and government take per barrel was introduced in Saudi Arabia in January 1974 and was then generalized to the world market. The government of Saudi Arabia had clearly led the way in a massive shift of economic rent to the host countries from the oil companies, importing governments and their citizens.

In addition to these changes, two other developments were taking place during the early seventies that had an important impact on the level of government revenue per barrel and on the market price of world crude oil: first, developments bearing on the share of host governments in domestically produced crude oil (i.e., their participation oil rights), and second, developments bearing on the price that the companies would pay for acquiring this participation oil (i.e., the buy-back price).

In 1952 an accord had been reached in the Middle East under which host governments had the right to take, in the form of crude oil, up to 12.5 per cent of the volume of the companies' net crude oil production, or alternatively, they could take a sum per barrel equal to 12.5 per cent of the level of posted prices.^{91/} With posted prices above market prices, host governments generally sold their participation oil (above the volume required in their domestic markets) to the companies, which in turn sold it through their networks.

The first big breakthrough in the area of participation came in October 1972, when a provisional understanding was reached between Saudi Arabia, Qatar, Abu Dhabi, Kuwait and Iraq and the oil companies. The agreement provided that, effective 1 January 1973, the countries could acquire 25 per cent participation, with the option to increase this share, in annual increments, to 51 per cent by 1982.

^{91/} Prior to this agreement, many host governments had the right to oil at cost for the purpose of satisfying their domestic market requirements. There were, however, a variety of specific country-government agreements in this area. For a brief discussion of the history of these provisions, see "End of an Era" and "Implications of Nationalization" in "The Petroleum Economist", January 1975 and April 1975, respectively.

The Kuwaiti National Assembly did not ratify this understanding, and the Government of Kuwait and the companies began negotiations once again on participation. They settled on 60 per cent.

By October 1974, 60 per cent participation was the standard in the Persian Gulf, and the buy-back price was set at 93 per cent of the posted price. Thus, the cost to the oil company of acquiring participation oil in the case of Saudi Arabian light crude oil at that time was 10.84 dollars (i.e., 93 per cent of 11.65 dollars). With Saudi Arabia's oil-related income tax in October 1974 fixed at 65.75 per cent of posted price less the sum of both royalty (at 16.67 per cent of posting) and production costs (then about 0.17 dollars per barrel), the tax-paid cost to the companies of Saudi Arabian equity crude oil in October 1974 was 8.38 dollars per barrel (Exhibit 51).

The equity/participation oil split in the case of Saudi Arabia in October 1974 was 40:53.75, the remaining 6.25 per cent being reserved for direct sale by the Saudi Arabian Government. Thus, the weighted average cost per barrel to the oil-producing company of acquiring Saudi Arabian crude oil in October 1974 was 9.79 dollars (Exhibit 51). The average government take per barrel was the sum of taxes (6.27 dollars) plus royalties (1.94 dollars) per barrel on equity oil plus the Government's revenue per barrel on participation oil, net of production costs (10.83-0.17 dollars), or after weighting for the two categories of crude oil, 9.62 dollars per barrels (Exhibit 51).

Additional changes in the financial parameters of Saudi Arabian oil were introduced in November 1974 and then again in January 1975 (Exhibit 51).^{92/} The result was that in January 1975 the weighted

^{92/} The posted price was reduced from 11.65 dollars per barrel as of 1 October 1974 to 11.25 dollars per barrel on 1 November 1974 continuing to 1 January 1975. Income tax rates were increased from 65.7 per cent (October) to 85 per cent (November 1974). Royalty rates were increased from 16.67 (October) to 20 per cent (November 1974). Buy-back percentage was increased from 93 per cent in October to 94.85 in November, and was then decreased to 93 per cent in January 1975.

/average tax-

average tax-paid cost of Saudi Arabian light crude oil to the companies was 10.23 dollars per barrel compared with 9.79 dollars in October 1974, and the government's weighted average take was 10.07 dollars per barrel compared with 9.62 dollars in October 1974 (Exhibit 51).

In September 1975, the OPEC Ministers agreed to introduce a new price structure for world oil based on parity with Saudi Arabia light crude oil selling in the open market at 11.51 dollars per barrel, FOB Ras Tanura. Significantly, no reference was made in the OPEC Ministers' convening communication to posted prices, buy-back prices, tax and royalty rates, or the like. However, in the light of the previously prevailing financial parameters (Exhibit 51), and production costs for Saudi Arabian light estimated at 0.29 dollars per barrel in early 1975, government take on equity oil was effectively raised from 9.76 dollars to 10.65 dollars per barrel and company tax-paid cost on equity oil was increased from 9.93 dollars to 10.94 dollars per barrel in September 1975. Since the buy-back price was increased from 10.46 dollars to 11.51 dollars per barrel, the weighted average tax-paid cost to the company of acquiring both equity and participation crude oil in Saudi Arabia increased from 10.23 dollars to 11.27 dollars per barrel, leaving the company with a weighted average margin of 0.24 dollar per barrel on crude oil sales at 10.51 dollars per barrel (versus a 0.23 dollar margin in January, 1975). Member governments of OPEC were left to adjust their financial parameters as they chose to bring their crude oils into financial parity with Saudi Arabian light crude oil.

In May 1976, at Bali, the OPEC Ministers agreed to freeze the structure of prices and government revenue per barrel to the end of 1976. The next meeting of OPEC Ministers took place in Qatar in December 1976. At that meeting, Saudi Arabia and the United Arab Emirates 93/ refused to endorse a proposal to increase the price of world oil by 10 per cent on 1 January 1977 and then by an additional

93/ The United Arab Emirates include Abu Dhabi, Duhai and Sharjah.

5 per cent on 1 July 1977. On 1 January 1977 Saudi Arabia and the United Arab Emirates raised their prices by 3-5 per cent, depending on the crude oil, and declared their intention of holding these new prices constant during 1977. Simultaneously, the other OPEC member countries raised their prices by 9-11 per cent, depending on the crude oil, and declared their intention of raising prices by another 5 per cent in July 1977.^{94/}

These disparate decisions introduced a spread in official prices beyond that explicable by the sum of quality, credit and transport differentials. In January 1977, the official price of Iranian light crude oil (340 API) was increased by 10.2 per cent to 12.81 dollars (FOB Kharg Island), a full 0.72 dollars above the comparable price for Saudi Arabian light (340 API) of 12.09 dollars FOB Ras Tanura; this compares with a 12 cent per barrel difference in official prices between these two crude oils in October 1975, when Saudi Arabia and Iran were reportedly both giving 60 days credit to third-party buyers of their 340 API crude oil. Saudi Arabia increased production rapidly and substantially, breaking the demand for crude oils in many countries that had raised prices in the range of 10 per cent.

This anomalous price structure was corrected at the OPEC meeting held in Stockholm in July 1977. Following this meeting, Saudi Arabia and the United Arab Emirates announced that they would raise prices by 5 per cent, effective 1 July 1977, while other OPEC member countries agreed to freeze their prices for the remainder of 1977. The official price of Saudi Arabian light crude oil was raised to 12.70 dollars per barrel. At this price, the weighted average cost to the oil company of equity and participation crude oil would be about 12.44 dollars per barrel (Exhibit 51). With Saudi Arabian light crude oil selling at

^{94/} The official price of Indonesian Conta (340 API) and Wali (34/370 API) crude oil were increased by 6.0 per cent and 8.3 per cent, respectively. All other OPEC country crude oils in this second group of countries were increased by percentages ranging between 9.2 per cent and 12.2 per cent. For full price details see Petroleum Intelligence Weekly, 14 March 1977, Supplement.

the official price of 12.70 dollars per barrel, the weighted average company margin would be 0.26 dollars per barrel, and the weighted average government take would be about 12.04 dollars per barrel. The 12.70 dollars price and the 12.04 dollars government take per barrel on 1 July 1977 stand in vivid contrast with 1.26 dollars and 0.96 dollars per barrel, respectively, which are the comparable data for 1971, the year of the Teheran agreement (Exhibit 48). As noted earlier, this agreement was widely heralded at the time in developed countries as a harbinger of relative stability in world crude oil prices and tax-paid company costs.

To sum up, then, between the Teheran Agreement in 1971 and July 1977 the official sales price of Saudi Arabian light crude oil purchased by third parties in the world market increased by 855 per cent, from about 1.33 dollars to 12.70 dollars per barrel. During this same period, worldwide inflation increased by roughly 78 per cent,^{95/} so that the real price of world crude oil probably increased by about 538 per cent during this period. Obviously, no comparable change occurred in the pattern of physical scarcity of world crude oil, and huge volumes of crude oil can still be economically developed and brought to loading ports in the Middle East at costs of the order of 0.40 dollars per barrel in the case of Saudi Arabian light: a striking contrast with the official market price of 12.70 dollars per barrel for this key crude oil in July 1977.

One need not be an Adam Smith to realize that in the seventies (as previously), prices in the world crude oil market are not being determined by the competitive interaction of supply and demand. The price of world crude oil is being fixed by a producers' cartel, which

^{95/} This is the approximate percentage increase in the worldwide consumer price index between (average) 1971 and (average) 1976, adding an estimated 11.3 per cent annual rate of increase in the world consumer price level during January-July 1977. Historical price data were taken from International Financial Statistics of the International Monetary Fund, January and December 1976 and July 1977 issues.

has very successfully maintained it by restricting the supply of world crude oil to levels compatible with the established price. However, this success in maintaining price far above cost has also been due, in large part, to the lack of aggressive policies in the industrialized countries to bring down the price of world crude oil. For the most part, these countries have been passively adjusting to the prices they have been facing for world oil. They have not, to date, taken action explicitly designed to break the price structure of world crude oil.

Thus, the structure of the world oil industry and the oil-related policies of the industrialized countries are the key considerations involved in an explanation of world crude oil prices in the seventies. However, the structure of the world oil industry has undergone profound changes since the Teheran agreement. Some producing governments are now the full owners of their crude oil producing industry. Others have participation agreements with the major companies and, within this group, some countries are in the process of taking over full equity ownership of the domestic crude oil producing industry.

Taken as a group, the producing nations now stipulate the price of internationally traded crude oil and its acquisition cost to the producing companies. Output is then adjusted to levels that are consistent with target market prices. No rigid quota system exists within OPEC to regulate crude oil output in support of desired prices.^{96/} The system is an informal one. However, for all its informality, and despite all the forces working in the market to disrupt it, that system has so far worked excellently for the OPEC member countries. The bulk of the economic rent generated in the world oil industry is now collected by the oil-importing governments in the form of their tax receipts on oil flows within their economies and by

^{96/} The need for such a system has been discussed several times at OPEC conferences.

the oil-exporting countries. The share of the oil companies in this economic rent has declined substantially in both absolute and relative terms during the seventies, much of it having passed to the host countries.

(e) Summary

World crude oil prices in the post-war period have not been determined by the competitive interaction of supply and demand. The basic reasons for the increase in world crude oil prices during 1945-1948 are not to be found in the pressure of rising demand on incremental supply cost but rather in the exercise of market power by the international major companies, on the one hand, and the protectionist energy policies pursued in many industrialized countries, on the other.

World crude oil prices declined during 1948-1949, but remained far above incremental supply costs. Even so, competition was at work in the world crude oil market at that time. The prices of world oil increased during 1950-1957. The reasons for this increase are to be found, once again, in the protectionist policies of the industrialized countries towards their domestic energy industries (and, in some cases, towards their foreign energy interests), together with the exercise of market power by the major companies, a force deriving its strength from the concentrated control and integrated structure of the world oil industry.

World oil prices declined during 1958-1970 because of the increasing competition that developed in the world oil industry during that period. The decline in the price of world oil during 1958-1970, as in 1948-1949, was a partial adjustment to the reality of the immense reserves of relatively low-cost oil in the Middle East and Africa.

Since 1970, the price of internationally traded crude oil has increased sharply. That increase has been the result, not of the competitive interaction of the demand for and the incremental supply cost of world oil, but of the actions taken by a highly successful

/group of

group of host governments, supported by their marketing arrangements with the major oil companies and at the same time unopposed by any policy action in the developed countries having as its principal objective the sharp and rapid reduction of world oil prices. The ability of these host governments to maintain prices far above long-run supply costs lies fundamentally in their tight control over the supply of crude oil entering international commerce.

This survey of the changes in the price of world oil since the Second World War leads to two fundamental conclusions that are of prime importance in a forecasting context: first, that the competitive interplay of demand and supply does not explain the pattern of change in the price of world oil since the Second World War; and second, that two factors have been of prime importance historically in explaining changes in world crude oil prices: the structure of the world oil market, and the oil-related policies of the major industrialized countries. The key to forecasting world oil prices lies in an analysis of the future operation of these two factors.

Section II: The present structure of the world crude oil producing industry

The preceding section concluded that the structure of the world crude oil producing industry has been a major factor in explaining changes in world crude oil prices in the post-war era. In this section, more detailed consideration is given to this structure as it exists today. This is a necessary prelude to the forecasting of world oil prices for the rest of this century.

The 13 member nations of OPEC account for all but a minor fraction of the volume of crude oil moving in international trade. Crude oil production in these nations takes place under a variety of country-company relationships. The structure of these relationships and the probable drift in them over time are vital to an understanding of the expected price of world oil. This section defines the principal features of the present structure of the world crude oil business, while section IV (iv) considers possible changes in this structure over time.

/Full State

Full State ownership of onshore operations has been realized, either in fact or in principle, in Saudi Arabia, Iran, Kuwait, Qatar, Algeria and Iraq. Additionally, Venezuela nationalized its crude oil producing industry in January 1976. In 1976, these seven countries accounted for roughly seven-tenths of the total crude oil production and production capacity of the 13 member countries of OPEC (Exhibits 52 and 53).

Saudi Arabia is the largest crude oil producing country in OPEC, accounting for about three-tenths of OPEC crude production and capacity. Saudi Arabia has been negotiating with the companies for full takeover of the domestic crude oil producing industry, and announcement of the takeover agreement is expected shortly.^{97/} At present, however, the four major oil companies participating in ARAMCO are still acquiring their crude oil at a weighted average price which is about 0.26 dollars per barrel below the official price at which third parties buy Saudi Arabian light oil in the open market (Exhibit 51).

Although Saudi Arabia does sell some of its oil offtake to third parties, the Government continues to sell the bulk of its participation oil back to the companies at the buy-back price, thus insulating itself from direct competition with buyers.

Thus, although nationalization is expected, the major companies operating in Saudi Arabia at present still have access to cheaper (equity) oil than is available to third parties in the open market, giving these companies, to that extent, an advantage in their competitive refining and marketing operations. On the other hand, by marketing the bulk of its participation crude oil through company networks, Saudi Arabia reduces the degree to which it would otherwise confront third-party buyers of its crude oil on a truly competitive basis.

^{97/} These companies are: Exxon, Mobil, Texaco and Socal. In 1973, the government of Saudi Arabia acquired a 60 per cent interest in ARAMCO's production operations and assets, the remaining 40 per cent equity interest being divided among Exxon, Socal and Texaco (30 per cent each) and Mobil (10 per cent).

/Each Of

Each of the major companies operating in Saudi Arabia is reluctant to cut the price of the crude oil that it secures there. As noted earlier, the tax-paid cost to the company of buy-back oil is 12.70 dollars per barrel, and this is also the official price for third parties purchasing Saudi Arabian light crude oil. Thus, if a major company does cut the price of Saudi Arabian light to third parties, it is reducing its weighted average margin of 0.26 dollars. Moreover, a discount by one major company is bound to be matched by another with its own equity oil to sell to third parties, so that the additional revenue of a major company which is the first to cut its prices would quickly disappear or be reversed. In any case, Saudi Arabia would probably act before this happened in order to support its 12.70 dollars official price for its light crude oil, which is now the pivot of the world crude oil price structure. Since Saudi Arabia fixes the rate of ARAMCO production,^{98/} it has the power to punish the companies and other oil-producing countries financially if they engage in price cutting.

The structure of the country-company relationship now prevailing in Saudi Arabia is roughly comparable to those existing in Nigeria (55 per cent State participation), Ecuador (25 per cent),^{99/} and Abu Dhabi (60 per cent). In each of these countries, the foreign producing companies secure their equity crude oil below the price that third parties must pay for it in the open market. Government revenue per barrel, company margin, and official price in each country are tied to rough parity with the OPEC benchmark crude oil, Saudi Arabian light. In each case, the State sells the bulk of its

^{98/} Saudi Arabia set a 10.0 million barrel per day production ceiling for ARAMCO in 1977. See: "Saudis Slash Flow of Light Crude for 'Technical' Reasons", Petroleum Intelligence Weekly, Vol. XVI, No 33, 15 August 1977, p. 1.

^{99/} CEPE held a 25 per cent interest in the crude oil production consortium in Ecuador. However, the Government has decided to acquire Gulf Oil's 37.5 per cent interest, and this will increase CEPE's interest to 62.5 per cent, with Texaco holding the remaining 37.5 per cent equity interest. See: "Ecuador moves toward further oil takeover", Petroleum Economist, October 1976, p. 380.

participation oil back to the companies at the official price, thus, once again, removing it to that extent from arms-length competition with third-party buyers in the open market. Although there are some State sales in the open market, the bulk of the crude oil produced in these countries reaches the market through the networks of the major companies.^{100/} The companies are hesitant to cut prices on the sale of crude oil secured in these countries for the same reasons as noted above in the case of Saudi Arabia.

In Libya, Indonesia and Gabon, foreign companies still have ownership positions in the crude oil producing industry. In Libya, the State has a majority equity position in each of the major producing companies with foreign interests there. It is the full owner of the National Oil Company, which in 1975 accounted for about one-fifth of Libya's total crude oil production. The State controls the crude oil output rates of the companies. It sells much of its crude oil directly on the open market at the official price, which is tied to Saudi Arabian light crude oil, taking account of the value of differentials for such factors as point of shipment, wax and sulphur content, specific gravity, etc. Libya has recently been placing special emphasis on direct sales of its crude oil, cutting the volume of crude oil sold to most of the foreign producing companies under buyback arrangements.^{101/} These companies still acquire their equity oil at a cheaper price than that prevailing in the open market, however, even though they also have to purchase government participation crude oil. The weighted average tax-paid cost of crude oil to the companies in Libya is tied to the comparable cost of benchmark crude.

^{100/} In Nigeria, for example, it was expected in early 1976 that about 60 per cent of the volume of the Government's 55 per cent participation oil share would be sold back to the companies producing there, the rest being sold by the State to outside buyers, both major companies and third parties. See: "Nigeria Lines Up Customers for Most of Its State Crude", Petroleum Intelligence Weekly, 6 February 1976, p. 7.

^{101/} "Libya Pressing to Boost Production and Direct Sales", Petroleum Intelligence Weekly, Vol. XVI, No 16, 18 April 1977, p. 5.

In Indonesia, the State oil company, Pertamina, holds production-sharing contracts with about 50 foreign companies. These contracts usually provide that the foreign company can recover its investment from the initial 40 per cent of crude oil production and that the remaining 60 per cent is split between the government and the company, the share varying in accordance with the specific contract.^{102/} The government sets the price for its crude oil sales with reference to the price of OPEC benchmark crude. The State controls the price and rate of indigenous crude oil production.

In Gabon, the major foreign companies are Elf and Shell. Instead of the usual participation arrangement, the Gabon Government holds a 25 per cent equity interest in the domestic operations of these companies. Government-take is composed therefore, of income tax, royalty and dividends. The foreign companies market Gabon crude oil at prices linked to Saudi Arabian light. Supply costs are relatively high in Gabon, which accounts for only a minor part of total OPEC output (Exhibit 52). In June 1975, OPEC specialists concluded that Elf's Mandji crude oil was "underpriced compared with other African crudes" and warranted "an upward price adjustment".^{103/}

In the remaining member countries of OPEC (Iraq, Iran, Kuwait, Venezuela, Algeria and Qatar) the State is now the sole owner of the crude oil producing industry, and foreign oil companies no longer have equity crude oil rights.

^{102/} Government-take had traditionally been about 60-70 per cent. However, production-sharing arrangements with the companies are now changing drastically. Recently, the three largest production-sharing companies in Indonesia agreed to an 85:15 per cent government-company split of oil production after a period of seven years, and the government is threatening that, if another group of companies does not accept its proposed 14-year limit recovery period, it will take over their operations. See: "Indonesia getting higher take it wants from foreign producers", Petroleum Intelligence Weekly, 9 August 1976, p. 4.

^{103/} "Gabon adjustment will follow recent Nigerian price cuts", Petroleum Intelligence Weekly, 22 September 1975. Government-take in Gabon also includes earnings on domestic investments undertaken jointly by the producing companies and the Government.

The Iraq National Oil Company (INOC) is the exclusive marketer of indigenous crude oil. The major companies purchase Iraqi crude oil on a commercial basis along with the other companies. In the past, some OPEC member countries have charged INOC with cutting prices to levels below parity with Saudi Arabian light. One trade source reports that this charge was discussed at OPEC's Bali Conference in May 1976, and that a "gentlemen's agreement" was reached, behind the scenes, on the price of Iraq's Basrah crude oil.^{104/}

In Iran, the 1973 country-company agreement is still under negotiation. The State's Iranian National Oil Co. (INOC) sells large volumes of domestically produced crude oil to the major companies, reportedly at market price less a 0.22 dollars per barrel nominal discount at a time when the companies' margin on Saudi Arabian light was about 0.22 dollars per barrel.^{105/} Until fairly recently, INOC used to sell the bulk of its crude oil to the consortium companies. In the first quarter of 1976, for example, INOC exported at a rate of 495,000 barrels per day while the eight companies of the Iranian consortium exported at a rate of 3.7 million barrels per day.^{106/} However, INOC is moving fast into third-party markets, competing directly with the consortium companies for their customers, using not only conventional commercial instruments of competition but barter trade as well.^{107/} Thus, by June 1976 INOC was exporting at a rate of 1,047,000 barrels per day while the consortium companies were exporting at a rate of 3,912,000 barrels per day.

^{104/} "Iraq hikes its prices above floor set by Gulf States", Petroleum Intelligence Weekly, 28 June 1976, p. 1.

^{105/} The eight largest integrated oil companies operate as producers in Iran. These companies are: Texaco, Socal, Shell, Mobil, Exxon, Compagnie Française des Pétroles, British Petroleum and Gulf.

^{106/} "Iran aims to hold high level of direct crude sales", Petroleum Intelligence Weekly, 26 July 1976, p. 3.

^{107/} See: "Iran Now Hungry For Barter Deals to Move Its Crudes", Petroleum Intelligence Weekly, Vol. XVI, No 3, 17 January 1977, p. 3; and "Iran Sets Deal to Supply 25 per cent of Brazil's Oil Imports", Petroleum Intelligence Weekly, Vol. XVI, No 26, 27 June 1977, p. 1.

Nationalization of the crude oil producing industry in Kuwait was effected in March 1976. A five-year crude oil supply contract provided for the sale of 500,000 barrels per day by the Kuwait Oil Company to Gulf, and a five-year agreement was under negotiation by which KOC would sell 450,000 barrels per day to British Petroleum.^{108/} On these purchases, each company would receive an after-tax discount of 0.15 dollars per barrel off the KOC's official selling price (compared with the then prevailing weighted average company margin of 0.24 dollars on Saudi Arabian light). With total crude oil production in Kuwait running at about 2.2 million barrels per day (1976 rate), these agreements would leave KOC with more than half of its output to be sold. To date, KOC has been selling primarily to the major companies, but there is strong pressure to enter third-party markets on a significant scale.

Nationalization of onshore crude oil production in Qatar was achieved in 1976, followed by nationalization of offshore assets and operations in 1977. The companies that previously produced equity oil in Qatar have signed a five-year agreement with the Government under which they will purchase onshore crude oil at a rate of 130,000 barrels per day (Qatar's then current onshore production rate was 220,000 barrels per day).^{109/} The companies will receive an after-tax fee of 0.15 dollars per barrel on production and a management service payment of 0.25-0.26 dollars per barrel, presumably to cover out-of-pocket company costs per barrel for their services there. Thus, the companies will be receiving their crude oil in Qatar at a discount off the State's official selling price, and they will be moving a large proportion of Qatar's crude oil output through their corporate

^{108/} The agreements with Gulf and British Petroleum reportedly provide for overlifting beyond these base volumes. See: "Kuwait-Gulf Oil pact on sales could set post-takeover trend", Petroleum Intelligence Weekly, 29 March 1976, pp. 49-50; and "OPEC Maintains Price Freeze", Petroleum Economist, July 1976, p. 247.

^{109/} "More terms emerge about onshore Qatar takeover", Petroleum Intelligence Weekly, 4 October 1976, pp. 7-8. Total crude oil production in Qatar in 1975 was about 439,000 barrels per day.

/channels. However,

channels. However, the Government is now a direct seller on a substantial scale of its own crude oil. As in the case of other States with nationalized oil industries, there is a strong pressure on Qatar to sell in third-party markets.

In Venezuela, the foreign companies producing there lost their access to equity oil when the crude oil producing industry was nationalized in January 1976. However, many of these companies remain as producers in Venezuela, operating under contract, and they are compensated by the State oil company for the costs they incur for work performed. The producing companies are acquiring crude oil from the State at a discount off the official price.^{110/} The bulk of Venezuelan crude oil is still marketed through the network of the major companies,^{111/} but Venezuela is aggressively promoting direct sales outlets.

Crude oil production and sales in Algeria are completely in State hands. The State oil company, Sonatrach, sells to all parties in the open market. State sales prices are fixed by adding to the official price of Saudi Arabian light a premium derived from a formal system for valuing differentials. This system is used by Algeria to monitor the market prices of the major crude oil moving in international trade. Algeria has at times openly criticized other OPEC member States for underpricing their crude oil; it has also been criticized by some OPEC countries for doing precisely this itself.^{112/}

^{110/} In January 1976, contracts with the former producing companies covered 1.5 million barrels per day, out of total crude oil production in Venezuela of 2.3 million barrels per day. See: "Venezuela solves its initial takeover problems", Petroleum Intelligence Weekly, 16 February 1973, p. 3.

^{111/} "Venezuela solves its initial takeover problems", Petroleum Intelligence Weekly, 16 February 1976, p. 3; and "OPEC maintains Price Freeze", Petroleum Economist, July 1976, p. 247.

^{112/} "Algeria barter deals fade from sight, but sales still lag"; and "Algeria gets sore with Libya, Nigeria over price cuts", Petroleum Intelligence Weekly, 14 July 1975, pp. 3-4.

From the point of view of price formation, the essential features of the world crude oil industry are the following:

First, the bulk of the oil moving in international trade is produced in the 13 OPEC member countries. Saudi Arabia and Iran alone account for slightly less than one-half of crude oil production in these countries (Exhibit 51). An idle crude oil production capacity of about 3 million barrels per day, together with immense reserves of low-cost oil, give Saudi Arabia a position of preeminent importance in OPEC and consequently a great deal of influence over the level of world crude oil prices today (Exhibit 53).

Second, the market price of world crude oil is far higher than its long-run incremental supply cost. In the case of Saudi Arabian light crude oil, for example, the official price is 12.70 dollars per barrel, FOB Ras Tanura, while the long-term supply cost is probably no more than 0.40 dollars of 1975 per barrel (Exhibit 56).

Third, this price-cost gap has been sustained by adjusting the supply of crude oil from OPEC member countries to levels that are consistent with the mandated official price of Saudi Arabian light.

Fourth, this price-cost gap has two basic implications: first, it will, inter alia, stimulate the production of more crude oil for the world market over time; and second, for many sellers it represents a powerful financial incentive to cut prices. The incentive is particularly powerful for the relatively smaller corporations in the crude oil supply industry, but there is not doubt that the incentive to cut prices to increase profits is powerful for all sellers in the industry.

Fifth, tempered though it has been so far, there is a degree of competition between host governments, on the one hand, and the companies, on the other, and this competition is centered on price. Companies acquiring crude oil in the world market try to minimize their purchase costs, given the constraints under which they operate. Third-party buyers, without equity oil or service fee arrangements with countries, seek the lowest price, which means, in their case, the largest discount off the official State price. To this end, they pit country /against country,

against country, company against company, and company against country. Oil companies with equity and participation oil arrangements abroad seek the lowest price (i.e., weighted average tax-paid cost) for their overall crude oil supplies, and they play country against country for this purpose. Companies which operate under service fee arrangements with countries try to acquire their crude oil at least cost, which means with the highest fee, or the highest net discount off the official State price.

This potentially very competitive process is greatly moderated by several factors such as the companies' legal offtake commitments, their desire for supplier diversification, their fear of reprisals from major host government suppliers, and the degree of solidarity among OPEC member countries (and others) in refraining from competing with each other over the level that each fixes for company offtake cost or service fees per barrel. To date, the countries have been highly successful in limiting the degree of competition between themselves, and the major oil companies have not been aggressive in playing off the countries in pursuit of lower acquisition costs for their crude oil.

Sixth, there is evidence of competition between host governments in their sale of crude oil in the open market, although once again the degree of this competition is significantly moderated. There is no scarcity of allegations by OPEC member countries that other member countries have been discounting their crude oil prices, and such reports frequently involve the countries with nationalized oil industries, where the companies have neither equity oil rights nor buy-back obligations but where the companies do have the international marketing outlets for crude oil that the countries lack.

Seventh, it is impossible to devise a watertight system by which the value of each OPEC crude oil can be linked to all the others in a rigid way over time. Differences in the value of crude oils arise from a variety of factors: changes in the demand for refined products

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in final markets over time around the world; changes in transport costs; differences between crude oils in their sulphur and wax content, viscosity, and inherent yields; changes in interest rates, and so on.

There are many ways in which host governments can secretly discount their crude oils. Crude oil can be sold on a CIF basis, with the discount being extended secretly on the insurance and freight components although the crude oil itself is billed at the official price; credit terms can be manipulated to achieve a hidden discount, the seller fixing a lower-than-market rate of interest to the buyer and stretching out the payment period; intermediary companies can be used for the actual extension of a secret discount, the host government selling to the intermediary at the official State price; barter trade can be employed for the purpose of discounting secretly; and so on.

OPEC member countries are keenly aware of the need to limit price competition in their direct sales as well as in their sales of crude oil to the companies. The protracted discussions within OPEC on the Algerian system for valuing differentials is testimony to the seriousness with which OPEC member countries view this treat. To date, OPEC member governments have been quite successful in limiting the extent of price cutting, the proof being the relatively small variations reported in the market between the official State prices of crude oils relative to their approximate individual parity with the price of Saudi Arabian light.

Eighth, the major companies still secure their crude oil from host governments at lower prices than those which third parties pay in the open market. Therefore, to this extent, they have a potential competitive advantage over other companies in their highly competitive downstream refining and marketing operations. Also, by moving much of their crude oil through the channels of the major companies (for resale to third parties and for their own corporate use), the host countries face less competition in their direct crude oil sales than would otherwise be the case (i.e., if they themselves sold that oil to all comers). This structural feature of the world crude oil market acts as a strong damper on the downward pressure on world crude oil prices.

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Ninth, the maintenance of the current price-cost gap in world oil sales depends fundamentally on the ability of the OPEC member countries to implement a system for adjusting the total volume of crude oil exports from OPEC countries to levels consistent with the established price and, at the same time, for allocating production among OPEC member countries. The system now used to regulate crude oil output in the aggregate and in each country is not a highly structured one. When prices deviate excessively from the price of OPEC's benchmark crude oil (Saudi Arabian light), the rate of crude oil production is adjusted accordingly, with Saudi Arabia usually leading the way. Although every OPEC member now controls the rate of crude oil production in its country, there is no system within OPEC for controlling total member country output or allocating that output among OPEC member countries. OPEC does not have a quota system for these two purposes, but the informal arrangements now being used in this respect have so far worked well for its member countries, as a huge price-cost gap has been sustained for several years. However, the absence of a formal system of price maintenance through production regulation constitutes the prime threat to the continued success of the OPEC member countries in maintaining this price-cost gap in the future.

Section III: Current energy policies in the oil-importing industrialized countries

The policy reactions of the oil-importing industrialized countries to the increased price of world oil since 1970 require definition at this point. Two forums of policy discussion and action are observable: first, the internationally forum; and second, the domestic forum.

International discussions of energy policies have been concentrated in the International Energy Agency (IEA), the OECD, and in the Paris Conference (i.e., the North-South Dialogue).

/The Paris

The Paris Conference began as a United Nations-proposed forum to discuss energy matters. Under pressure from the group of nineteen developing countries, however, the eight developed countries agreed to broaden the discussion agenda to include other critical economic topics as well. With regard to the treatment of energy matters, the energy commission of the North-South dialogue reached consensus on the need for a shift in reliance from oil to other energy resources, particularly those that are renewable and relatively more plentiful, and for the need to step up the rate of oil exploration and energy conservation. Also underscored were: the need of the oil-deficit countries for access to financial and technical aid from international sources such as the World Bank to promote the growth of their domestic oil industries; the need to co-ordinate the expansion of the oil-exporting countries' refining and petrochemical industries, and the need for the oil-exporting countries to increase their efforts in the fields of energy research and development.

The Dialogue ended in Paris in June 1977 after eighteen months of discussion, the group of nineteen having rejected the proposal of the eight for continuing energy consultation and the eight having rejected the proposal of the nineteen for linking continuing energy consultation to discussions in the United Nations on technological transfer. The results of the Paris Conference were forwarded for consideration by the General Assembly of the United Nations.113/

By and large, discussions of energy matters in the OECD and the IEA have concentrated on the problems of adjusting the member countries' economies to increased world oil prices and of minimizing damage

113/ For a discussion of the results of the North-South Dialogue insofar as they relate to energy matters, see "North-South Parley Fails to Set Ongoing Energy Talks", Petroleum Intelligence Weekly, Vol. XVI, No 23, 23 June 1977, pp. 7-8; "Why South Balked at North Pressure for Energy Talks", Petroleum Intelligence Weekly, Vol. XVI, No 24, 13 June 1977, pp. 1-2; "Idea of North-South Energy Dialogue May yet Survive", Petroleum Intelligence Weekly, Vol. XVI, No 25, 20 June 1977, pp. 4; and "UN Schedules Post-Mortem on North-South Talks", Petroleum Intelligence Weekly, Vol. XVI, No 34, 22 August 1977, pp. 2-3.

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to these economies in the future in the event of oil embargoes. Emphasis has been placed on the need for a minimum safeguard price for crude oil imports in the future in order to stimulate investment in alternative energy supplies by reducing the investment risk factor.^{114/} The need to restrain the rate of growth of oil consumption through the use of the price mechanism has been underscored. Progress has been achieved in increasing oil stockpiles in the industrialized countries and devising a system for oil-sharing in the event of disruptions in oil supplies due to oil embargoes in the future. The IEA has also embarked on the periodic publication of prices of imported crude oil.

In general, internationally co-ordinated action among the oil-importing industrialized countries has concentrated on ways of adjusting to the fact of higher oil prices and to the possibility of oil embargoes in the future. So far, however, there has not been any emphasis on the formulation of action designed explicitly to bring world oil prices down substantially and quickly.

In the oil-importing industrialized countries, refined product prices have moved upward in line with the increased cost of imported crude oil in the seventies. This adjustment process has not been smoothly synchronized over time, however, and refiners' margins have been under pressure from time to time in the developed countries due to the lag in adjusting refined product prices to increased crude oil costs. Although there is still a wide disparity between countries in this regard, refined product prices are now more or less adjusted to the current cost of imported crude oil in many of the industrialized, oil-deficit countries.

In the United States, however, the adjustment of refined product prices to the increased cost of world crude oil has been substantially less than in many other industrialized countries. Crude oil costs and refined product price ceilings are controlled by the Federal Government, and the costs of the former are heavily affected by two

^{114/} This subject is discussed in more detail in Section IV.

programmes: the crude oil equalization programme and the allocation programme. The United States crude oil equalization programme is designed to equalize the cost of crude oil to domestic refiners, while the crude oil allocation programme aims to distribute crude oil supplies among all refiners.^{115/} Deviations from average final costs of crude oil to domestic refiners have been considerably narrowed in the United States as a result of these two programmes, and these costs are now substantially lower than those in other industrialized countries.

In September 1977, the United States Congress exempted from price controls all crude oil produced from stripper wells in the United States, so that the prices on this component of national crude oil output (about 14 per cent of national production in March 1977) were at international levels (13.31 dollars in March 1977). The remaining supplies of domestic crude oil are divided into two components: "old" crude oil, about one-half of United States output, the price of which averaged about 5.15 dollars per barrel in March 1977; and "new" crude oil, which was selling on average for 11.03 dollars per barrel in March 1977.^{116/} The average composite wellhead price for United States crude oil in March 1977 was 8.45 dollars, far below the level of world crude oil prices at that time, which was about 12.09 dollars FOB Ras Tanura in the case of the official State price for Saudi Arabian light crude oil (Exhibit 51).

President Carter's proposed energy programme was presented in April 1977 and is now under consideration in the United States Congress. It would, inter alia, freeze indefinitely the current ceiling on the price of "old" oil (i.e., 5.25 dollars per barrel), and "new" oil

^{115/} "United States programmes influence refiners oil import moves", Petroleum Intelligence Weekly, 22 March 1976, pp. 3-4.

^{116/} "Old" crude oil refers to the volumes of crude oil produced in specific wells in 1972. "New" crude oil refers to the volume of crude oil produced in specific wells in excess of their 1972 level. See: "Hostages to fortune", Petroleum Economist, Vol. XLIII, No 2, February 1976, pp. 43-44.

(i.e., 11.28 dollars per barrel), allowing price increases only for general inflation. "Newly discovered oil"^{117/} would be allowed to rise to the current real world price over a three-year period; thereafter, this oil would be priced at the real price of world crude oil in 1977. Incremental crude oil recovered from oil fields using tertiary techniques and oil produced from stripper wells would be exempt from price-controls. Through the application of wellhead taxes in three stages, the price of all United States crude oils would be brought up to the level of world oil prices in 1980.^{118/} At that time, the crude oil entitlements programme and related regulatory arrangements would be dismantled.

The proposed programme would, inter alia, end the distinction for pricing purposes between inter- and intra-State sales of "new" natural gas. It would subject sales of all new natural gas in the United States to a maximum price based on BTU parity with the pre-tax average acquisition cost to oil refiners of all domestic crude oil: about 1.75 dollars per Mcf at the beginning of 1978, or about one-fifth higher than the current federally imposed limit of 1.47 dollars per Mcf on most inter-State sales of new natural gas. Prices of intra-State sales of "new" gas, moreover, would be subject to federal price regulation, which is not the case at present. Prices on sales of natural gas covered by existing contracts would remain in force, but natural gas released by expiring inter-State contracts could be sold for 1.42 dollars per Mcf and gas released by expiring intra-State contracts could be sold for 1.75 dollars per Mcf, both prices to be revised for inflation.

^{117/} In President Carter's proposed energy programme, "newly discovered oil" is defined as oil produced "... from a well drilled more than 2 1/2 miles from an existing onshore well as of 20 April 1977, or more than 1,000 feet deeper than any well within any 2 1/2 mile radius". See: "Carter Explains his Energy Plan for the United States", Petroleum Intelligence Weekly, Vol. XVI, No 17, 25 April 1977 (Special Supplement), Supplement p. 7.

^{118/} The proposed energy programme would return to consumers the revenue obtained from the crude oil equalization tax and the mechanism for lifting United States crude oil prices to the world level in 1980.

In its essentials, the proposed energy programme emphasizes the need to restrict the rate of growth of domestic oil consumption and oil imports and to substitute domestic fuels for imported oil. It does not emphasize the objective of reducing world oil prices sharply and quickly.^{119/} This programme has been generally well received in Western Europe, where the OECD had previously expressed disappointment with the pace of adjustment in the United States to the international level of crude oil costs.^{120/} At the time of writing, the United States Congress has not yet given its reaction to President Carter's proposed energy programme.

In general, in the structuring of their national energy policies the governments of the oil-importing industrialized countries emphasize the need to develop energy sources that would decrease the degree of their reliance on Middle Eastern oil supplies in the future. Stress is placed on the need for reducing the rate of increase in domestic oil consumption. Particular emphasis is placed on nuclear power and on increasing the supply of indigenous energy sources as substitutes for imported oil, when these options are open. However, nuclear power expansion, even when economically desirable and politically realizable, cannot give relief on the oil account for some years to come. Despite strong increases in refined product prices, many of these governments are experiencing more difficulties than anticipated in reducing the extent of their reliance on imported oil in general and on Middle Eastern crude oil supplies in particular. This difficulty is due to three simple facts: first, increases in the supply of

^{119/} The details of this proposed energy programme are presented in the following source: "Carter Explains the Energy Program", Petroleum Intelligence Weekly, 25 April 1977, Supplement; and: "Carter Energy Plan for United States Faces A Tough Fight", Petroleum Intelligence Weekly, Vol. XVI, No 17, 25 April 1975, pp. 3-4. "New" natural gas would be defined using the same definitional standards used in defining "newly discovered oil".

^{120/} "OECD chides United States for poor progress in energy policy", Petroleum Intelligence Weekly, 16 August 1976, p. 1.

oil-substitute fuels, such as nuclear power and coal, are not quickly realized; second, for all of these countries, increased domestic oil consumption means increased oil imports, although the marginal oil import coefficient varies among them; and, third, the bulk of the oil produced for the world market is produced, now and prospectively, in the Middle East.

Section IV: A forecast of world crude oil prices, 1978-2000

(i) Introduction

This section presents a forecast of the price of Saudi Arabian light crude oil, FOB Ras Tanura, over the rest of this century.^{121/} Given the pivotal role of this crude oil in determining the structure of world crude oil prices, a forecast of its price is tantamount to a forecast of the structure of world crude oil prices, the two being linked by differential values arising from distinctions between crude oils in respect of specific gravity, sulphur content, point of shipment, and so on.

Neither the decision to try to predict world oil prices nor the selection of the forecast horizon were taken at random. The decision to forecast was taken simply because huge sums of money must be committed by governments and private investors in Latin America and elsewhere to energy projects, the expected financial and economic viability of which will depend very largely on the forward prices postulated for world oil.

The forecast horizon (1978-2000) was selected for the practical reason that project evaluations are usually made on the basis of a twenty to twenty-five year time span. Whether they like it or not, project analysts must go this far into the future. The objective here

^{121/} The price being forecast here is not the spot price, which is the price paid for immediate delivery. The price that is being forecast is the price paid on relatively large contracts for future delivery. It corresponds to the official State selling price today, assuming the absence of any significant discounting off that price.

is to provide some help to these analysts as they confront the difficult task of forecasting world crude oil prices over such an extended period of time.

The forecast of the price of world crude oil through the year 2000 is developed in the following way:

First, an estimate is made of the maximum long-run economic supply cost of world oil in 1977, 1990 and 2000. This is the price below which, in each of those years, the market price of world crude oil cannot fall without throttling the physical supply of crude oil by State producers to satisfy international demand for it. It is the economic floor for world crude oil prices: if it is breached, the physical supply of crude will not satisfy demand. An estimate is also provided of the financial floor of oil prices, holding constant the level of weighted average government take per barrel of oil acquired for sale in July 1977 by the oil companies in Saudi Arabia.

Second, an estimate is presented of the minimum long-run economic supply cost of synthetic crude oil in 1977, 1990 and 2000. If the price of natural crude oil rises above these limits in those years, it will stimulate the creation of a synthetic oil industry. An estimate is also provided of the minimum financial long-run supply cost of synthetic oil in 1977, 1990 and 2000: i.e., the levels of cost which, if exceeded by the price of natural crude oil in those years, will provoke the supply of synthetic oil by private, profit-oriented corporations.

Third, an examination is made of prospective developments over the forecast horizon in the structure of the world crude oil producing industry, on the one hand, and in the structure of energy policies in the industrialized countries, on the other. This analytic discussion draws on the historical treatment of these two subjects presented earlier (i.e., in Chapter 2, Sections I-III). The objective of this discussion is to gauge the direction and degree of prospective pressure on world crude oil prices owing to the operation of these factors through the year 2000, given the upper and lower limits on price previously estimated.

/Fourth, a

Fourth, a forecast of world crude oil prices is then presented for 1990 and 2000. Following this, a Baseyan-based analysis is developed focusing on the likely distribution of possible world crude oil prices in 1990 and 2000. The presentation closes with a discussion of the forecast exercise, its inherent strengths and weaknesses.

(ii) The maximum long-run incremental supply cost of world crude oil through the year 2000

Crude oil supply is subject to increasing unit cost in both the short and the long run. If the price of world crude oil were competitively determined - which it is not and has not been in the post-war era - then, over time, increasing demand for it would entail higher prices to cover its increasing unit cost of supply. This would be so unless, over time, nature's stinginess were more than offset by man's ingenuity in the form of technical progress or unless cheaper supplies of world oil were found and exploited.

What can be said, then, about the maximum economic scarcity of world crude oil over the next two decades and about the maximum price that would have to be paid as a consequence of that scarcity in a competitive market for world oil over time? In short, what will be the maximum level of long-run supply cost of natural crude oil produced for the world market over the forecast horizon?

Adelman provides the most painstaking and empirical treatment of this subject.^{122/} He begins with the observation that the levelized sum of development plus operating costs defines the maximum long-run supply cost of world crude oil. A rational oil investor will undertake an oil exploration programme only if this levelized cost per barrel for exploration, development, and production in now unknown fields is less than the levelized per barrel cost of supplying more oil from known fields through more development and operating expenditures. He then makes an estimate of maximum long-run supply

^{122/} M. Adelman, The World Petroleum Market, published for Resources for the Future, Inc., by the Johns Hopkins University Press, 1972.

/costs in

costs in the world's major crude oil producing centres, using the levelized cost per barrel of developing more reserves in known fields, producing from them, and bringing those surfaced volumes of oil to seaboard for export as the quantitative referent for measuring the maximum long-run supply cost of world oil. Actual supply costs may turn out to be lower than this referent cost; they will not be higher unless, a posteriori, it turns out that supply costs were underestimated.

In his empirical work, Adelman made a series of basic assumptions that intentionally imparted an upward bias to his estimates of maximum long-run supply costs (1970-1985) of crude oil in the Middle East, which currently accounts for about three-fifths of crude oil production by OPEC member countries.^{123/} He assumed, inter alia, that there would be no crude oil discoveries, no technological progress in crude oil development and production, and no increase in the degree of competition from natural gas and nuclear power. In calculating maximum long-run supply costs in Saudi Arabia, Iran, Iraq and Kuwait, he made the additional assumptions that output in this group of Persian Gulf countries would grow at 11 per cent a year compounded during 1971-1985; that there would be no increasing competition of African with Persian Gulf crude oils; that the production of crude oil in the Persian Gulf would take place in the large fields there once they were down to a reserve: production ratio of 16. A discount rate of 20 per cent and a well decline rate increasing from 1 per cent in 1970 to 6 per cent in 1985 were used by Adelman in his calculation of long-run incremental cost (1970-1985) of crude oil supply by State oil corporations in the Middle East.^{124/} The combined discount rate employed, therefore, was 26 per cent for 1985.

Having made these assumptions, his calculations led him to the quantitative conclusions summarized in Exhibit 54. He then stated:

^{123/} Adelman also translated his estimate of maximum long-run supply costs in the Persian Gulf (1970-1985) into maximum long-run supply prices in other producing countries by adding an estimate of the long-run freight advantage of these countries over the Persian Gulf in sales to specific markets. See: Adelman, op.cit., p. 76, and Exhibit 54 of this study.

^{124/} Adelman, op.cit., p. 6 and p. 72.

/"The estimate

"The estimate of 20 cents is in theory an estimate of what it would have cost in 1966-1970 to produce from the big Persian Gulf fields once they were depleted to the point where the reserve: production ratio was down to about 16." Given that assumption, the method used here exaggerates the consequences. Hence the result forms a convenient maximum for any prediction of what long-run developing-operating cost is likely to be".125/

He concluded that:

"For at least 15 years we can count on, and must learn to live with, an abundance of oil that can be brought forth from fields now operated in the Persian Gulf at something between 10 and 20 cents per barrel at 1968 prices and in some other provinces at costs even lower when account is taken of transport."126/

Adelman's cost estimate was published in 1972. Crude oil output in the Persian Gulf stagnated during 1973-1976 (Exhibit 52). With Adelman's assumed 11 per cent per annum growth, cumulative Persian Gulf output would have been 170 billion barrels during 1971-1985. Proven reserves in the Persian Gulf at the end of 1976 were 274 billion barrels.

An 11 per cent average annual rate of growth in Persian Gulf production now seems indefensible. If crude oil production there were to increase by 5 per cent from 1977 onwards, Adelman's 170 billion barrel figure would be reached in 1990, taking into account the production of 44 billion barrels during 1971-1977 (est.). His estimate of long-run incremental supply costs in the Persian Gulf (i.e., 0.40 dollars of 1975 per barrel, FOB) 127/ would still

125/ Adelman, op.cit., p. 73.

126/ Adelman, op.cit., p. 77.

127/ This is 0.20 dollars of 1968 (Exhibit 54) converted to dollars of 1975 and rounded from 35.8 cents to 40.0 cents of 1975 per barrel. The estimate of maximum long-run supply costs of 0.40 dollars of 1975 per barrel in 1990 is, therefore, purposely biased upward, once again, to the extent of this rounding operation. The deflator used to convert from prices of 1968 to 1975 is the world consumers' price index of the International Monetary Fund as reported in International Financial Statistics, Vol. XXIX, No 5, May 1976, (Spanish edition) pp. 550-551.

be valid until 1990 under this assumption. At that time (i.e. in 1990), the proven reserves: production ratio in the Persian Gulf would have fallen to 9.8. With the world's demand for OPEC crude rising by five per cent per annum from 1977 onward, the Persian Gulf countries alone could supply that demand up to 1991 entirely from proven reserves existing at the end of 1976. It seems obvious, however, that proven reserves in the Persian Gulf are bound to be augmented, either through development and/or exploration and development programmes to satisfy world crude oil demand in the nineties and onwards. This will increase the maximum long-run supply cost of world oil produced there during the nineties.

A comparison of cumulative production of crude oil in the future with the present level of the stock of proven reserves of crude oil gives a misleading idea of the pressure of rising demand on the physical supply of crude oil. This is so because proven reserves of crude oil are a shelf inventory. They have been cut out of the stock of oil-in-place, and with rising demand and the proper incentive, oil-exporting governments and oil companies will continue to cut more proven reserves out of that stock to satisfy rising demand; they are not limited, in their future production, to producing from proven reserves that exist in the present. Therefore, one needs to know the size of the stock of petroleum in-place in a given area to gauge the impact on supply costs of drawing upon that stock in the future, in the form of proven reserves, to satisfy increasing demand for petroleum.

Adelman estimates that "... in 1970 Persian Gulf deposits that, through development and new-pool drilling, ... [could] ... be turned into proven reserves ... [were] about 550 billion barrels, given sufficient time and incentive to develop between 1970 and 1985".^{128/} This level of potential proven reserves relates only to the amount that can be produced using primary recovery techniques, based on a

^{128/} M. Adelman, The World Petroleum Market, published for Resources for the Future by the Johns Hopkins University Press, Baltimore and London 1972. p. 71.

recovery factor of about 40 per cent. Secondary and tertiary techniques would raise this recovery factor substantially. Subtracting Persian Gulf production during 1970-1977 (est.) of 49 billion barrels (Exhibit 52), this leaves a stock of potential proven reserves of about 501 billion barrels in the Persian Gulf in 1978 that could be drawn upon to yield proven reserves for production of crude oil. This sum of 501 billion barrels would be just about equal to the expected cumulative total of all OPEC member-country production rising by 5 per cent during 1978-2000 (i.e., 508 billion barrels), and this without any additions to the stock of oil-in-place being made in the Persian Gulf during 1970-2000 and without the use of secondary and tertiary recovery techniques in the Persian Gulf.

Focusing on the Persian Gulf alone, with output there rising at 5 per cent per annum during 1978-2000, cumulative production would be 313 billion barrels. This would leave a stock of potential proven reserves in the Persian Gulf in the year 2000 of 237 billion barrels, or 10.7 times the anticipated level of production there in the year 2000, once again, under the very conservative assumptions that no additions are made to the stock of oil-in-place in the Persian Gulf during 1970-2000 and that secondary and tertiary recovery techniques are not employed there. Given the apparent adequacy of potential proven reserves in the Persian Gulf through the end of this century, the key question, then, from an economic point of view, is this: what would be the level of real long-run supply cost there in the year 2000 with the reserve: production ratio down to 10.8 and with a production rate in the year 2000 of 22.1 billion barrels pressing on a stock of potential proven reserves there conservatively estimated at 237 billion barrels in that year?

What, then, is the most likely maximum level of the long-run cost of supplying Saudi Arabian crude oil in the year 2000, given its estimated maximum level of 0.40 dollars of 1975 per barrel in 1990? Adelman assumed that the decline rate in Saudi Arabia would increase from 1 per cent in 1970 to 6 per cent in 1985. Earlier, it was

/assumed in

assumed in this study that the 6 per cent decline rate would be hit in 1990, not 1985, due to the lower rate (i.e., 5 per cent p.a.) than Adelman assumed for growth in Saudi Arabian crude oil production during 1970-1985 (i.e., 11 per cent p.a.). In this context, what would be the maximum level of combined development and operating cost levelized per barrel (i.e., maximum long-run supply cost) in the year 2000 if the decline rate in Saudi Arabia increased by the same geometric rate of increase during 1990-2000 that Adelman assumed implicitly that it would during 1970-1985 (i.e., 12.7 per cent p.a.)? This is a rapid rate of increase in the decline rate, and the effect of assuming it is to bias upward, and strongly so, the resulting estimate of long-run incremental cost of crude oil supply in Saudi Arabia in the year 2000.

Levelized, total long-run supply cost per barrel (C) is composed of development cost (C_D) and operating cost (C_O) per barrel; so:^{129/}

$$(C)_{2000} = (C_D)_{2000} + (C_O)_{2000}$$

where

$$(C_D)_{2000} = (C_D)_{1990} \left[\frac{(PBE)_{1990}}{(PBE)_{2000}} \right] (1 + a_{1990})^N \sqrt{\frac{1 + a_{2000}}{1 + a_{1990}}} \sum_{n=1}^N \frac{1}{1 + a_{1990}^n}$$

and

$$(C_O)_{2000} = (C_O)_{1990} \left[\frac{1 + a_{2000}}{r} \right] \sqrt{(1 + a_{1990})^N \frac{1 + a_{2000}}{1 + a_{1990}}} \sum_{n=1}^N \frac{1}{1 + a_{1990}^n}$$

where "PBE" is the present barrel equivalent factor, which was 4.31 in 1990, and the value of which is given by the general expression:
 $PBE = \int_0^{10} (1 + r + a + ra)^{-t} dt$; "r" is the target rate of return (i.e., 20 per cent in both 1990 and 2000); "a" is the decline rate (i.e., 6 per cent in 1990, growing at 12.7 per cent p.a.,

^{129/} For a discussion of this manner of estimating long-run supply costs, refer to M. Adelman, The World Petroleum Market, published for Resources for the Future by the Johns Hopkins University Press, Baltimore and London, 1972, pp. 48-77 and, especially pp. 48-53 and p. 72.

reaching a level of 19.8 per cent in the year 2000); "N" is ten years (i.e., from 1990 to 2000); C in 1990 is 0.40 dollars of 1975 per barrel; C₀ in 1990 is 0.127 dollars of 1975 per barrel and C_D in 1990 is 0.273 dollars of 1975 per barrel.^{130/}

Letting the decline rate in 2000 (a₂₀₀₀) be 0.198 [equals .06 (1.127)¹⁰], and substituting where necessary, the level of long-run supply cost in Saudi Arabia in the year 2000 is 1.26 dollars of 1975 per barrel, FOB Ras Tanura:

$$C_{2000} = (0.40 - 0.127) \frac{4.31}{10(1+0.198+0.20+0.20+0.198)^{-t}} \left[1.06 \sqrt[10]{\left(\frac{1+0.198}{1.06}\right)^{55}} \right] + 0.127 \left[\frac{0.20+0.198}{0.20} \right] \sqrt[10]{1.06 \sqrt[10]{\left(\frac{1+0.198}{1.06}\right)^{55}}} = 1.26.$$

In other words, if the decline rate in Saudi Arabia increased from 6 per cent in 1990 to 19.8 per cent in the year 2000, then the level of long-run supply cost there would rise from 0.40 in 1990 to 1.26 dollars of 1975 per barrel in 2000. As a rough approximation, it is assumed here that the level of long-run supply costs (including pipeline cost) will be no higher than 2.00 dollars of 1975 per barrel in Saudi Arabia in the year 2000. Not considering pipeline costs, this assumption would imply a decline rate of about 27 per cent there in the year 2000 a derived figure which is surely upward-biased, and in all probability very markedly so.

Earlier, the conclusion was drawn that the Persian Gulf countries alone could probably satisfy the demand for internationally traded crude oil if this grew at 5 per cent per annum during 1978-2000. But what would be the implications for Venezuela, for example, a relatively high-cost OPEC producer, of this 2.00 dollars per barrel estimate (in 1975 dollars) of maximum incremental supply cost of Saudi Arabian light crude oil in the year 2000 if Venezuela too were exporting crude

^{130/} The value of C for 1985 in the case of Saudi Arabia, as estimated by Adelman, was 0.20 dollars of 1968 (Exhibit 54); his estimate of C₀ in 1985 was 0.071 dollars of 1968 (Ibid., p. 73); C_D by subtraction. Costs in dollars of 1968 were converted to dollars of 1975 using the price index presented in Exhibit 58, the estimate of C being rounded from 0.358 to 0.40 dollars of 1975 per barrel, as explained earlier (see footnote 127).

oil in a perfectly competitive world oil market? Assuming a freight advantage for Venezuela over the Persian Gulf for crude oil deliveries to the United States East Coast in the year 2000 of 0.35 dollars (of 1975) per barrel, the 2.00 dollars figure would set a competitive cost limit on Venezuelan production of crude oil for sale in that market of 2.35 dollars of 1975 per barrel in that year. Adelman estimated that during 1966-1968 maximum long-run incremental supply costs in Venezuela were 0.462 (current) dollars per barrel (Exhibit 54). Adjusting this cost figure to 1975 dollars ^{131/} yields 0.91 dollars of 1975 per barrel. This is an estimate of the per barrel long-run supply cost of crude oil produced in Venezuela in 1966 in 1975 dollars. Thus, if the level of Venezuela's long-run supply costs increased by 2.3 per cent p.a. during 1966-2000, it would hit the ceiling (i.e., the maximum long-run supply price) imposed on it in the year 2000 by virtue of the fact that Saudi Arabia's long-run supply cost had risen to 2.00 dollars of 1975 per barrel (FOB Ras Tanura) in the year 2000 (with the assumed real freight advantage of 0.35 dollars of 1975 in that year for crude oil sales to the United States East Coast). This 2.3 per cent figure is an estimate of degree of increasing scarcity of Venezuelan crude oil on average, during 1966-2000 that would be consistent with the 2.00 dollars (of 1975) per barrel cost figure (FOB) for Saudi Arabia crude oil in the year 2000. Many old fields in Venezuela would probably be rendered uncompetitive by this price in the year 2000, but many new ones would not, and the latter would thus displace the former.

By way of summary, the price of Saudi Arabian crude oil (FOB Ras Tanura) could fall as low as 0.40 (1975) dollars per barrel in the year 1990 and a nationalized oil company there would still have an economic incentive to launch new development and/or exploration programmes for crude oil export in the future. Below that price, even

^{131/} The index used for this operation is the international consumer price index (1970=100) as reported in: International Monetary Fund, International Financial Statistics, May 1977, p. 551. The 1966 value of this index was 81.6 and the 1975 value was 141.3.

/a nationalized

a nationalized oil producing industry would prospectively lose economically by undertaking crude oil development programmes with exports in view. Depending on expected costs, however, even in this situation the State might find it economically defensible to explore for and produce new oil. This would be the case if the long-run incremental cost of so doing were less than 2.00 (1975) dollars per barrel in the year 2000 (i.e., the levelized sum of development and operating costs per barrel in that year).

Weighted average taxes and royalties received per barrel of Saudi Arabian light crude oil were 12.04 dollars in July 1977 (Exhibit 51), or 10.25 dollars per barrel in 1975 prices. Adding 10.25 dollars (of 1975) to the 0.40 dollars (of 1975) per barrel figure for maximum long-run supply cost of crude oil from Saudi Arabia in 1990 yields an estimate of the minimum price (FOB Ras Tanura), in 1975 dollars, that a private oil company would have to receive in 1990 on the sale of oil purchased from the Saudi Arabian government under current conditions of tax and royalty payments and with maximum long-run supply cost of this crude oil prevailing at that time: the minimum price thus estimated is 10.65 dollars of 1975 per barrel, FOB Ras Tanura. The comparable financial floor of the price under the assumption of constant host government tax-take per barrel for the private oil company in the year 2000 is 12.25 dollars of 1975 per barrel, FOB Ras Tanura.

Sales by private companies at prices below 10.65 (1975) dollars per barrel (FOB Ras Tanura) in 1990 and below 12.25 (1975) dollars in the year 2000 would take place only if the weighted average level of tax and royalty payments per barrel were reduced accordingly. For this reason, and in that limited sense, 10.65 dollars is the financial floor price in 1990 for a profit-oriented company moving Saudi Arabian crude oil. As just noted, however, the economic floor price for direct sales by the State is neither 10.65 in 1990 nor 12.25 in 2000, but, rather 0.40 dollars (of 1975) per barrel in 1990 and 2.00 dollars (of 1975) per barrel in the year 2000, both figures FOB Ras Tanura. The reason for this difference between the financial

/and the

and the economic floor prices is simply that taxes and royalty payments, which are financial costs to private oil companies, are not economic costs to a State oil company.

(iii) The minimum long-run supply cost of synthetic oil through the year 2000

The upper economic limit to the price of natural crude oil produced for sale in the world market is the minimum price for it at which it becomes feasible to build facilities today for the supply of substitutes for natural crude oil in large quantities in the future.^{132/} The substitutes for natural crude oil are synthetic crude oils produced from coal or shale.^{133/} Five points must be kept in mind when discussing this upper limit on the price of natural crude:

First, this limiting price is not now the profit-maximizing price on the sale of natural crude oil in the world market. Today, the price at which large-scale supplies of synthetic crude oil would be forthcoming is still above the market price of internationally

^{132/} Another approach to estimating the upper limit of the price of natural crude oil is to identify the most likely weighted average price of refined products that would produce a value of refined product sales so low that crude oil would not be produced and refined to satisfy it. Long before this situation would be reached, however, synthetic crude oils would have entered the world oil market in competition with oil products refined from natural crude oil. Hence, the effective upper limit on the price of natural crude oil is taken here as the limit given by the minimum price for natural crude oil at which synthetic crude oils will enter the market on a significant scale.

^{133/} Synthetic oil may also be produced from tar sands, but owing to the lack of cost data on producing oil from tar sands this technology will not be discussed here. In any event, the conclusions reached on the basis of cost data for producing oil from shale should be more or less comparable with the case of tar sands, owing to the basic similarity of the two conversion processes.

/traded crude

traded crude oil.^{134/ 135/} If the major crude oil-exporting countries are motivated, inter alia, by profit-maximization, which seems to this author to be a reasonable assumption, then it follows that the price of natural crude oil, as endorsed by the OPEC member countries, has been set keeping the price of its substitutes in mind. The actual selection of a target market price for world crude oil by these countries, however, is properly the result of examining the expected impact on profitability as the price for their natural crude oil in the world oil market is varied.

Second, the levelized minimum long-run supply cost of synthetic crude oil fixes the upper limit on the price of natural crude oil only if the synthetic oil is sold competitively. If this condition is not met (say, if synthetic oil suppliers respected the OPEC-endorsed

^{134/} With the official State price of Saudi Arabian light crude oil at 11.51 dollars per barrel (FOB Ras Tanura) in September 1976, the Petrofina group suspended exploratory work on its oil sands mining extraction plant in Alberta, Canada. This followed a comparable shut-down decision by Shell in Canada. See: "New Trend in Oil Sands Planning", Petroleum Economist, Vol. XLIII, No. 10, October 1976, p. 398.

^{135/} South Africa is one of the countries most experienced in the production of synthetic fuels from coal. A new synthetic oil project was approved there in 1975 with a coal input of 40 thousand tons per day at a time when the price of Saudi Arabian light crude oil was 11.51 dollars per barrel, FOB Ras Tanura (Exhibit 51). This project is up to three times larger than the first one, which has been in operation for twenty years. This second synthetic oil project was approved for completion in 1981. Aside from non-energy by-products, the 40 thousand tons of coal input per day will yield 40 thousand barrels of motor fuel output per day. Reportedly, South Africa plans to cover between 40 and 60 per cent of its fuel needs from coal by 1981, or about triple the present rate, at a total cost of 1.7 to 1.9 billion dollars. See: World Petroleum Report 1976, Vol. XXII-1976, pp. 98-99; The International Petroleum Encyclopedia 1976, (The Petroleum Publishing Co., 1976), p. 131.

/price line)

price line),^{136/} then the supply cost of synthetic crude oil would be inoperative as an upper limit on the price of natural crude oil, leaving the profit-maximizing price as the only binding ceiling on the price of natural crude oil, which it is economically speaking in the first place.

Third, as was done in the case of estimating the lower limits on the price of natural crude oil, it is once again necessary to distinguish between financially and economically imposed upper limits on the price of natural crude oil. The financially imposed upper limit on the price of natural crude oil is the minimum levelized cost per barrel (including opportunity cost of invested funds) to a private oil company of supplying synthetic crude oil, using a discount rate that properly accounts for the opportunity cost of capital and the assessed economic risk and uncertainty inherent in the project. For a private oil company, taxes, royalties and rent payments for the use of otherwise useless land must be included as relevant financial costs in the evaluation of the minimum acceptable cost of supplying synthetic oil. In the case of a State oil corporation, however, these charges (and possibly others as well) are economically irrelevant in the calculation of its minimum supply price of synthetic oil.^{137/} Hence, whether the ownership of the synthetic oil industry is in private or in State hands is of paramount importance in gauging the supply response to price in the synthetic oil business. The implication of this distinction between financially and economically relevant costs is that typically the minimum long-run supply cost (FOB conversion plant) of synthetic crude oil is given by the price for natural crude

^{136/} In this connexion, in 1975 the Canadian Government apparently agreed, inter alia, to the sale at "world prices" of synthetic crude from the Syncrude project based on tar sands there. The project would also be free of output controls and exempt from "...tax measures in the current federal budget which imposed "double-taxation" on oil companies". Partners with the Canadian government in this project at that time were Exxon's Imperial Oil, Gulf Oil, and Cities Service. See: "Canada Steps In to Salvage future of Tar Sands Oil", Petroleum Intelligence Weekly, Vol. XIV, No 6, 10 February 1975, p. 8.

^{137/} Also the degree to which the discount factor is adjusted upward for certain categories of risk (e.g., expropriation of assets and profits) will be less in the case of a public than of a private corporation.

oil at which a State fuel corporation would be induced to enter the market as a supplier of synthetic oil on a large scale (i.e., on a scale large enough to put down the price of natural crude oil).

Fourth, there are in operation today only a few synthetic oil pilot plants and a handful of synthetic oil operations, all of them small in scale and probably none of them profitable on a total-cost basis. In short, the synthetic crude oil business is still a nascent one, and at present it does not constitute a significant threat to the maintenance of the OPEC-supported price structure for world oil. With a minimum lead time of, say, a decade before a synthetic fuel industry can be created,^{138/} the price of synthetic oil would not become an operational limit on the price of natural crude oil, assuming competitively priced supplies of synthetic oil, until at the earliest the nineties even if, today, investment commitments in the synthetic oil business were being made on a grand scale. Until the nineties at least, then, profit-maximization will remain the only operationally binding force on the price of natural crude oil in the world market; which it is to begin with, of course.

Fifth, the price of natural crude oil can rise above the minimum supply cost of synthetic oil. That cost is not a limit in the strict sense of the word, but it is a limit in the sense that if the price of natural crude oil rises above it, it will trigger the growth of the synthetic oil industry.

With these points in mind, then, what appears to be the minimum long-run supply cost of synthetic oil now, in 1990, and in the year 2000?

^{138/} See: "United States: Synfuel Plan", Petroleum Economist, Vol. XLIII, No 2, February 1976, p. 56. See also, United States Department of Interior, Energy Perspectives, 1975, p. 184, in which the following estimate for the lead-time of an individual plant is provided: "Five years is the best available estimate of the average lead time needed for completion of a shale oil production operation. This lead time assumes a concurrent activities schedule. Plant construction activity should take approximately 4 years".

Detailed cost estimates for mid-1973 are available for a variety of processes for producing distinct combinations of refined oil products from coal, and for producing synthetic crude oil from shale.^{139/} This discussion will be limited to the estimated long-run supply cost of producing the following: first, naphtha and fuel oil, the major products refined from natural crude oil, from a coal conversion plant sited in the Pennsylvania coal mining area, with the coal mine and the conversion plant owned by the same corporation, private in one case, State in the other; and, second, synthetic crude oil from a plant located in the area of the Colorado shale oil deposits, with both the shale extraction plant and the conversion plant owned by the same corporation, in the one case, private and, in the other, public. Appendix A presents the assumptions underlying the various estimates of minimum long-run supply costs of producing oil from coal and shale as presented in Exhibit 55.

A number of factors should be noted about the methodology used to calculate the summary cost estimates presented in Exhibits 55 and 56.

First, the original data on which these cost estimates are based relate to prices, costs, and technology of mid-1973. Long-run supply costs in subsequent years were approximated by decreasing the level of minimum supply cost in 1973 by one per cent per annum, after having converted that cost from 1973 to 1975 dollars, using as the deflator the industrial goods component of the United States wholesale price index.

Second, the original cost data implicitly assumed a constant acquisition cost for coal and shale. This assumption probably imparts a downward bias to the resulting estimate of coal costs over time.

^{139/} See: K.C. Vyas and W.W. Bodle, "Coal and oil-shale oil conversion looks better", Oil and Gas Journal, 24 March 1975, pp. 45-54. See also Appendix A of this study, which presents some of the data and assumptions tabled in this journal article.

/A similar

A similar bias is contained in the handsome credit assumed for the sale of by-products in the case of coal and to a lesser extent, shale. Both biases work in favour of the calculated competitiveness of these two synthetic oil technologies. In addition, the original coal estimate takes no position on productivity gains, because the plants considered are only for the year 1973. Over time, however, this consideration should be treated explicitly, and this is partly behind the one per cent per annum reduction in supply costs during 1973-2000. With these comments in mind, those who believe that another rate is appropriate may easily recompute the unit cost figures for 1977, 1990, and 2000 accordingly.

Third, the estimates of the minimum supply cost of synthetic oil are for relatively efficient plants of a scale that was probably more or less least-cost for the industry in 1973. Each plant was assumed to be sited nearby large quantities of good grade raw material (i.e., Pennsylvania coal and Colorado shale). With respect to plant scale, the coal conversion plant produces 34 and 13 thousand barrels per day of fuel oil and naphtha respectively, while the shale oil plant produces 55 thousand barrels per day of synthetic crude oil. Although plants of this scale were more or less least-cost plants in 1973, over time, with technological progress, the least-cost plant will probably increase in scale over time. It is hoped that the one per cent per annum reduction in real cost per unit of output noted above will capture the associated reductions in unit cost as this occurs.

Fourth, the estimates of minimum supply cost presented in Exhibits 55 and 56 are only partially helpful because these data are presented FOB the synthetic oil producing site. Obviously, the long-run supply cost of ocean oil transport must be entered specifically as well as any other inland transport and related costs if valid competitive comparisons are to be made between the minimum long-run supply price of synthetic oil and the expected market price (CIF) of natural crude oil at any given oil consuming centre. Additionally, adjustment has not been made for the inherent saving in long-run

/refining costs

refining costs when naphtha and fuel oil are produced from coal or for the additional refining costs involved in processing low-gravity synthetic crude oil of relatively high sulphur content. For these reasons, the costs presented in Exhibits 55 and 56 should be taken as very rough indications of what they purport to measure. The interested reader is advised to make his own estimates of these additional and important elements of cost as they appear appropriate for specific oil consuming centres in which synthetic and natural crude oil will be competing with each other in the future.

Given these caveats, the figures presented in Exhibits 55 and 56 point to the following conclusions:

First, estimated minimum supply costs for synthetic oil produced by the State corporation are significantly below the comparable levels for the private-sector plant for all discount rates employed and for both coal and shale.

Second, the minimum supply costs of producing oil from coal are significantly below the comparable costs of producing it from shale in the case of both the public and private companies and for all discount rates employed.

Third, if coal is purchased at arms-length by an independent coal-to-oil conversion plant, the resulting level of supply cost for synthetic oil from it is far above the level of the cases in which coal is produced and converted to synthetic oil by the same integrated corporation. In fact, a private-sector synthetic oil plant standing on its own competitive feet and buying its coal in the open market would appear to be a monumentally bad investment. Integration back into coal production, or State protection, appears to be a necessary condition for the financial viability of private-sector coal-based synthetic oil projects.

Fourth, it should be recognized that if an oil company were considering this kind of investment, the minimum supply cost of its

synthetic oil would be increased if sales of synthetic oil displaced its sales of natural crude oil.

Fifth, the operational upper limit on the price of natural crude oil is taken here as corresponding to the case in which a State corporation produces oil from coal with a 20 per cent opportunity cost of capital and with access to its own coal at cost (approximated at 0.30 dollars per million BTU in 1973 dollars) held constant purposely to favour the competitiveness of this kind of synthetic oil project against natural crude oil supplies. As shown in Exhibits 55 and 56, this limit in 1977 is 16.34 dollars of 1975 per barrel (FOB Pennsylvania plant), falling to 14.05 in 1990 and then to 12.71 dollars (of 1975) per barrel in the year 2000, all figures FOB the coal conversion plant.

Thus, if the price of natural crude oil is below these levels of cost in those years (not considering transport and other costs, as noted previously), it will not provoke the supply of synthetic oil from coal by State corporations. But if the price of natural crude oil rises to this level of cost or above, it will provoke the formation of a synthetic oil industry based on coal. The data in Exhibit 55 should prove helpful to those who wish to choose a different opportunity cost of capital than 20 per cent, as well as to those who wish to choose a different delivered cost of coal to the conversion plant. Exhibit 55 also shows the level of minimum supply costs for a private corporation comparable to the cases generated for a State synthetic oil supplier.

Fifth, additional calculations indicate that if the delivered price of imported crude oil remained at 12.42 dollars of 1975 per

/barrel 140/

barrel 140/ over the life of the project, and if a twenty per cent internal rate of return were required, then the delivered cost of coal to a State coal conversion plant could rise to (but not above) 2.38 dollars (of 1975) per short ton without threatening the economic viability of the State's investment in the synthetic oil plant. This would imply an economic cost of coal in current dollars of less than 3.00 dollars per short ton, which is a prohibitively low cost figure throughout the world. In short, a twenty per cent target rate of return would destroy project viability in this case. With a fifteen per cent internal rate of return requirement, the comparable cut-off cost of coal (CIF the conversion plant) would be 8.01 dollars (of 1975) per short ton. This works out to an economic cost of less than 11 dollars per short ton in current dollars, which is restrictive, but not a prohibitively low cost level.

140/ This is equivalent to the State official price of Saudi Arabian light crude oil (FOB Ras Tanura) in 1975 dollars per barrel plus fifteen per cent.

(iv) Prospects for change in the crude oil producing industry and in the energy policies of the oil-importing industrialized countries over the forecast horizon

(a) Introduction

The previous discussion led to the conclusion that the economically imposed lower limit on the price of Saudi Arabian light crude oil in 1990 will be of the order of 0.40 dollars per barrel in 1990 and, in the year 2000, 2.00 dollars per barrel, both figures in dollars of 1975 and FOB Ras Tanura. A Saudi Arabian State oil company would continue to add to capacity through more development work with market price (FOB) at these levels in those years, but it would not do so at lower prices. These are the economic floor prices in those years for State sales of crude oil by this country in the world market. The financially imposed minimum price in 1990 for internationally traded crude oil is the company's tax-paid cost, however, which is estimated to be about 10.65 dollars of 1975 barrel, FOB Ras Tanura. An oil company will not purchase crude oil at this price to sell it for less. Thus, it was concluded that if the weighted average government take per barrel on Saudi Arabian light crude oil in April 1977, converted to dollars of 1975, remained constant through the year 2000, a private oil company would not purchase crude oil from the State oil company there for sale in the world market at less than 10.65 dollars per barrel in 1990 nor at less than 12.25 dollars per barrel in 2000, both prices in 1975 dollars FOB Ras Tanura. With market prices below these levels in those years, government take per barrel on sales to private oil companies would have to be reduced if the companies there were to continue to purchase crude oil from the State corporation for resale in the world oil market.

Additionally, the market price (in dollars of 1975) of natural crude oil could rise to 10.26 dollars per barrel in 1990 and to 9.28 dollars in the year 2000 (both figures FOB the Pennsylvania coal conversion plant) without provoking large-scale supplies of synthetic /oil from

oil from coal by State corporations. Above those limits, however large-scale supplies of synthetic oil from coal might be forthcoming from State corporations. The comparable trigger prices of natural crude oil for private synthetic oil suppliers are 24.48 and 21.06 dollars of 1975, FOB the oil conversion plant, in 1990 and 2000.

(b) Changes in the world crude oil producing industry over the forecast horizon

What changes are expected over the next two decades in the structure of the world crude oil industry and in the complex of energy policies in the industrialized oil-importing countries? How are these changes likely to impact on the market price of internationally traded crude oil, keeping in mind these financially and economically imposed constraints on its market price? This price is now 12.09 (current) dollars per barrel or 10.80 dollars per barrel in 1975 prices, FOB Ras Tanura.

One change can be identified with certainty: the current price-cost gap in world oil will bring about an increase in its supply, straining OPEC's control over it and putting its price under strong downward pressure over time. The problem involved here is not that of identifying the direction of the supply response; that is already observable.^{141/} The problem is to quantify and date that response with respect to its impact on the price of world oil.

Large volumes of crude oil that could not have been economically exploited before 1973 can now be developed, produced and brought to seaboard for export at unit costs far below the current price of world oil. In short, it now makes sense economically to undertake many exploration and development projects that would have been rejected prior to 1973. What, then, are the prospects for an increased supply of world crude oil in response to the current price-cost gap?

There are two major groups of countries that produce crude oil for the world market other than the group of OPEC countries: first,

^{141/} See: "World Oil Production Gains by Non-OPEC Sources", Petroleum Economist, Vol. XLIV, No 8, August 1977, pp. 297, 328 and 329.

/the group

the group of centrally planned economies and, second, the remaining group of largely developing, oil-exporting countries.

The centrally planned countries (USSR, Eastern Europe, and China) are one of the major potential sources of non-OPEC oil during the eighties. Excluding intra-regional trade, this group of countries exported on a net basis about 635 and 795 thousand barrels of crude oil and refined oil products per day in 1976, respectively, or about 2 and 15 per cent of world exports of these commodities in that year.^{142/} The bulk of these interregional exports were in the form of Soviet sales of crude oil and refined products to Western Europe. The evidence suggests that this group of countries has not been using price discounting as a means of promoting oil exports, but, rather, has been profiting handsomely by accommodating itself to the current price structure for world oil. It is expected that, as long as they remain net oil exporters, the centrally planned countries will continue to see their economic interest in supporting the OPEC-endorsed price line.

This group of countries may encounter difficulties in the future in expanding its crude oil exports, however.^{143/} In fact, some

^{142/} BP Statistical Review of the World Oil Industry 1976, p. 10. Interregional imports and exports of crude oil by the centrally planned economies averaged 365 and 1,000 thousand barrels per day, respectively, in 1976; net crude oil imports in 1976 were, therefore, 635 thousand barrels daily. Imports and exports of refined oil products in 1976 by these countries were 20 and 815 thousand barrels per day, respectively.

^{143/} See: "Energy Prospects for Eastern Europe", Energy Policy, Vol. 4, No 2, June 1976, pp. 119-129; "Primary Energy Production in the USSR", Energy Policy, Vol. 3, No 3, September 1975, pp. 223-224; U. S. Committee on Interior and Insular Affairs, United States Senate, Geopolitics of Energy, Energy Publication No 95-1, January 1977, p. 141. A.W. Wright, "The Soviet Union in World Energy Markets", in E.W. Erickson and L. Waverman, The Energy Question, Vol. 1, (University of Toronto Press, 1974) pp. 85-99; and T.G. Rawski, "China and Japan in the World Energy Economy", Ibid, pp. 101-119. "CIA Doubts China will Play a Major Oil Export Role", Petroleum Intelligence Weekly, Vol. XVI, No 28, 11 July 1977, p. 1; and "World Oil Shortage Looms in Early '80s, CIA Study Warns", Petroleum Intelligence Weekly, Vol. XVI, No 17, 25 April 1977, p. 3.

authorities believe that the USSR will have difficulties maintaining its position as a net oil exporter (above and beyond its oil exports to Eastern Europe) in the eighties, although there is a wide variety of opinion on this account. To the extent that the USSR does rely in the future on imports from the world crude oil market on a net basis, it would be under economic pressure to secure these imports at least cost by pitting crude oil sellers, both State and corporate, against one another for Soviet contracts and thereby putting downward pressure on the price of world oil.^{144/} On the other hand, to the extent that the USSR can continue to release indigenous oil for export to countries other than in East Europe during the nineties, this potential downward pressure on the price of world oil would not be activated.

It does not seem that, in the aggregate, increased crude oil output for the world market from the other group of oil-exporting countries will put OPEC's control of supply under unmanageable strain during the eighties. For example, crude oil exports in 1975 by countries other than the centrally planned economies were about 25.0 million barrels per day, of which about 24.0 million barrels per day were accounted for by the 13 member countries of OPEC. If crude oil exports in 1975 of 0.6 million barrels per day from the United States and Canada (both of which will probably be net oil importers over the next two decades) are excluded from the remaining 1.0 million barrels per day, a residual of about 400 thousand barrels per day is left.^{145/}

^{144/} In a competitive market for world oil, the entry of the USSR as a crude oil importer would imply higher prices, given a positively inclined supply function. However, the world crude oil market is not now, and is not expected to be, one of perfect competition. In the actual market for world oil, however, with its price far above its supply cost to begin with, reflecting the severe restraint on competition, the same increase in demand for world oil would leave its price logically indeterminate: it might rise, fall, or stay the same. The outcome in this case will depend on the change in the volume of oil offered by sellers in the world oil market in response to the increase in the demand for it. Thus, the question is the degree to which crude oil suppliers resist the temptation to cut price to get Soviet sales, should that country become a crude oil importer.

^{145/} Figures on OPEC country exports of crude oil were taken from Exhibit 52. All other figures were taken from BP Statistical Review of the World Oil Industry, 1976 issue, R.19 and 1975 issue, p. 10.

These 400 thousand barrels per day were exported from the non-OPEC, non-centrally planned group of largely developing countries in Africa, Latin America, Asia, and the Middle East. If crude oil exports from this group of countries increased by 10 per cent per annum through 1990 and OPEC exports remained at their 1975 level, the resulting 1,671 million barrels per day in 1990 would be 7 per cent of OPEC crude oil exports in 1990 (i.e., $1.7/24.0=7.0$ per cent). However, many of the countries that would account for this 1.7 million barrels per day of crude oil exports in the year 1990 are now, by and large, capital-starved and, for a variety of reasons they are having serious problems increasing their crude oil exports. It would therefore be difficult for many of the countries in this group to achieve a 10 per cent average annual rate of increase in their crude oil exports up to the end of the eighties, above and beyond the increase in production required because of rising domestic oil requirements. In addition, the 7 per cent figure derived above is an upward-biased estimate of the resulting pressure on OPEC, because the volume of the OPEC crude oil output would also be increasing in satisfaction of rising world demand for crude oil. For example, if crude oil exports from OPEC countries were to increase at 5 per cent per annum through 1990 while the 10 per cent per annum rate was sustained in the other group of countries, then they would be exporting a volume of crude oil in 1990 that would be about 3 per cent of OPEC's expected exports in that year (i.e., $1.7/49.9=3.4$).

Thus, it is expected that crude oil exports from this group of non-OPEC oil-exporting countries will be small relative to OPEC exports during the eighties: small that is to say, in the sense that OPEC producing countries will probably be easily capable of accommodating them by relatively minor cutbacks in the volume of their exports of crude oil to the world market.

The basic conclusion at this point is that during the eighties the main threat to the price structure for world crude oil is presented neither by the centrally planned group of economies nor by the remaining group of non-OPEC oil-exporting and developing countries but, rather, by forces within the OPEC country membership itself.

/A lead-time

A lead-time of about a decade is required between the initial decision to explore for oil and the time at which oil from new fields begins to reach the world market in significant quantities. This would mean that in the nineties, production of crude oil for export from the non-OPEC, non-socialist block group of countries could represent an increasingly significant threat to the price structure of world crude oil, or, at least, it might be seen that way by some OPEC member producers. There are two critical variables here. The first is the rate at which new and large oil discoveries are made in non-OPEC countries and then exploited by them for sale in the world oil market (i.e., the price elasticity of supply of crude oil from these countries).^{146/} The most important imponderable however, is the degree of threat that OPEC country producers perceive in these rising crude oil exports and the price-cutting disposition that it generates on their part as this process unfolds.

Clearly, it is impossible to predict the outcome of these pressures with high confidence, but two assumptions will be made here: first, that during the nineties large volumes of crude oil from now undiscovered fields will begin reaching the world oil market in increasingly significant quantities, and second, that the downward pressure exerted on prices by these volumes of newly-discovered oil will increase during the nineties.

It has just been stated that newly-discovered crude oil produced in developing, non-OPEC member countries will probably begin reaching world market in the nineties, thereby depressing the price of internationally traded crude oil. Just how realistic is it however, to believe that these countries really have these volumes of crude oil, quite apart from the obvious fact that we simply do not have sufficient knowledge to predict with any reasonable degree of certainty either the scale or the precise timing that will be involved in bringing these volumes to bear on prices.

^{146/} The rapidity of this process will hinge largely on the ability of this group of countries to secure foreign capital and technological expertise.

The information provided in Exhibit 57 is useful in gauging the present potential for successful oil exploration investments in the developing countries. Geological knowledge suggest that sedimentary areas have a relatively high probability of containing significant deposits of natural crude oil. One-half of the world's sedimentary land area lies in the developing countries of Latin America, Africa, and Asia. The potential oil-bearing land area in this group of three regions is five times the oil-bearing land area in the Middle East.

The cumulative number of exploratory wells indicates the degree to which investments have already been made to identify the stock of oil in place, while the division of the cumulative number of exploratory wells by the area of potentially oil-bearing land measures the extent to which the process of identifying the stock of oil in place has been undertaken historically. In the case of the developing countries other than the Middle East, the data in Exhibit 57 show that this task has hardly begun, there being less than one exploratory well drilled for every one hundred thousand square miles of potential oil-bearing land area. This ratio is less than one-twentieth of that for the United States, the world's most thoroughly explored country, and it is less than one-third the comparable ratio for the USSR and for the world as a whole.

The following conclusions seem reasonable: "...there is a substantial petroleum drilling gap in the developing countries of the world. Moreover, the non-OPEC developing countries of the world possess about half the world petroleum prospective area. An opportunity for substantial discoveries in Latin America, Africa and Madagascar, S. and S.E. Asia is apparent".^{147/}

^{147/} B.F. Grossling, "The Petroleum Exploration Challenge With Respect to the Developing Nations", published in R.F. Mayer (Ed.), The Future of Nature-made Petroleum and Gas, Technical Reports of an International Conference sponsored by the United Nations Institute for Training and Research (UNITAR) and the International Institute for Applied Systems Analysis (IIASA), (Pergamon Press: New York, 1977), p. 68.

/But obviously

But obviously what is at issue in the present context is not simply having the oil in the ground in the developing countries. Clearly, this is a necessary condition for surfacing it for export in the future. But, as noted earlier, accomplishment on this account in the future will hinge largely on the degree to which the developing countries can secure the capital and the technological expertise to undertake these tasks successfully and relatively rapidly. This forecast assumes that the supply response in the developing countries will be sufficient to depress price during the nineties. If this expectation is not realized, then, it would be argued that the price of internationally traded crude oil will be higher during the nineties than anticipated here. No one really knows the outcome in store on this account.

Whatever the outcome, however, during the eighties and the nineties there will be a sustained downward pressure on price given the expectation that OPEC will continue to lack a quota scheme for allocating total production among its member countries. In the absence of such a scheme, there will be an enduring and financially hard-to-resist temptation for all crude oil sellers to cut prices. This is exactly the case at present, but, up to now, this pressure has been contained.

The containment of this downward pressure on prices in the future warrants comment. The incentive for private and State oil companies to cut oil prices has existed in the past, and it has not always been resisted by them. For the most part, the extent of price cutting has been quite limited in recent years, but the progressive tendency towards the direct sale of crude oil by host governments - a trend which is expected to continue during the forecast period - will accentuate this pressure even more in the future. The incentive for countries to sell direct and to cut prices to do so will also be intensified with the progressive nationalization of the crude oil producing industries in OPEC member countries and with the desire of many of these countries to capture a larger share of the large, increasing and extremely profitable United States oil import market. The

/existence of

existence of this pressure does not imply that it will actually be transformed into lower prices, however, and judging the degree of containment of this mounting pressure on the price of world crude oil is the most critical step in its forecasting.

Changes in the structure of the crude oil producing industry over the forecast period are expected to increase the downward pressure on the price of world crude oil. It is expected that Saudi Arabia will soon nationalize its crude oil producing industry. At that point, about seven-tenths of crude oil production in OPEC member countries will be accounted for by countries in which the major oil companies have neither equity crude oil rights nor buy-back obligations (the current proportion is about one-half), and when this happens, legally stipulated buy-back prices and volumes in the non-nationalized oil-exporting countries will, to all intents and purposes, become non-binding: then, either company tax-paid costs per barrel in the States where the oil industry has not been nationalized will stay competitive with those being offered in the States where the industry has been nationalized or business will simply be transferred from the former to the latter. Host governments which previously had buy-back agreements with the companies will be under greater pressure as they find that they must market their own oil without the protection afforded to them in the past by these agreements.

Nevertheless, the assumption of a move toward the increased nationalization of crude oil production in OPEC member countries in the future is certainly not a sufficient basis for concluding that, on this account alone, crude oil prices will decline. One need look no further than to the pattern of crude oil prices since 1973 to appreciate the fallacy of such a position. However, that pattern also shows that alleged price cutting by host governments since 1973 has been heavily, but certainly not exclusively, concentrated in OPEC States with nationalized oil industries: Iran, Iraq, Algeria and Libya. With the loss of buy-back arrangements as a result of nationalization and the growth in the volume of nationalized oil entering world markets, the pressure on prices will increase.

/Thus, it

Thus, it may be expected - though this need not be the case in any logically compelling sense - that competition between the producing countries in third-party markets and in the fixing of crude oil acquisition costs to the companies will increase over time, and that, given the continuing competition in oil refining and marketing operations, this increased competition at the point of crude oil sale could be transformed into a downward pressure on world crude oil price. Once again, the critical step in forecasting world crude oil prices is to gauge the degree to which this pressure is contained over the next two decades.

(c) Changes in the energy policies of the industrialized, oil-deficit countries

Energy policies in the industrialized, oil-deficit countries will have repercussions on the price of world crude oil over the forecast horizon. As noted earlier, there is a noticeable absence of interest among these countries in multilaterally co-ordinated action to reduce the present level of world crude oil prices quickly and substantially. This is not surprising, given the diversity of vested interests and expectations involved. Great Britain, Norway, and other European countries with crude oil and natural gas interests in the North Sea are not disposed to support multilateral action designed to break the price structure for world oil. They see their future from the point of view of the oil exporter, and this makes them inclined to oppose such action. The Netherlands, which is a major exporter of natural gas, takes a similar view.

A variety of industrialized countries, many with no substantial overseas interests in oil, are also reluctant to join with others in action designed to bring down the price of world oil: the fear of embargo is ever-present with them, and policy-makers in these countries probably believe that the likely costs of domestic economic disruption resulting from an embargo would not be adequately compensated by the gain in the form of the lower prices expected through concerted action. One may disagree with such an evaluation, but what counts in the present instance is that it undoubtedly underlies the decision of some governments not to join such groups.

/There are

There are also a variety of industrialized, oil-importing countries with producing ventures in the Middle East who fear reprisals if they were to join in multilaterally organized price-breaking schemes. Again, one may disagree with the evaluation. Nonetheless, a country's decision whether or not to join the price-breaking group can only be explained in terms of its own expectations.

After the abrupt increase in world oil prices in October 1973, there was an initial period in which the United States government was apparently testing the degree of solidarity among the industrialized oil-importing countries in support of action that might, inter alia, bring down world oil prices. There was no official commitment to such a strategy; it seemed that the idea was merely being mooted. For the reasons noted above, however, solidarity was found lacking. Since then, the makers of United States foreign policy have not placed any stress on the possibility of multinationally co-ordinated action among the oil-deficit, industrialized countries as a means of achieving the objective of immediately lower prices for world oil.

The pronounced lack of support among the industrialized, oil-importing countries for price-breaking schemes is expected to persist over the forecast period. In short, if world oil prices do fall during the next two decades, it is not expected that it will be due to any multinationally co-ordinated action taken by the industrialized, oil-importing governments to break the price structure of world oil.

In the shaping of national energy policies, there is at present widespread emphasis in the industrialized oil-importing countries (and in others as well) on the substitution of nuclear power plants for fuel-oil fired plants. Many policy makers believe that this substitution is desirable on the grounds of decreasing the degree of national vulnerability to oil embargoes in the future. Economic gains are also expected. On this latter point, however, the possibility of a downward trend in world oil prices is recognized by energy-policy makers in these countries, and this is the fundamental reason for deliberations on the setting of a minimum safeguard price for imported oil.

/In January

In January 1976 the European Commission adopted a minimum price of 7.00 dollars per barrel for imported crude oil in order to protect investments in alternative energy sources, particularly in North Sea oil and gas. Should the average FOB price of imported crude oil fall below 7.00 dollars per barrel, an import duty would be levied to cover the difference. Other price control mechanisms are reportedly under consideration in the European Commission. The International Energy Agency (IEA) has also adopted a minimum safeguard price of 7.00 dollars per barrel, and its member countries undertake not to sell imported crude oil in their domestic markets at less than that price.^{148/} The 7.00 dollars per barrel minimum safeguard price will not afford protection to all prospective investments in new energy sources, however. According to IEA estimates, only one-third of the new capacity expected to be operational in IEA countries by 1980 will have average costs below 6.00 dollars, and only one-half will have average costs below 8.00 dollars per barrel. However, according to the IEA, the 7.00 dollars minimum safeguard price will be sufficient to protect "...large-to-medium-sized North Sea fields, much of the deep- and surface-mined United States coal output, oil produced in North America by secondary and tertiary recovery, North Alaska and Canada's MacKenzie Valley crude oil and gas, and most United States (and European) nuclear plants..."^{149/}

The message for sellers of world oil is clear: reductions in the FOB price of world crude oil to the level of the minimum safeguard price are welcome, but prices lower than this will threaten the financial viability of past investments in nuclear power plants and other substitute energy projects in the industrialized countries. The analogy with coal during the fifties and sixties is all too clear.

^{148/} "Brighter prospects this year?", Petroleum Economist, January, 1976, p.2; and "EEC Commission adopts 'floor' price, Petroleum Economist, February 1976, p.48. See also: "EEC also seeks 'protection' plan for new energy sources", Petroleum Intelligence Weekly, 19 January 1976, pp.3-4.

^{149/} See: Petroleum Intelligence Weekly, op.cit., p.4.

It is to be expected that if and when world oil prices approach the IEA's minimum safeguard limit of 7.00 dollars (of 1976) per barrel (6.30 dollars in 1975 prices), these governments will take action to 'protect' their investments in coal, nuclear power and other alternative energy-supply projects. If this policy of protection does emerge, these governments will confront a situation similar to that which they faced in the fifties and sixties, the difference being that, in addition to protecting indigenous coal and oil from imported oil as was the case in the fifties, they will now be under pressure to protect nuclear power as well. One may disagree strongly on economic grounds about the wisdom of protecting coal and nuclear power on a total cost basis, but what counts in the present instance is the fact of protection, not its defensibility. For if protection is accorded to these energy industries against imported oil, it will help to break the rate of decline in world oil prices at that time.

Some clarification is needed on this latter point. The governments of the industrialized oil-importing countries may not want the 7.00 dollar price for world oil to be breached. However, as they themselves realize, they do not have the power to set the price of world oil, for they do not control its supply. These governments may, at that point, use import tariffs, price regulation, or both devices to keep the domestic price of imported crude oil at no less than 7.00 dollars per barrel, FOB. Alternatively, they may let domestic energy prices fall and grant direct subsidies to inefficient energy suppliers.

However, although these countries cannot fix the price of world crude oil, their energy policies can have an impact on its price. As was shown in Section I, the protective energy policies of the industrialized countries towards indigenous energy industries have been quite important in determining the level of world oil prices in the post-war period. It is assumed here that if and when the price of world crude oil begins to approach 7.00 dollars per barrel in 1976

/dollars (or

dollars (or 6.30 dollars per barrel, in 1975 prices),^{150/} these governments will initiate action to protect their nuclear power (and other) energy industries. It is also assumed, however, that if this point is reached, the competitive interplay between sellers and buyers of world crude oil will be sufficient to drive price below the IEA's 6.30 dollars per barrel limit (converted to 1975 prices). If tariffs are levied on imported crude oil sold at prices below this level, a portion of the economic rent in crude oil production will then be transferred from producing to importing countries. At that point, the importing countries will no more be able to fix the level of world crude oil prices than they could in the past when the aim of their policies was basically to protect their domestic coal and oil industries.

(v) A forecast of the price of Saudi Arabian light crude oil through the year 2000

(a) Introduction

This section presents a forecast of the official price (in 1975 dollars) of Saudi Arabian light crude oil (FOB Ras Tanura) through the end of the century. The following points should be kept in mind in approaching this forecast:

First, the price being forecast here is the official State price for large volume contracts for future delivery of this crude oil, assuming all discounting to be reflected in its price. Discounts aside, this is the price received for direct sales of crude oil by State oil companies and also the price at which the major oil companies sell their crude oil in third-party markets (Exhibit 51).

Second, the price being forecast is not the spot market price for this crude oil. The spot price is the price paid now for immediate delivery, and it will fluctuate above and below the official State

^{150/} The index of world consumer prices increased by 11.2 per cent during 1975-1976. See: International Monetary Fund, International Financial Statistics, Vol. XXX, No 8, August 1977, p. 29.

price over time, the two prices being linked by storage costs, interest rates, and so forth.

Third, two forecasts are presented of the official State price for Saudi Arabian light crude oil. The first forecast presents the track of the most likely price of this crude oil through the end of this century. Since it is realized that it is extremely improbable that any of these most likely prices will actually emerge, however, a Bayesian-based forecast is also presented of the probability that the actual price of this crude oil will fall within specified ranges of price over the forecast horizon. The forecast of the track of most likely prices is advantageous to investment analysts, who, when all is said and done, must ultimately select what they believe is the most likely track of prices of this crude oil over the next quarter-century. The forecast of likely price ranges is helpful to these same analysts in approaching the task of sensitivity analysis, while it also gives a clear idea of the pattern of potential dispersion in future prices for world oil as anticipated by the author. If the reader disagrees with the author's selection of price ranges and their assigned probability values, he may retain the methodology developed here, making his own assumptions and deductions.

Fourth, the forecast presented here was generated qualitatively. Quantitative forecast methods were considered, but they were rejected. The review of world crude oil price formation presented in Section I of this Chapter argued that in the post-war era there have been four analytically distinct periods of price formation, not just one. The application of least squares or related techniques to groupings of these distinct periods would be indefensible because of the serious hetroskedasticity that would be generated.

In general, statistical forecasting procedures are rejected because they are incompatible with the large element of instability inherent in the process which generates world crude oil prices and also because of the extended duration of the forecast period, 1978-2000. These reservations are relevant to both time-series forecasting techniques and to the variety of mathematical modelling (i.e., causal)

/predictive techniques

predictive techniques as well. This latter collection of techniques are particularly inappropriate insofar as they assume a tendency toward the equilibrium price of perfect competition and also presume knowledge of the value of a series of independent, causal variables over the next quarter century. In these circumstances, it seems better to predict price itself, qualitatively and directly.

As noted earlier, judgement on the degree to which the strong pent-up pressure on the price of world oil continues to be dammed up in the future as it has been in the past is the critical step in its forecast. Any forecast method that assumes that the price of world crude oil is the simple result of the interaction of demand and supply in a competitive market for world crude oil reflects ignorance of both the past and the present price formation process for this commodity. This does not give a very sound basis for predicting its price in the future. Forecasting world crude oil prices using time as the only independent variable, however elegant the lagging sequence and complex the mathematics, is an exercise devoid of economic content, and it is rejected out-of-hand. On the other hand, the qualitative method used here does suffer logically because the jump from analysis to forecast is not rationally compelling. In this case, however, the forecast is rooted in prior analysis, and this analysis may prove helpful to those whose subsequent judgement about future price carries them elsewhere, even though they may agree on the underlying dynamics at work in shaping prices, historically and prospectively.

Fifth, in this same vein, it is believed that crude oil price formation during the eighties will be essentially comparable, in terms of the dynamics involved, to the period 1952-1957 (Exhibit 48). During the nineties, different price dynamics are expected, more akin to the period 1958-1970, but, again, analytically distinct from it. Although it is useful to make analogies between each of these past two periods and future periods, the assumption that the price performance during these two past periods will be replicated in the future would constitute a glaring non-sequitur. Analogies of this sort are useful for gauging the pressure on price in the future, but not for measuring it.

/Sixth, although

Sixth, although the description of the critical forces bearing on the future price of world crude oil is presented cryptically in this section, in each case the past and future operation of the forces noted briefly here has been discussed at length in previous sections of Chapter 2.^{151/} The reader is referred to those discussions for amplification.

(b) The most likely price of world crude oil in 1990 and 2000

The track of the most likely price of Saudi Arabian light crude oil (in 1975 dollars, FOB Ras Tanura) is shown in Exhibit 58 together with historical prices in current and constant dollars. Historical and forecast real prices are plotted graphically in Diagram 1.

The real price of this crude oil is expected to remain at its current level through the eighties and then to decline by an average of 2 per cent per annum during the nineties. The terminal prices in 1990 and 2000 should be interpreted as rough averages, say for 1989-1992 and 1998-2002, respectively, rather than as precisely applicable to those two terminal years. All prices for years between 1990-2000 are simple geometric interpolations and, again, should be taken with a grain of salt.

The following ideas underlie the forecast of the price of Saudi Arabian light crude oil during the eighties:

First, OPEC member countries, taken as a group will continue to act as if they viewed the profit-maximizing price during 1978-1990 as 10.80 dollars of 1975 per barrel of Saudi Arabian light crude oil. Prices could go higher, but this is viewed as improbable. It is much more likely that they will be lower.^{152/} Whatever the turn of events politically, it is assumed that OPEC member countries taken as a group will not deviate from a policy of profit-maximization. They need not, so it is expected that they will not.

^{151/} See Chapter 2, Sections I-III.

^{152/} Later, in the Bayesian-based forecast, probabilities will be assigned to statements such as these, and the reason for the expectations presented will be explained.

/Second, increased

Second, increased pressure on price from increased supplies of crude oil for the world market produced in countries outside OPEC will not be significant during the eighties.

Third, if the group of countries with centrally planned economies do become net importers of petroleum during the eighties, the increased pressure on the price of world crude oil on this account will not be significant during that decade.

Fourth, the energy policies of the industrialized, oil-importing countries in general and of the United States in particular will not be oriented to bringing down the price of world oil sharply and rapidly. These countries will remain passive price-takers in this policy sense.

Fifth, it is assumed that the downward pressure on price born of the continuing and large price-cost gap during the eighties will be contained by group cohesion on price-policy within OPEC and by cohesion between the host governments and the major international oil companies. By way of comparison, during 1951-1957 the real price of this crude oil declined, on average, by 1.1 per cent per annum. This was a period during which control over world crude oil supply and price was firmly in the hands of the seven major international oil companies, which also managed to maintain high group cohesion on price policy. While there were seven companies in power during 1951-1957, however, power within OPEC is now heavily concentrated in two countries (Saudi Arabia and Iran), and will continue to be so during the eighties. The first of these countries has already shown its willingness and ability to punish those oil-exporting countries which establish prices higher than the level it considers appropriate, and in this regard there is evidence to suggest that one of the basic ideas behind Saudi Arabia's pricing strategy since 1975 has been to stabilize the price of world oil in real terms (see Exhibit 58). On the other hand, Saudi Arabia has no comparable power to stop price-cutting. However, three forces are seen as sufficient during the eighties to dam up the immense downward pressure on price born of the price-cost gap: first, the ability and willingness of Saudi Arabia and some of the other major producers in OPEC to

OPEC to cut back on the volume of crude oil production for the world market as its price weakens through the action of price-cutters; second, the resistance to price-cutting by the major crude oil exporting countries on the grounds that each knows that the price could be pushed down rapidly toward the long-run incremental supply cost of crude oil; and, finally, the force of nationalism, which in the present context means the force rooted in the desire of the oil-exporting countries not to lose face internationally by engaging in economic competition with each other that, in the end, would work to the disadvantage of every one of them and to the clear advantage of the developed countries.

During the nineties, the price of Saudi Arabian crude oil is expected to decline on average by 2 per cent per annum from its most likely price of 10.80 dollars (of 1975) per barrel in 1990. Hence, the most likely price of this crude oil in the year 2000 is expected to be 8.82 dollars (of 1975) per barrel (FOB Ras-Tanura). The key ideas on which this forecast rests are the following:

First, energy policies in the industrialized oil-importing countries will continue to be passive with respect to the price of world oil.

Second, the downward pressure on the price of natural crude oil in the world market will be greater during the nineties than during the eighties because the increased supply of crude oil for the world market and the increased number of non-OPEC sellers will loosen the grip of OPEC over its supply and, therefore, over its price, while the group of countries with centrally planned economies will become a progressively larger net importer of oil in the world market during the nineties, and it will pit seller against seller to get its imported oil at least cost, thus putting oil prices under stronger downward pressure in the process.

Third, although OPEC's control of supply will be weakened during the nineties, the degree of that control will still remain relatively strong. This is implied in the selection of a 2 per cent average annual rate of decline in world crude oil prices during 1990-2000.

/By way

By way of comparison, during 1958-1970 the real price of world oil declined by 7.1 per cent annually, due largely to the loosening grip of the majors over the supply of crude oil in the world market (Exhibit 58).

Fourth, a price of 8.82 dollars (of 1975) per barrel in the year 2000 implies significant reductions in the weighted average government-take per barrel during the nineties under the pressure of rising long-run incremental supply costs (Exhibit 56). The assumption is made here that these reductions will be accepted because it will make good business sense at each step in time to accept them.

Fifth, while some synthetic oil investments might be triggered towards the end of the eighties, during the nineties the price of natural crude oil will be substantially below the minimum economic supply cost of synthetic oil (even at a 12 per cent opportunity cost of capital), so that downward pressure on prices on this count during that time can be discounted.

(c) The range of expected prices in 1990 and 2000

The probability that the process of crude oil price formation will generate these most likely prices exactly as forecast (10.80 and 8.82 dollars of 1975 in 1990 and 2000, respectively) is virtually zero in a strictly statistical sense, although these prices are viewed as more probable than any others in those years. For this reason, it is important to specify as clearly as possible the pattern of stability thought to be inherent in world crude oil prices over the forecast period. This involves the necessity of estimating the probability that specified ranges of price at given points-in-time in the future will include the actual price of world crude oil.

For this purpose, Bayesian analysis will be applied by isolating distinct ranges of world oil prices within which the actual price might fall in 1990 and then in 2000. Following this, a level of probability is assigned to the possibility that the actual price will fall within each of these ranges in each of these two years. The joint probability is then calculated that the price will fall within a specific range in the year 2000, given the prior probability of it having fallen in a particular range in 1990.

/With market

With market prices now so far above the maximum long-run supply cost of natural crude oil, a forecast of even higher prices in the future would imply that OPEC member countries are underestimating the profit-maximizing price, that they realize this in the future and that they correct the underestimations during the forecast period. In turn, this requires that, as a group, these countries retain the power to fix the higher, profit-maximizing price in the future by reducing supply. It is argued that while, as a group, they probably will have this power during the eighties, they will probably suffer a relative loss in it during the nineties.

On the other hand, a forecast of declining real prices for world oil implies erosion of control over supply - in short, a weakening of the OPEC cartel. The higher the rate of decline in price that is predicted, the higher the implied rate of erosion of the cartel's control over supply. Conversely, the higher the rate of increase in the forecast price, the stronger the implied control over supply.

With respect to the identification of price ranges for 1990, the first range isolated is given by all prices above the estimated minimum supply cost of synthetic oil in 1990, i.e., 14.05 dollars of 1975 (see Exhibit 59 and Appendix B). A zero probability is assigned to the possibility that the actual price in 1990 will fall in this upper price range. This follows from the assumption that the profit-maximizing price is, and will continue to be, substantially below the substitute-inducing price.

The second price range isolated for 1990 is that defined by the minimum price of synthetic oil, at the upper limit, and by the present price of world oil at its lower limit (i.e., between 14.05 and 10.80 dollars of 1975 per barrel). A 5 per cent probability is assigned to the set of prices in this range, reflecting the assumption that the perceived 10.80 dollar profit-maximizing price will not change substantially over the forecast horizon from its assumed current level of 10.80 dollars of 1975 per barrel. These assumptions are obviously debatable, and those who think otherwise may assign their own probability estimates to these events.

/The third

The third price range isolated for 1990 includes all prices below the estimated maximum long-run supply cost of world oil in 1990. A zero probability is assigned to all prices in this range. If, during 1979-1980, price were in fact to decline to the long-run supply cost of world oil, the structure of the world crude oil market would have been converted in just twelve years from one of an oligopoly to one of perfect competition. While possible, this change is viewed as not being even remotely probable.

The next price range isolated for 1990 is given by the long-run supply cost of world oil in 1990 (i.e., 0.40 dollars of 1975 per barrel) at the lower limit and by 8.31 dollars of 1975 per barrel at the upper limit. This upper limit would emerge if the present price declined at an average rate of 2.0 per cent p.a. through 1990. A negligible probability is assigned to prices in this range (i.e., 0.40-8.31 dollars per barrel), since it is expected that control over the supply of world oil will be sufficiently strong during the eighties to keep its real price from declining by more than 2 per cent per annum during 1978-1990. Again, this position is debatable.

The last two price ranges isolated for 1990 are accorded the lion's share of probability. If the real price of world oil declined by 1 per cent per annum from its present level, it would reach 9.49 dollars of 1975 per barrel in 1990. The range between the present price, 10.80 dollars per barrel, and that price, 9.49 dollars, is assigned a 70 per cent chance of including the actual price in 1990, while the price range between 9.49 and 8.31 dollars per barrel is assigned the remaining probability of 25 per cent. Obviously, the expectation involved here, in both cases, is that while OPEC member countries as a group will continue to exercise a tight control over the supply of crude oil being offered for sale in the international market during the eighties, price-slippage is expected, with slow rates of slippage being viewed as more probable than higher rates.

With respect to the year 2000, if the actual price in 1990 were in fact above the present price of 10.80 dollars of 1975 per barrel, then a zero probability would be assigned to the event that it would,

/once again,

once again, fall within that range in 2000. The reason for this position is the expectation that declining control over supply will be sufficiently intense during the nineties to drive price below its present level by the year 2000, whatever its level in 1990. A zero probability is also assigned to the possibility that the actual price in 2000 will fall below the estimated maximum long-run supply cost of world oil in that year, i.e., 2.00 dollars of 1975 per barrel, FOB Ras Tanura. In other words, the possibility that the world oil market will be converted to one of perfect competition in this century is viewed as nil.

The 'most likely' price range in 1990 was defined as 9.49-10.80 dollars of 1975 per barrel, and this was assigned a 70 per cent probability. If prices in 1990 actually were to fall within this range, this would constitute an indication on the degree of erosion in control over the supply of world oil during the eighties, a decade during which it is expected that OPEC will retain a relatively strong degree of control over the supply of world oil. This information on the rate of slippage in price during the eighties provides the basis for a rough estimate of the downward pressure on price during the nineties, a decade during which the cartel's control over supply is expected to weaken.

During 1990-2000, three potential movements from the 9.49-10.80 dollar price range are identified (see Exhibit 59 and Appendix B):

(a) The first estimates that in 2000 the upper limit will be 10.80 dollars and the lower limit 8.58 dollars, the latter being the result of the 9.49 dollar price declining by 1 per cent per annum during 1990-2000. While a rate of decline in prices as low as zero to one per cent is possible, higher rates of decline than this are considered far more probable during 1990-2000, due to the expected loosening of OPEC's grip on supply. With this in mind, a twenty per cent probability is assigned to prices in the range of 8.58-10.80 dollars per barrel in 2000, given the prior probability of 70 per cent that was assigned to the range of 9.49-10.80 dollars for 1990.

(b) The second range isolated for the year 2000 is 7.75-9.77 dollars per barrel. The price of 9.77 dollars would result if the

/upper limit

upper limit price of 10.80 dollars in 1990 declined by 1 per cent per annum through the year 2000, while the price of 7.75 dollars would emerge if the lower limit price of 9.49 dollars in 1990 fell by 2 per cent per annum through the year 2000. This range (i.e., 7.75-9.77 dollars) is viewed as the most probable of the three being discussed here, and a 60 per cent probability is assigned to it.

(c) The remaining 20 per cent probability is assigned to the price range 7.00-8.82 dollars in the year 2000. The 7.00 dollar price would emerge if the upper limit of the 9.49-10.80 dollar price range declined by 2 per cent per annum and the lower limit of this range declined by 3 per cent per annum. Rates of decline of this order are considered quite possible, but much less so than the 1 and 2 per cent per annum rates of decline in price, to which 60 per cent probability was just assigned.

If the actual price in 1990 did fall within the range of 8.31-9.49 dollars, what price ranges would be isolated for the year 2000, and what probabilities would be assigned to them? The range 8.31-9.49 for 1990 it will be recalled, includes those prices bracketed by the present price declining at rates of 2 and 1 per cent per annum, respectively. The three price ranges identified for the year 2000, on the basis of a 1990 price range of 8.31-9.49 dollars, are as follows:

(a) The most probable case for the year 2000 in this instance is given by the range 6.13-7.75 dollars, the lower limit of which is defined by the price of 8.31 dollars falling at 3 per cent annually through the year 2000, while the upper limit is given by the 9.49 dollar price falling by 2 per cent per annum. Price declines of this order are what are expected if prices were indeed to fall by between 1-2 per cent per annum during 1978-1990. A sixty per cent probability is therefore assigned to the range 6.13-7.75 dollars per barrel in the year 2000.

(b) The last two ranges, 6.80-8.58 and 5.53-7.00 dollars per barrel, 153/ are each assigned a 20 per cent probability. Relative to

153/ $(8.31) (1.00-0.02)^{10} = 6.80$; $(9.49) (1.00-0.01)^{10} = 8.58$
 $(8.31) (1.00-0.04)^{10} = 5.53$; and $(9.49) (1.00-0.03)^{10} = 7.00$
/the 'most

the 'most likely' range just discussed (i.e., 6.13-7.75 dollars), the former range implies a rate of decline in price that is slower than anticipated during 1990-2000 if, in fact, prices did decline by between 1 and 2 per cent per annum during 1978-1990, while the latter range implies a faster rate of decline than that expected on this basis. Both ranges are viewed, then, as equally probable in one sense and equally improbable in another.

(d) Conclusions

The subjective assumptions just explained (and shown graphically in Appendix B) lead to the conclusion there is about a seventy-five per cent chance that the actual price of Saudi Arabian light crude oil in the year 2000 will fall within the range of 7.70 to 9.77 dollars of 1975 per barrel FOB Ras Tanura (Exhibit 59 and Diagram 2). The odds that the actual price in the year 2000 will be included in ranges outside this most probable range are much smaller. Thus, the odds are three-out-of-five that the actual price will fall between 7.75-9.77 dollars, and within this range, the odds are about three-out-of-ten each that the actual price in the year 2000 will be above or below the mid-point of this range (i.e., 8.76 dollars).

Even at the lower limit of the price range with the lowest probability (i.e., 6.14 dollars in the range 6.14-6.79 dollars), the 6.14 dollar price is far above the strongly upward-biased estimate of the maximum long-run economic cost of crude oil supply in the year 2000 (i.e., 2.00 dollars of 1975 per barrel). Similarly, the chances that the actual price in 2000 will be below the minimum safeguard price of the IEA and the European Commission (6.30 dollars of 1975 per barrel) are taken as less than ten per cent.^{154/} At the other extreme, the chances that the price of natural crude oil in the year 2000 will exceed the minimum long-run economic cost of synthetic oil supply are seen as nil.

^{154/} See the discussion of the minimum safeguard price in Chapter 2 (Section IV). When account is taken of transport and insurance cost from the Persian Gulf to Western Europe, the probability of the safeguard price being breached is even less.

The well-informed reader will understand that each of these two forecasts must be taken with a good deal of reservation. It is possible, although improbable, that competition between sellers and buyers in the world crude oil market could break the price structure for world oil tomorrow. Nothing in economic theory opposes this possibility. All that is required is that the strong forces working to break the price structure (i.e., increased supply and its mirror image, market competition) are not offset by strong forces working to dam up the downward pressure on price (i.e., OPEC's control over supply and the pattern of country-company crude oil marketing arrangements). On the other hand, OPEC member countries may be successful in maintaining the present price structure for world oil over the next two decades. Again, nothing in economic theory rules out this possible, but improbable, outcome in a technically logical sense. One very important imponderable is the future emphasis of United States energy policy on bringing down world oil prices. There is no such emphasis in either actual or proposed policy at the present time and effectively, this consideration has been treated as a parameter in this price forecast exercise. If the United States continues its essentially passive attitude towards world crude oil prices, a major potential force for bringing the whole structure of these prices down will remain dormant. On the other hand, if the United States moves determinedly to break world oil prices (believing itself forced, for example, through balance-of-payments pressure), then a powerfully depressant force on world crude oil prices will have been activated. The present forecasts are predicated on the assumption that this change in United States policy will not occur.

While plummeting and steady price trajectories through the year 2000 are perfectly possible, it is hoped that the reader will understand, on the basis of the preceding arguments, why each of these extreme possibilities is believed to be improbable over the rest of this century. However, belief is not certainty, and all that can be hoped, in the present instance, is that the reader understands the logical development supporting the final forecast prices, price ranges

/and probabilities

and probabilities tabled in this study. The selection of the specific rates of decline in the real price of world crude oil was clearly a subjective operation, but no apologies are called for on this account. The use of a more complicated mathematical forecasting technique might be more fashionable, but it would in no way be more convincing per se, and analysis of the process of world crude oil price formation, historically and prospectively, leads to the conclusion that the use of these methods would be misguided. It is hoped that the background material underlying the forecasts is sufficiently clear to enable readers who disagree with the specific rates of decline chosen to substitute their own, preferably within the framework of the overall arguments presented here.

Section V: The options open to Latin American oil-deficit countries for confronting future prices of world oil

(i) Introduction

In very general terms, the prime implications of the forecasts just presented are that, in all probability, the oil-deficit countries of Latin America (and elsewhere) can expect to face the same real price for world oil during the eighties that they face now, and that during the nineties only moderate relief can be expected on this account. As a consequence, the balance-of-payments-induced pressure on domestic output and employment which these countries currently suffer is expected to persist over the rest of this century. From this it follows that there is a continuing and intense need to design a set of energy policies in these countries that minimize over time the damage caused to their economies by the price of internationally traded oil, on which they will continue to be reliant in the future.

In approaching a discussion of energy sector policy, it is important to distinguish, at the outset, two policy fields. The first is energy-sector policy, focused on action initiated in the energy sector in reaction, in this case, to the expected price of world crude oil. The second is macroeconomic policy, oriented towards action designed to affect broad economic variables such as the level and /composition of

composition of domestic output, employment, domestic prices, imports and exports, savings and investment.

These two fields of policy are obviously interrelated. Decisions in the sphere of energy policy must be taken in the broader context of macroeconomic policy as well as in the light of policy formulation in other sectors of the economy. Pricing policy on refined oil products, for example, will obviously have macroeconomic implications for the level and composition of domestic production, employment, foreign reserves, and so on. Conversely, monetary and fiscal policy will affect prices and costs in the energy sector.

This section concentrates on policy options open at the level of the energy sector, assuming that the macroeconomic mandate is to minimize the threat of oil prices to domestic output and employment. Moreover, it is oriented towards policy options open to Latin America's oil-deficit countries, since these are the countries where the increased cost of imported oil has posed a threat to domestic output and employment.

Three other issues need to be clarified: first, the objectives of energy sector policy as discussed in this section; second, the level of generality on which this discussion of energy policy will be conducted; and, third, the organizational framework that will be used to discuss this subject. It is assumed that the price of world crude oil over the rest of this century will follow the track presented in Exhibit 58 and Diagram 1.

With regard to the objectives of energy sector policy in the region's oil-deficit countries, the forecast of world crude oil prices presented earlier implies a heavy and continuing drain on the foreign reserves of these countries over the rest of this century, threatening, in turn, their prospects for economic growth and social advancement. Within this context, the objectives of energy sector policy as discussed in this section are: first, the promotion of the least-cost supply of energy sources in the region's oil-deficit economies; and, second, the promotion of economic growth and efficiency through rational energy pricing and investment decisions. Even if there had never been an /"energy crisis"

"energy crisis", these same two objectives would still have been proposed to guide energy policy-makers.

The extent to which these two objectives are realized will likewise determine the extent to which the threat to domestic output and employment in these countries caused by the high cost of imported crude oil can be mitigated, and this, it is assumed, will be a key objective of macroeconomic policy in the region's oil-deficit countries. Conversely, to the extent that these countries do not seize the opportunities for reducing the unit costs of domestic energy and do not follow economically rational energy pricing and investment policies, the economic dislocation provoked by the increased price of world oil will remain unchecked by policy action in the energy sector.

It is obviously not feasible to carry out an abstract discussion of energy sector policy in a way that would apply on a detailed level simultaneously to each of the region's oil-deficit countries. For example, the policy recommendation to increase the production of lower-cost indigenous crude oil would be absurd for the many Latin American countries that do not now have such a production capability. In this context, the diversity of the region's oil-deficit countries in terms of both their energy sectors and their socio-economic structures must be stressed at the outset. The energy sectors of these countries vary widely in the level and composition of energy production and consumption, in the extent of their foreign trade in energy sources, the scale and complexity of refining activity, the degree of reliance on imported oil, the structure of refined product consumption and refinery output, the extent of State control over the energy industries, the supply cost of indigenous energy sources, the level and structure of energy prices, and the national policy parameters that condition the formulation of energy-sector policy (e.g., receptivity to foreign capital in the domestic oil industry). These country-by-country differences, taken in conjunction with patently broad differences in economic structure, degree of nationalism, and socio-economic circumstance of these countries, underscore the need to tailor a detailed discussion of energy policy to each individual country.

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However, a country-to-country approach to a discussion of energy sector policy is simply beyond the scope of this study. Instead, a more general approach must be adopted, focusing on the policy options that are potentially open, in general, to various groupings of the region's oil-deficit countries in their attempt to achieve the two objectives of energy sector policy just specified. For purposes of discussion, the energy sector policies open, in general, to Latin America's oil-deficit countries for coping with the expected price of world crude oil over the next two decades may be classified under the following headings:

1. Policies aimed at decreasing the demand for imported oil, comprising those which:
 - (a) do not require international co-operation for their implementation; and
 - (b) Those which do require it.
 2. Policies aimed at mitigating increases in the cost of energy supplies in general and of oil in particular, once again comprising those which:
 - (a) do not require international co-operation for their implementation; and
 - (b) those which do require it
- (ii) Policies aimed at decreasing the demand for imported crude and not requiring international co-operation.

Exhibit 60 shows the increased share of oil imports in total imports in various Latin American countries since 1972. As concluded earlier, the crude oil price forecasts presented in Exhibits 58 and 59 (see also diagrams 1 and 2) mean that the drain on foreign reserves on oil account in the region's oil-deficit countries is expected to persist over the next two decades, and on a significant scale.

The first imperative, therefore, is to reduce the growth rate of the demand for imported crude oil and refined products, but in such a way as to minimize the threat to economic growth and efficiency. Three options on pricing are open:

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First, to use international prices for refined oil products as the parity basis for fixing the domestic price of internationally traded energy sources in those countries in which the State legislates the price of domestic energy flows, which is the typical case in Latin America. In those cases where there is no interference by the State in the establishment of prices for energy products, domestic oil prices at international parity would emerge automatically, and these prices would reflect the real economic cost (i.e., the opportunity cost) of consuming them in the economy. The balance-of-payments pressure that would result from this policy would be transmitted through the economy as a whole by changes in the exchange rate. The pattern of price inflation would be energy-specific, and this would, in turn, favour economically rational patterns of substitution by both producers and consumers.

Second, the State energy authority may fix higher prices for refined oil products than their international parity prices. If domestic prices for imported energy products are set by the State at levels higher than international parity, this amounts to levying an indirect tax on all consumers, insofar as they all consume refined oil products, either directly or indirectly. The tax is regressive to the extent that it takes away a higher fraction of income from lower than from higher income groups. Fixing prices for imported oil higher than international parity would work to the favour of domestic energy suppliers and to those vested-interest groups whose economic advantage is allied with them.

Third, the State may fix prices for refined oil products at levels lower than international parity, extending an implicit subsidy to all citizens in the economy, insofar as each is an oil consumer, in proportion to their consumption of refined oil products. To the extent that the subsidy is extended proportionally more to lower than to higher income groups, the subsidy is progressive. The financing of the subsidy may take the form of printing money, increased taxation, or selling bonds. Increased taxation would be inconsistent with the original aim of extending a subsidy, while the option of selling bonds /is scarcely

is scarcely viable in the region owing to the underdeveloped state of capital markets. Printing money would generalize the inflationary process over the whole economy (i.e., the pattern of inflation would not be energy-specific), and it would therefore lead to inefficiency in resource allocation on an economy-wide scale, so that it would have a cost in terms of foregone economic growth. The policy of setting oil prices below international parity would work to the disfavour of domestic energy (and affiliated) suppliers to the extent that they suffer a loss in otherwise viable production and profits. Employment in these industries would be similarly prejudiced. This policy would stimulate, not brake, the rate of growth in oil consumption, in contrast with the case of pricing at or above international parity.

Economic considerations favour the first policy option. The economic cost (i.e., the opportunity cost) of consuming refined oil products and other internationally traded fuels in the domestic economy is accurately reported, and for this reason the system is preferable on grounds of economic efficiency. Moreover, to the extent that capital, fuel, and other resources are not applied inefficiently in the economy, they are released for use elsewhere, thus promoting economic growth and employment as well. Finally, the pattern of inflation that this policy would generate would lead producers and consumers to economically efficient patterns of substitution, minimizing inefficiency and lost growth in the economy as a whole.

A second way of restricting the growth of domestic demand for imported oil is to increase the supply of lower-cost indigenous energy substitutes.^{155/} Clearly, many projects to increase the supply of

^{155/} The short-term manoeuvrability of many Latin American countries on this account is quite limited. Of the 26 countries listed in Exhibit 10, only seven produced crude oil, natural gas, coal and hydropower; one produced crude oil and hydropower; eleven produced only hydropower; one produce only crude oil and natural gas; and four countries did not produce any of the four primary energy sources in 1975. By way of comparison, however, non-commercial (i.e., traditional) fuels are consumed throughout the region in relatively significant quantities in each country.

indigenous fuels that were not economically viable prior to 1973 are viable now, both financially and economically. Projects to increase the supply of indigenous energy sources are defensible up to the point where indigenous supply costs (including net externalities) reach international parity. Beyond this point, however, there are no more direct benefits to be captured from differences in the cost of domestic and imported energy supplies. The analysis and forecast of world crude oil prices presented earlier may prove helpful in estimating the economic and financial feasibility of these kinds of energy projects.

Increased production of energy flows from traditional energy sources such as solar and geothermal energy and energy flows from organic wastes (e.g., bio-gas) may offer promising prospects in some countries in the region as substitutes for refined oil products. In general, however, the potential scope of the substitution of traditional fuels for oil is quite limited in the region. This is due, in many cases, to the relatively high and near-term capital requirements per unit of output often characterizing these substitute energy technologies, taken in conjunction with the high cost of the capital available to the region's oil-deficit countries.

One problem in this whole area of action is timing, since it will take several years for many oil-substitute projects to become operational. Economically viable investments in hydropower and nuclear facilities, natural gas transmission and distribution facilities and coal production and marketing projects, even when viable, have long lead-times, and they cannot be expected to provide much in the way of economic relief in the region's oil-deficit countries during much of the coming decade. The major difficulty for Latin America's oil-deficit countries is not in identifying such projects, but in financing them.

Much of the potential substitution of indigenous fuels for imported oil in Latin America is concentrated in the electric power industry. The revision of prices for refined oil products discussed previously has its counterpart need in the upward revision of electricity tariffs towards the now higher level of total costs of power supply. In restructuring the prices of refined oil products and electricity,

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however, it is necessary to bear in mind that this could trigger undesirable inter-fuel substitutions.^{156/} In a strategic sense, the major candidate for increases in electricity tariffs is the household sector, because relatively major economies are possible in this component of the market without too much of a threat to output and employment. This option is particularly attractive in the oil-deficit countries to the extent that their electric power industry is based on oil-fired generating plants and to the extent that the household sector weighs heavily in electric energy consumption.

In addition to encouraging the substitution of indigenous energy sources for oil in the generation of electric power, the increased cost of world oil has made investments in upgrading the efficiency of electric power transmission and distribution systems even more attractive now than in the past. In many Latin American oil-deficit countries, the ratio of system losses to generated power is relatively high (Exhibit 32). Again, however, as in the case of projects oriented towards the increased use of indigenous fuels in generating electric power, the major problem involved in efficiency-upgrading projects is not in identifying them but in finding financing for them.

The option of increasing the supply of lower-cost indigenous crude oil is particularly promising, but the prospects vary widely between the region's oil-deficit countries. Only seven of Latin America's oil-deficit countries produce crude oil. These countries can increase their production and development activities relatively quickly, thus reducing the foreign exchange drain for imported oil in the near future. Given the expected world crude oil prices as presented in Exhibit 58 and Diagram 1, production from existing fields can be accelerated sharply and, despite rising unit costs, still be

^{156/} For example, if the price of household kerosene were increased far more sharply than the price of household electricity, then consumers might shift from kerosene heating to electric heating. If the power industry, in this case, were heavily reliant on fuel oil and diesel-fired plants, this could generate an increase in the demand for imported oil that would be opposed to the original objective of minimizing the foreign exchange cost of imported oil.

economically viable over a broad range of incremental output. The critical choice to be made is between developing more reserves in known fields and then producing from them; launching exploration programmes; or some combination of both. Clearly, whatever the choice, the objective remains clear: minimum energy supply costs. Finally, to the extent that a rapid increase in the production of indigenous crude oil can be combined with strong downward pressure on domestic consumption of refined oil products, it might be possible for some of the region's few oil-deficit, oil producing countries to export oil at its opportunity cost in the world market.

Given the relatively low risk typically characterizing crude oil development vis-à-vis exploration investments, it should be possible for many of these countries to secure foreign capital from private or international banks for partial financing of their crude oil development programmes. A strong case can be made for World Bank and/or IDA financing of oil development projects in these countries, in addition to the traditional support of these institutions for projects in other areas such as electric power. In this regard, the World Bank recently approved its first loan for the development of oil resources.^{157/}

The Latin American oil-deficit countries without a crude oil producing capability face the choice of continuing to rely on imported oil, launching domestic exploration programmes, or, as will be discussed further on, investing in oil projects abroad. The lack of geological knowledge in many of these countries regarding the extent of oil (and other energy) resources, taken together with the long lead-time involved, even when an oil exploration programme is successful, means that these countries probably cannot rely on this source of economic relief in any significant way during most of the eighties.

157/ In 1977, the World Bank approved a 150 million dollar loan to India for facilities to develop and produce up to 140 thousand barrels of oil a day and 2.2 million cubic metres of natural gas. See: World Bank Report 1977, p. 72. Also refer to "New Sources Emerge to Bankroll World Oil Search", Petroleum Intelligence Weekly, Vol. XVI, No 28, 18 July 1977, p. 6.

Nevertheless, for those oil-deficit countries in the region that do have promising prospects for discovering crude oil through domestic exploration programmes, two lines of thought seem worthwhile pursuing. The first of these is to approach the governments of oil-deficit developed countries, or groups of such governments, with an invitation to extend loans to help finance crude oil exploration programmes. Both parties stand to benefit potentially. The oil-deficit developed countries would benefit to the extent that an increased supply of crude oil ultimately puts oil prices under ever greater pressure in the future, quite apart from the interest earned on the loans. The oil-deficit developing countries would benefit to the extent that possibly successful oil exploration programmes could be launched that, for lack of foreign exchange, might otherwise be impossible to undertake. Additionally, the oil-deficit developing countries in the region could push the case with the developed countries for increasing their access to these kinds of loans from international financial institutions in which both participate.

The second possibility is to approach private corporations such as the United States Overseas Private Investment Corporation with this same kind of proposition.^{158/} Again, both parties stand to benefit potentially. The private foreign investor benefits to the extent that exploration investments abroad turn out to be profitable for it, while the host oil-deficit country benefits to the extent that a successful oil exploration programme lowers the supply cost of energy in the domestic economy and conserves scarce foreign exchange into the bargain.

The third way of decreasing the demand for imported oil is to increase efficiency in the energy systems that continue to use it. In addition to electrical generation, transmission, and distribution facilities in the power industry, the major energy systems involved here are the automobile, truck, bus, locomotive, ship, aeroplane,

^{158/} See: "New Sources Emerge to Bankroll World Oil Search", Petroleum Intelligence Weekly, Vol. XVI, No 25, 18 July 1977, p. 6.

/industrial boiler,

industrial boiler, and home heating systems. Laws have been passed in a variety of countries to reduce maximum driving speeds so as to increase the average distance covered per unit of motor gasoline input, and proposals have been made to permit tax deductions for improving home insulation systems. The list could easily be expanded: inspection programmes could be introduced for the purpose of upgrading the thermal efficiency of automobiles, trucks, and buses, etc.; the cruising speed of aircraft and other transport media could be regulated in order to increase the physical efficiency of their energy use; inspection programmes could be introduced designed to increase the physical efficiency of fuel use in industry, and so on.

These kinds of proposals have received far more praise than they deserve. At best, they probably secure little, if any, economically defensible saving of oil beyond what would be secured by the natural reaction of consumers to increased prices for refined oil products in the first place. The incentive to consumers to increase efficiency in the use of a fuel is a function, inter alia, of its price, and it is far simpler for governments to achieve the goal of increased economic efficiency in oil consumption by operating on the price of refined oil products directly rather than by instituting grand programmes aimed at bending consumer behaviour to this purpose. At relatively low prices for motor gasoline and diesel oil, for example, the financial incentive for carrying out engine tune-ups is less than at higher prices. As the price of electricity, kerosene, natural gas and other household fuels increases, the corresponding incentive to economize on their use also increases. The first economic priority is to put the domestic price structure for all energy sources at international parity so that the cost of using fuels is reflected in their price to consumers.

One area for efficiency gains that that does warrant immediate consideration is the possibility for governments to transport a higher proportion of their freight by train than by truck. Capacity conditions permitting, this might generate desirable economies in energy input per unit of freight transported and conserve foreign exchange. Additionally, over longer periods of time, it may be economically defensible in some

/countries to

countries to install electric locomotives and trolley-bus systems, and to gear the expansion of hydropower facilities to the introduction of these energy systems. In this same vein, the increased cost of energy supplies has increased the economic attractiveness of mass vis-à-vis private personal transport. In view of this, there is a clear need for a widespread review of public transportation policy.

Another area of potential efficiency gains is the interconnexion of domestic electric power systems. The higher unit cost of oil makes investments in such interconnexions even more feasible now than in the past. In countries using hydropower (and other indigenous fuels) together with imported oil in generating electric power, such investments would retard the rate of increase in (or lower) unit-energy costs and conserve oil. Even in systems that are wholly reliant on oil-fired generating plants, unit oil requirements could be reduced by concentrating generation in larger-scale and more efficient oil-fired plants. Once again, however, the lead-time involved in such projects may not permit very significant economies in oil consumption for several years forward, and the main difficulty is not identifying such projects but arranging for their financing.

One broad imperative emerges from the preceding discussion: the need to deal with the problem of restructuring the prices of final energy flows to consumers on an integrated basis, not just with respect to the price of refined oil product prices but in the context of the whole price structure of fuels in general. The price of motor gasoline cannot rationally be fixed in isolation from the price of diesel oil, nor can the price of household kerosene be set without reference to the price of gas, fuel oil, and traditional fuels consumed in the household heating market. Similarly, the price of fuel oil cannot be fixed in isolation from the price of natural gas and coal in the industrial boiler market or the price of petrochemical naphthas without reference to the price of natural gas to the petrochemical industry. In all this, however, one very important point must be kept in mind: the international market for refined oil products (and other fuels) gives a clear indication of the opportunity cost of consuming them in
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in the domestic economy. Refined product prices below international parity constitute subsidies to their consumers and encourage their consumption more than their production. Prices higher than international parity constitute an implicit tax on their consumption, depress consumption and stimulate production of indigenous fuels. The case for international parity of domestic oil (and other energy) price is economically clear and compelling. In this context, Exhibit 61 shows the retail prices of selected refined petroleum products in some Latin American countries and the prices (FOB) of these products in the Caribbean in June 1977.

Lastly, a co-ordinated approach is required to the now intensified need for strategic energy planning in the economies of the region's oil-deficit countries, proceeding from an overall strategy of economic development to critical assumptions on the price of world crude oil and refined products over time and, then, to the scale and mix of investments required in the energy sector. This need is evident throughout the oil-deficit countries of the region where the State typically controls energy prices and undertakes the bulk of investments in the energy sector.

(iii) Policies aimed at decreasing the demand for imported crude oil and requiring international co-operation

There are two major areas of action currently open in this area: first, the joint development by Latin American countries of their hydropower reserves; and second, interconnexions of electrical systems across national frontiers.

By substituting domestic hydropower for oil-based supplies of electricity, and by the substitution of lower-cost imports of electricity through interconnexions, the region's oil-deficit countries may be able to retard the rate of increase in the supply cost of electricity and, in the process, conserve foreign exchange as well. Once again, however, these two kinds of projects cannot realistically be expected to provide much of a depressant on the rate of growth in the demand for imported oil in the very near future. The lead time is too long for this, and, especially in the case of multinational projects for the development
/of hydropower

of hydropower reserves, the capital requirements may be prohibitive unless external assistance is provided on semi-concessional or concessional terms. Nevertheless, this does not diminish the importance of evaluating the possible introduction of such projects in the future, and it surely does not negate the viability of these two options in specific cases.

- (iv) Policies aimed at reducing the supply cost of imported crude oil and energy supplies in general and not requiring international co-operation

The two previous categories of policy action had as their immediate objective an economically defensible retardation of the growth rate in the demand for imported oil. By contrast, the policy options considered in this and the following section of this chapter are oriented towards the objective of securing imported oil on a least-cost basis.

Several options not requiring international co-operation are open to the region's oil-deficit countries in attempting to reduce the supply cost of their imported oil: first, the normal playing-off of sellers by buyers in the international oil market; second, the application of excise taxes on refined oil products; and third, measures based on the exercise of greater centralized control by Latin American governments over their domestic oil industries.

The playing-off of sellers by buyers (and not just by Latin American buyers) in the world oil market constitutes one of the major hopes of the oil-deficit countries for securing reductions in the price of their imported oil supplies. Prior to the seventies, this mostly involved pitting the major international oil companies against each other, against the minor international companies and, at that time to a minor extent, against the oil-exporting governments. Since then, however, control over the supply and price of world crude oil has shifted to the oil-exporting countries who, in turn, are becoming more active as direct sellers of their own crude oil and refined products.

As discussed previously, it is expected that the oil-exporting countries will retain this control and become progressively more active

/as direct

as direct sellers of their crude oil, although many of them will also remain closely associated in crude oil production and sales with the international oil companies. Hence, while the success of buyers in the international oil market will, as in the past, continue to reflect their skill in playing-off the oil companies (both major and minor) against one another, it will now reflect progressively more their skill in playing-off the oil-exporting governments against one another and these against the oil companies, so as to secure their imported oil supplies on a least-cost basis.

One major problem facing the region's oil-deficit countries is the practical one of meeting the physical and financial requirements for their continuing oil imports, without foreclosing the possibility of securing reductions in the unit costs of those imports in the future. Involved here is the overall strategic approach toward crude oil imports under long-term purchase contracts.

Commitment to such contracts with the price of internationally traded oil at unprecedentedly high levels would make sense, of course, only if even higher real prices for it were expected. Such contracts would mean significant losses in foreign exchange over time in a market of falling real crude oil prices. The Bayesian forecast of world crude oil prices developed earlier argued that lower prices are more probable than higher prices over the next two decades. This would suggest a general reluctance on the part of the oil-deficit countries to make long-term oil import contracts over the forecast horizon.

The imposition of excise taxes on refined oil products, especially in countries that import oil on a scale which is large by international standards, may induce a downward movement in landed oil import costs, and particularly if these taxes are levied along a broad front by large-scale crude oil importing countries. Sellers of crude oil in the world market may decide to absorb these taxes, thus lowering the acquisition cost of oil to importers. In Latin America, this route is potentially interesting to only the few oil-deficit countries that have absolutely large volumes of oil import contracts to offer to

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sellers. As discussed previously,^{159/} the policy of setting domestic oil prices above international parity has serious economic drawbacks, and the case seems strong for not adopting it in the relatively small oil markets of Latin America.

The third way of trying to secure reductions in the unit cost of imported oil involves two kinds of action: first, the centralization of oil imports in the hands of the State in those oil-deficit countries where this control is not currently centralized, and second, using prices in the arms-length, competitive segment of the international oil market as the referent for fixing the book cost of oil imported by the affiliates of the integrated international oil companies in the oil-deficit countries.

This second point warrants explanation. Where the domestic buyer of imported oil is an affiliate of an international oil company, there is no competition between it and its parent company, and the price of the oil entered on the affiliate's books is a transfer price, not a price in an economic sense. Although the margin per barrel of the international oil companies has been compressed considerably in recent years, the use of transfer pricing will still work against the interests of the oil-importing country when the tax-paid cost to the foreign oil companies of acquiring crude oil abroad falls more rapidly than the transfer price used by the foreign affiliate.

Thus, if the price of oil, as entered in its books by the domestic refining (and/or marketing) affiliate of an international oil company, is higher than the cost of that oil in the arms-length component of the international oil market (plus competitive freight and insurance to the importing refinery), one option open to the government for closing this gap is to legally establish the price prevailing in the competitive component of the world oil market as the reference price for booking the cost of imported crude oil by the domestic affiliate, while at the same time allowing the latter a margin sufficiently above cost to ensure a continued supply of refined oil products to the domestic economy.

^{159/} See Chapter 2 (Section v, (ii)).

This approach would reduce the drain in foreign exchange on oil account and increase the tax contribution of the domestic affiliate to the central government, without impeding the flow of refined oil products.

Where private parties have the ability to import oil directly, centralization of oil imports in the hands of the State might be used to secure a lower unit price for imported oil through the lever of increased purchases by the State. However, this option, like the one discussed just previously, has limited applicability in the region's oil-deficit countries since the bulk of the oil that they import is already being imported by the State energy entity.

(v) Policies aimed at reducing the supply cost of imported crude oil and of energy supplies in general and requiring international co-operation

Four possible lines of action are open under this heading: first, integrating the oil import requirements of oil-deficit countries in the region as a means of increasing the downward pressure on the price of imported oil through the lever of increased sales; second, State participation in oil ventures abroad, either on a sole participant basis or jointly with other oil-deficit countries or country-industry consortia; third, a world crude oil commodity agreement; and fourth, a broad-ranging consumers' cartel.

The option of combining the import requirements of oil-deficit countries is based on the idea that the larger the sales volume being offered to sellers, the greater the pressure on them to reduce the price in order to secure the deal. By increasing competition between sellers, the buyers in such group-purchasing schemes might secure a reduction in the unit cost of their oil imports. There are, of course, technical problems to be solved under such a scheme (e.g., the division of costs and benefits among the participating countries). However, the potential benefits involved do warrant consideration of this option, especially from the point of view of the smaller oil-deficit countries, which are precisely those that cannot now bring the volume of their purchases to bear on price.

The second way of possibly reducing the cost of imported oil supplies for the region's oil-deficit countries is to enter into crude oil ventures abroad.^{160/} Consortia of Latin America and other oil-deficit countries and/or foreign industrial companies (e.g., steel, petrochemicals and electric utilities) might be organized for this purpose, thus overcoming the negative effect, in some of the region's oil-deficit countries, of the lack of knowledge about their indigenous oil resources, as well as the restrictions imposed by the large-scale capital requirements for such ventures if undertaken alone. The governments of oil-exporting countries will probably not be offering their oil for development work by foreign newcomers on any significant scale (or on knock-down terms) for two reasons, however: first, many of them are under pressure to restrict production, not increase it, in support of the current structure of official State selling prices; and second, development work is a relatively low risk undertaking which these countries can finance either independently or together with banks and the integrated oil companies, the latter offering them the important advantage of serving as a competitive buffer for them in the world oil market.

Finally, it is highly unlikely that investments made today in oil exploration ventures abroad (even if accepted by host governments) will yield substantial relief to the oil-deficit countries for many years to come. On the other hand, it does seem likely that the region's oil-deficit countries have before them now a variety of alternative investment projects (e.g., efficiency upgrading in the electric power industry) that are at least as competitive, after considering the economic uncertainty, as investments in overseas oil exploration projects.

Crude oil has never been covered by a formal international commodity agreement, but it would be worth exploring the possibilities

^{160/} Brazil, for example, has launched oil ventures in Colombia, Egypt, Iran and Iraq, and in Norway's portion of the North Sea.

for such an approach under the auspices of an international forum such as the United Nations. The primary obstacle to reaching such an agreement is in specifying an acceptable price for world crude oil. The oil-deficit countries would benefit if this price were lower than the price that they otherwise expected to pay, whereas the oil-exporting countries would stand to benefit if the price of world crude oil under such an agreement were higher than they would otherwise expect to receive, which, in the present context, would mean an assumption on their part of a downward trend in crude oil prices. Moreover, a retardation in the rate of inflation in the developed countries, induced by a reduction in the price of world oil, would give an important advantage to the oil-exporting countries with sizeable financial holdings in these countries. However, if the oil-exporting countries rejected the assumption of declining oil prices in favour of continuing high prices, their incentive to consider the possibility of a world crude oil commodity agreement would be significantly weakened.

Downward pressure on the price of crude oil could also be exerted by concentrated purchases of oil through an international consumer cartel. Latin America's oil-deficit countries would not have to participate in such a cartel to secure the benefit of the reduced prices that it might generate. Indeed, it is unlikely that an effective consumer cartel would include the many small oil-importing countries in the region, due to the administrative complexity that this would generate. What would be required would be a cartel whose member countries as a group accounted for a relatively large share of world oil imports. This would enable the cartel to use the leverage of large volume purchases to secure reductions in price. There is no evidence, however, of serious interest among the major oil-importing countries in setting up a formally constituted cartel of this kind, for a number of very powerful reasons.^{161/}

^{161/} See the discussion of this topic in Section III and Section IV (iv).

(vi) Security of imported oil supplies

A concluding remark is in order on the problem of the security of imported crude oil supplies. This concept is rarely clarified by its users. It is generally employed in reference to the widespread desire by oil-deficit governments for continuously assured access to the requisite volumes of imported oil, implicitly under any and all circumstances. Such a desire is as widespread as it is chimerical.

The briefest reflection will suggest that oil-importing countries can never achieve security in this absolute sense. If they have crude oil producing ventures abroad, which is one conventional approach to the problem of security, difficulties with host producer countries can endanger them; the post-war history of the international oil industry is full of examples of this. Long-term crude oil contracts for their part, may be broken under the pressure of boycotts by oil-exporting countries. In such a situation, international buyers in general face the prospect of sharp increases in oil prices, such as occurred in later 1973: if a buyer pays the new price, he may have some modicum of security, but if he cannot or will not pay it, then he will have no security at all.

Domestic stockpiles of crude oil do provide real physical security, but only for relatively short periods, which, of course, is their objective. However, even in the case of this potentially viable immediate solution to the security problem, its economic evaluation requires an explicit assumption as regards expected crude oil prices (and storage and other costs). The price and security of imported oil are conceptually related, and very intimately so.

If security is viewed in terms of the ability to satisfy all future oil consumption from domestic reserves of crude oil conceived by some as the absolute in security, this concept needs to be defended empirically. Whether or not this approach makes sense economically turns on a comparison of the expected present value of the savings over time associated with this strategy, on the one hand, with the present value of the costs of its adoption, on the other. For the few oil-deficit countries in the region which are in a position to consider

/this option

this option of self-sufficiency in oil supplies, the cost of following it will essentially be the present value of the excess cost of supplying indigenous over imported oil. Benefits include the avoidance of paying panic prices for oil in times of crisis and the fact that production in the economy can continue during times when oil flows might otherwise be physically interrupted.

Only a few of Latin America's oil deficit countries can even think at present in terms of self-sufficiency in crude oil supplies in this sense over the next several decades, however. The question that most of the region's oil-deficit countries presently face is whether it makes sense now to invest in an oil-stockpile programme. Again, the imperative need for economic evaluation is clear, since it is first of all necessary to predict the probability, timing and duration of the expected partial or total physical interruptions in imported oil supplies. Benefits include the avoidance of paying panic prices when oil supply lines are not ruptured and of avoiding lost production in the economy when they are ruptured. Costs include the oil purchased for stockpiling and all associated expenses for delivering it to stockpile, maintaining it there, and then withdrawing it for use in the future. The application of standard discounting and probability techniques will reveal the extent to which the expected present value of benefits of oil storage exceeds the comparably calculated costs of the oil storage programme, on the basis of a discount rate properly selected to take account of the scarcity of capital in the economy and the economic risk and uncertainty involved.

Another approach is to find the time rate of discount that equates the present value of expected economic benefits to the expected economic costs of the oil storage programme and then to compare this internal rate of return on the oil storage project, after adjusting for economic risk and uncertainty, with the estimated social opportunity cost of capital in the economy. If the former is lower than the latter, then capital locked up in the oil storage programme would be better applied elsewhere in the economy. A reverse pattern would suggest that the oil storage programme is economically competitive with other projects in the economy.

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Obviously, depending on the specific assumptions underlying the analysis, an oil-deficit country may choose to run its risks in the world oil market without stockpiling. The prospectively low probability of a physical rupture in the oil import lines of Latin America's oil-deficit countries would argue strongly in favour of this option. The typically high social opportunity cost of capital in Latin America's oil-deficit countries and the large amounts of capital locked up in oil inventory would also weigh heavily against storage programmes in the region. The expected value of whatever production is foregone in the economy as a result of expected oil stoppages obviously would weigh in favour of stockpiling. A conclusion about the economic viability of an oil-storage programme cannot be reached on a priori grounds, however. Investment analysis is required, and this can be done only after all assumptions and expectations have been clearly specified in quantifiable terms.

Section VI: Summary

There have been four distinct periods of price formation in the international crude oil industry in the post-war era, but in none of these periods has the market price of world crude oil been explainable in terms of the increasing pressure of the rising demand for world crude oil on its long-run incremental supply cost. Two variables have played the key roles in explaining world crude oil prices in the post-war era: first, the structure of the world oil industry, and second, the structure of energy policies in the developed countries.

Over the rest of this century, it is expected that this pattern of causation will endure. The pressure of increasing demand for world oil on its long-run incremental supply cost will not require higher prices over the rest of this century. Quite the contrary. Prices could fall substantially over the next quarter-century without endangering the physical supply of crude oil produced for the world market. Taking the level of long-run economic cost of supplying crude oil for the world market as the indicator of its scarcity, it is concluded that the dire

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predictions about the world running out of crude oil in two or three decades are simply rhetoric.

On the other hand, a forecast of world crude oil prices must focus squarely on the continuing importance of structural changes in the world oil industry, on the one hand, and in the energy policies of the developed oil-importing countries on the other. The analysis presented here of these two key variables, from the point of view of price formation, leads to the conclusion that the price of world crude oil in constant dollars will, most probably, remain at its present level through the end of the eighties and then decline, on average, by two per cent annually during the nineties, falling to 8.82 dollars (of 1975) in the year 2000. This price is substantially above the long-run incremental cost of crude oil in 2000. It is also significantly above the minimum safeguard price adopted by the International Energy Agency and the European Commission in 1976. Additionally, this price is far below the estimated minimum economic supply cost of synthetic oil from both coal and shale oil in the year 2000. Finally, during both the eighties and the nineties, the chances that actual prices for world oil will be higher than these 'most likely' prices in 1990 and 2000 are viewed as being relatively small: actual prices will probably be lower, not higher, than these prices.

The expected track of most likely prices for world crude oil (1978-2000) does mean, however, that Latin America's oil-deficit countries will continue to suffer substantially on balance of payments account, with a consequent drag on economic growth and social advancement. It is argued that the objectives of energy policy in these countries should be to minimize the overall costs of energy supply, on the one hand, and to forge an economically rational set of energy prices and investment policies, on the other. To the extent that these objectives are pursued successfully, the economic and social damage to these countries stemming from the expected price of world oil will be minimized.

A broad range of policy options are open to Latin America's oil-deficit countries, in general, to achieve these two policy objectives.

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Analytically, these options fall into the classes of demand-oriented and supply-oriented policies. Many of them require international co-operation, but some do not. Most of the oil-deficit countries in the region have little in the way of short-term manoeuvrability, simply because they lack diversified energy bases: in 1975, only six of them produced each of the four modern fuels; eleven produced only hydropower; and three were totally reliant on imported oil for their modern energy supplies (Exhibit 10b). Tactical manoeuvrability aside, the first priority in all the oil-deficit countries of the region is to establish prices for both domestically produced and imported energy supplies that reflect the opportunity cost of their consumption, using the price of internationally traded oil and other energy sources as the referent for this purpose.

