ENERGY AND DEVELOPMENT: FOSSIL FUELS IN DEVELOPING COUNTRIES

NAZLI CHOUCRI
Professor of Political Science
Associate Director, Technology Adaptation Program
Massachusetts Institute of Technology
Cambridge, U.S.A.

1. Introduction

The developing states are a very diverse group — with great variation in population size, level of economic activity, resource endowments, and energy profile. Despite their differences, every developing state has a modern sector that relies on commercial fuels. In contrast to industrial societies, however, traditional sources of energy are also used extensively. This paper focuses on one major source of energy — fossil fuels — and highlights some critical policy issues. Developing countries are confronted with a crowded policy agenda, which makes a focus on energy difficult, yet critical.

Energy use everywhere is tied to population growth, industrialization, expansion of urban centers, and development of industrial and infrastructural facilities. For developing countries the most immediate consequences of oil price changes in the decade of the 1970s have commonly been seen in terms of the import bill and attendant needs for borrowing from international institutions or commercial markets. Adjustments of economic targets were set in place, as were a reassessment of priorities, involving reappraisal of investment strategies and infrastructure development. The potential for expanding alternative energy sources and exploiting indigenous resources in both conventional and nonconventional forms is now being examined, as are new responses to the constraints imposed by the world oil market of the early 1980s.

Changes in energy prices and availability have strongly affected

public policy in developing countries. The energy situation has influenced economic performance and provided new constraints for government policy. Now developing countries must take into account the energy dimension of any major investment or public policy. Yet in those societies, as in industrial states, nothing of substance can be done without explicit recognition of the limits of social, political, and economic parameters. In countries where development planning has become a tradition, the use of government machinery for public sector enterprises constitutes an essential corollary of planning programs.

The impact of changes in oil prices on the balance of payments of developing countries is well documented and, together with statistical estimates of impacts on growth, provides the picture we have of these countries' energy problems. Beyond that, however, many of the insights on energy and development come from existing analyses of industrial economies with the implicit expectation that the developing states may follow a well known path of industrialization.

Clearly, changes in prices or availability of energy already have had distinctive macroeconomic effects for all countries, developed as well as developing. This is especially true for countries that are high users of petroleum and do not have readily available substitutes, or cannot easily make adjustments in demand in response to change in prices or quantities. The process of development itself is deeply affected by energy inputs.

Between 1974 and 1978, combined economic shocks upon the developing world (in terms of oil prices, inflation, reduced growth, loss of export market) were varied in their impacts. On the average, the oil importing developing state lost about 2 percent of their GDP. The rapidly industrializing group, also oil importers (Brazil, Hong Kong, South Korea, Philippines, and Turkey) lost 1.8 percent of GDP. The large South Asian oil importing countries lost about 2 percent, and the poorest of the developing countries witnessed a 1.5 percent loss in GDP.([1]) These figures must be viewed in the dual context of productivity foregone as well as population growth.

The full effects of the energy parameters on policy planning in developing countries are not yet known. There is little specific information on the impact of energy on sectoral performance. Even less information is available about long-term effects of policies designed to

([1]) Economist Intelligence Unit, Nr. 125, *Oil Imports of Developing Countries* (London: Economist Intelligence Unit, 1982), pp. 23-24.

alleviate immediate strains, or impacts of longer-term policies designed to reorient development strategies.

In its most fundamental guise development in itself entails four distinct but inter-related processes that lead to improvements in human conditions. These are: (1) economic growth, in terms of greater productivity and increasing overall national output; (2) structural change, in terms of transformations in employment patterns, distribution of economic activity, rates of urbanization, and overall industrialization; (3) social equity and welfare, in terms of the allocation of resources and attention to social services, education, health, and other aspects of social well-being; and (4) institutional development, in terms of the establishment of government agencies to allocate and manage resources for development.([2]) These processes reflect the complexity and comprehensive nature of development. Energy variables play an important role in each of these four dimensions of development, although it is clear that we still need to determine precisely *how* and *how much.*

One common underlying objective for most developing countries is to exercise national autonomy in decision-making: the ability to make decisions in areas of national policy without outside interference. This concern generally means exercising greater self-reliance and autonomy in making decisions of national importance. Thus, in all developing countries, the search for national autonomy has emerged as a driving force in public policy debates. This drive is also becoming evident in the energy sector. While the search for autonomy has guided both the nature and the content of development planning, for many states effective autonomy is not possible in any sphere of activity, and least of all in energy. This reality thus necessitates international cooperation and collaboration.

The following section highlights the great variation among countries at different levels of industrialization, not only in population, size, and economic activity, but especially in terms of energy dependency. The countries we consider include the semi-industrialized states (such as Brazil, Korea, Taiwan), the industrializing states (such as Mexico, Egypt, Tunisia, Portugal, and Turkey), as well as the least developed (Sudan, Zaire, and others).

([2]) Nazli Choucri, *Energy and Development in Latin America: Perspectives for Public Policy* (Lexington, Mass.: D.C. Heath/Lexington Books, 1982).

2. Diversity in Development

2.1 *Population*

While it is customary to consider industrializing countries as one homogeneous group, the fact remains that there is an enormous diversity among them. This diversity makes simple generalizations particularly misleading. On demographic grounds alone, the variation is impressive. Four countries have populations of 100 million or more, while over 50 countries register populations of under 20 million (see Table 2-1).

2.2 *Economic Activity*

On a per capita GNP basis, the distribution is less skewed and the four population giants lose some of their prominence. Over 20 countries are in the high income group, with $1000 per capita or more. The low income group of $ 500 or less per head is somewhat smaller in size (see Table 2-2). Many of the highest income states are also among those growing at the fastest rates, of 7 percent a year or more (see Table 2-3). Then there are over 10 countries that claim an industrial component of 40 percent share of total GNP. The majority of the states are in the « medium » range, with an industrial sector of 25-40 percent of GDP (see Table 2-4).

2.3 *External Debt*

The foreign debt issue is perhaps one of the most critical problems facing the developing world. Even then, however, despite massive financial claims of the external environment, close to 30 countries have « low » debts of 20 percent or less relative to GDP. Conversely, however, there are 12 extremely critical cases whose GDP is almost entirely mortgaged to external creditors. The difficulty, of course, is that such comparisons hide the idiosyncrasies of individual cases: the massive debt of several Latin American countries pales relative to the size of the GDP, while much smaller debts of other states loom large relative to total economic output (see Table 2-5).

2.4 *Energy Dependency*

We turn to one central aspect of their energy profile: the dependency issue. (Other aspects are examined in subsequent sections of this

TABLE 2-1 - *Variation in Population Size.*

High *(100 million or more)*	High Medium *(50-100 million)*	Low Medium *(20-50 million)*	Low *(under 20 million)*
Brazil	Bangladesh	Argentina	Algeria
China	Mexico	Colombia	Angola
India	Nigeria	Egypt	Benin
Indonesia	Pakistan	Ethiopia	Bolivia
		Korea	Burundi
		Morocco	Cameroon
		Philippines	Chile
		Thailand	Congo
		Turkey	Costa Rica
		Yugoslavia	Dominican Republic
		Zaire	Ecuador
			El Salvador
			Gabon
			Ghana
			Greece
			Guatemala
			Haiti
			Honduras
			Hong Kong
			Iraq
			Ivory Coast
			Jamaica
			Kenya
			Malawi
			Malaysia
			Mozambique
			Nepal
			Nicaragua
			Niger
			Panama
			Papua New Guinea
			Paraguay
			Peru
			Portugal
			Rwanda
			Senegal
			Sierra Leone
			Singapore
			Somalia
			Sri Lanka
			Sudan
			Tanzania
			Trinidad and Tobago
			Tunisia
			Uganda
			Uruguay
			Venezuela
			Zambia
			Zimbabwe

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

TABLE 2-2 - *Variation in Per Capita GNP.*

High (*$1000 per capita or more*)	Medium (*$500-$1000 per capita*)	Low (*$500 per capita or less*)
Algeria	Bolivia	Bangladesh
Argentina	Cameroon	Benin
Brazil	Congo	Burundi
Chile	Egypt	China
Colombia	El Salvador	Ethiopia
Costa Rica	Honduras	Ghana
Dominican Republic	Mozambique	Haiti
Ecuador	Nicaragua	India
Gabon	Nigeria	Indonesia
Greece	Papua New Guinea	Kenya
Guatemala	Philippines	Malawi
Hong Kong	Thailand	Nepal
Ivory Coast	Zambia	Niger
Jamaica	Zimbabwe	Pakistan
Korea		Rwanda
Malaysia		Senegal
Mexico		Sierra Leone
Panama		Somalia
Paraguay		Sri Lanka
Peru		Sudan
Portugal		Tanzania
Singapore		Uganda
Trinidad		Zaire
Tunisia		
Turkey		
Uruguay		
Venezuela		
Yugoslavia		

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

TABLE 2-3 - *Variation in GNP Growth Rates.*

High *(7 percent or more)*	Medium *(4.0-7.0 percent)*	Low *(4.0 percent or less)*
Algeria	Bolivia	Argentina
Brazil	Cameroon	Bangladesh
Ecuador	China	Benin
Egypt	Colombia	Burundi
Hong Kong	Congo	Chile
Indonesia	Costa Rica	Ethiopia
Iran	Dominican Republic	Ghana
Iraq	El Salvador	Haiti
Korea	Gabon	India
Malaysia	Greece	Jamaica
Paraguay	Guatemala	Mozambique
Singapore	Honduras	Nepal
Thailand	Ivory Coast	Nicaragua
Tunisia	Kenya	Niger
	Malawi	Papua New Guinea
	Mexico	Peru
	Morocco	Senegal
	Nigeria	Sierra Leone
	Pakistan	Somalia
	Panama	Uganda
	Philippines	Uruguay
	Portugal	Zaire
	Rwanda	Zambia
	Sri Lanka	Zimbabwe
	Sudan	
	Tanzania	
	Trinidad and Tobago	
	Turkey	
	Venezuela	
	Yugoslavia	

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

TABLE 2-4 - *Variation in Levels of Industrialization.*

High *(40 percent of GDP or more)*	Medium *(25-40 percent of GDP)*	Low *(25 percent or less of GDP)*
Algeria	Argentina	Bangladesh
China	Bolivia	Benin
Congo	Brazil	Burundi
Gabon	Chile	Cameroon
Indonesia	Colombia	El Salvador
Iran	Costa Rica	Ethiopia
Iraq	Dominican Republic	Ghana
Korea	Ecuador	Ivory Coast
Nigeria	Egypt	India
Peru	Greece	Kenya
Portugal	Honduras	Malawi
Trinidad and Tobago	Hong Kong	Mozambique
Venezuela	India	Nepal
Yugoslavia	Jamaica	Rwanda
	Malaysia	Sierra Leone
	Mexico	Somalia
	Morocco	Sudan
	Nicaragua	Tanzania
	Niger	Uganda
	Pakistan	
	Papua New Guinea	
	Paraguay	
	Philippines	
	Senegal	
	Singapore	
	Sri Lanka	
	Thailand	
	Tanzania	
	Tunisia	
	Turkey	
	Uruguay	
	Zaire	
	Zambia	
	Zimbabwe	

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

TABLE 2-5 - *External Public Debt 1981.*

Low *(20 percent of GNP or less)*	Medium *(20-50 percent of GNP)*	High *(50-100 percent of GNP)*
Argentina	Algeria	Benin
Brazil	Bangladesh	Congo
Chile	Bolivia	Costa Rica
Colombia	Cameroon	Ivory Coast
Dominican Republic	Ecuador	Jamaica
El Salvador	Egypt	Morocco
Ethiopia	Haiti	Nicaragua
Ghana	Honduras	Panama
Greece	Kenya	Somalia
Guatemala	Korea	Sudan
Hong Kong	Malawi	Zaire
India	Niger	Zambia
Indonesia	Pakistan	
Malaysia	Papua New Guinea	
Mexico	Peru	
Nepal	Portugal	
Nigeria	Senegal	
Paraguay	Sierra Leone	
Philippines	Sri Lanka	
Rwanda	Tanzania	
Singapore	Tunisia	
Thailand	Turkey	
Trinidad and Tobago		
Uganda		
Uruguay		
Venezuela		
Yugoslavia		
Zimbabwe		

Source: *World Development Report 1983* (Oxford University Press for the World Bank, 1983).

paper). Table 2-6 ranks the developing states in terms of « self-sufficiency », domestic production in relation to total consumption of commercial energy. Here the variation among them is extensive and their respective policy agendas are shaped accordingly.

Excluding the oil-rich countries with low populations — Saudi Arabia, Kuwait, the United Arab Emirates, and Libya — there are 19 developing countries that are *self-sufficient* in commercial energy, and of these only seven are OPEC members.

Among the notable self-sufficient exporters are Mexico and Egypt, two countries whose energy profile combined with their demographic and economic profiles highlights the "typical" problems of this group: (1) expanding domestic consumption due to industrialization, and government policies subsidizing domestic energy prices; (2) a robust petroleum and natural gas industry whose performance depends on the world oil market; and (3) a national oil company regulating this sector. In the case of Egypt investments in exploration and development are governed by production sharing agreements with foreign oil companies. For Mexico, the government and the public sector enterprises make the investments.

These two states highlight the dilemmas and opportunities for fossil fuel management in developing states. Domestic pricing policies are needed to rationalize consumption; and substantial investments are needed to expand production capacity in the expectation that international market conditions might change and then require greater production from these two states (if existing capacity permits). Finally, both countries illustrate the potential perils of extensive reliance on a petroleum export market.

The five *nearly self-sufficient* states, in Table 2-6, are very diverse. India, Argentina, and Colombia share an economic and energy profile that is highly "advanced" relative to Zaire and Zimbabwe, with considerably greater scope for energy diversification.

The *less dependent* group includes states as varied as Brazil, which has made notable experiments in alcohol fuel, and Turkey, whose geology precludes ready expansion of a petroleum sector.

The *dependent states* all share the typical problems of developing countries. Of the 33 countries in Table 2-6 only five (Portugal, Singapore, Hong Kong, Greece, and Korea) stand out as semi-industrial and relatively unburdened economically by their highly energy-dependent profile.

This diversity in energy profile obscures the fact that in *all* the developing countries (from the least to the most industrialized) consump-

TABLE 2-6 - *Self-Sufficiency Ratios of Total Commercial Energy (Production as Percentage of Consumption).*

Self-Sufficient (Exporters)		*Nearly Self-Sufficient*		*Less Dependent*		*Dependent*	
Iraq	1210	Zaire	98	Pakistan	68	Nepal	35
Nigeria	1059	Colombia	90	Zambia	68	Honduras	33
Congo	630	Zimbabwe	87	Yugoslavia	64	Malawi	32
Gabon	601	Argentina	86	Chile	63	Burundi	31
Angola	588	India	79	Ghana	59	Uganda	31
Algeria	575			Rwanda	48	El Salvador	31
Venezuela	391			Turkey	48	Ivory Coast	25
Cameroon	351			Brazil	48	Greece	24
Indonesia	350			Bangladesh	44	Korea	24
Ecuador	277			Costa Rica	42	Tanzania	23
Iran	250			Mozambique	41	Uruguay	22
Trinidad and Tobago	266			Paraguay	41	Portugal	22
Tunisia	215					Morocco	21
Egypt	196					Ethiopia	20
Bolivia	195					Haiti	20
Malaysia	181					Sri Lanka	18
Mexico	162					Philippines	17
Peru	133					Nicaragua	16
China	105					Papua New Guinea	14
						Benin	13
						Sudan	12
						Panama	10
						Niger	10
						Kenya	10
						Guatemala	10
						Thailand	6
						Dominican Republic	—
						Jamaica	—
						Hong Kong	—
						Senegal	—
						Sierra Leone	—
						Singapore	—
						Somalia	—

Total for all 69 countries: 125 percent.

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

tion of commercial energy has been growing rapidly. The demand for liquid fuels takes the lead, and pressure on petroleum uses are particularly acute. In Egypt, for example, domestic consumption has been growing at 10 percent per year over the past decade. Thus, the demand side of the equation bears scrutiny, as does supply expansion potential. On both sides of the energy equation there is extensive scope for adjustment and change. It bears stressing that in the ten years since the initial oil price increases of 1973, there have been tremendous changes in both demand and supply.

2.5 *The Energy Imperative*

The pattern of industrialization in the West has provided the model for anticipated growth in the industrializing world. The near perfect positive correlation between energy consumption and GDP, so famous for industrial countries, appears to be replicated for the developing world as well. Figure 2-1 shows the relationship between energy use and GDP (on a per capita basis). The countries indicated in this figure are a subsample of the tables discussed so far. Even then, we see the strong connections between energy and GDP.

The relationship between energy consumption and industry as a share of GDP is shown in Figure 2-2. There the connection is also apparent, but with less strength in patterns than in Figure 2-1.

Finally, we turn to the population factor, the relationship between population size and energy consumption. The near-linear scatter in Figure 2-3 shows the role of numbers in shaping the demand for energy. The level of total economic output is, however, a more important factor.

These three figures illustrate the basic dilemma inherent in growth: industrialization plus added population invariably results in greater energy consumption. This conclusion summarizes the past and the present. It does not necessarily define the future. Energy management is becoming imperative everywhere, and in conjunction with technological change, provides the basis for future patterns of energy consumption and of growth.

The following section of this paper looks at the demand side, with particular emphasis on macroeconomic effects of changing domestic energy prices.

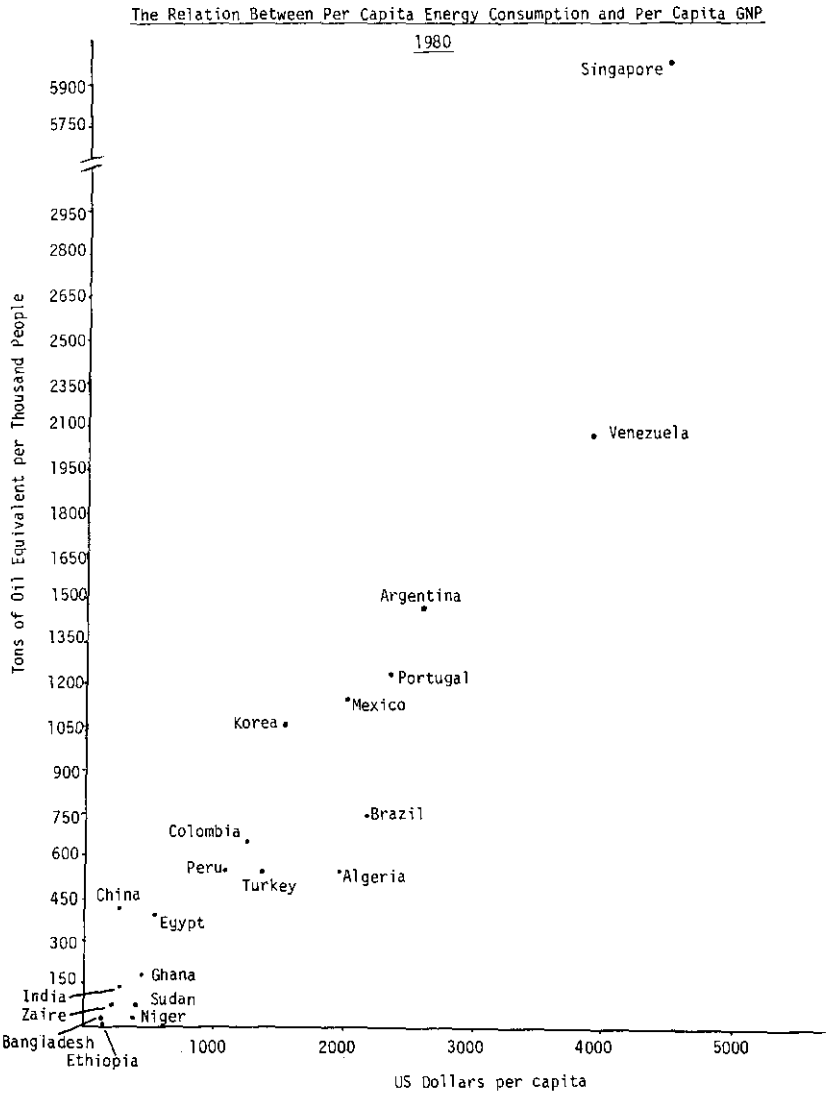
The Relation Between Per Capita Energy Consumption and Per Capita GNP
1980
Tons of Oil Equivalent per Thousand People
US Dollars per capita
Singapore
Venezuela
Argentina
Portugal
Mexico
Korea
Brazil
Colombia
Peru
Turkey
Algeria
China
Egypt
Ghana
India
Sudan
Zaire
Niger
Bangladesh
Ethiopia
5900
5750
2950
2800
2650
2500
2350
2100
1950
1800
1650
1500
1350
1200
1050
900
750
600
450
300
150
1000
2000
3000
4000
5000

FIG. 2-1

The Relation Between Energy Consumption and Industry as a Percentage of GDP
1980

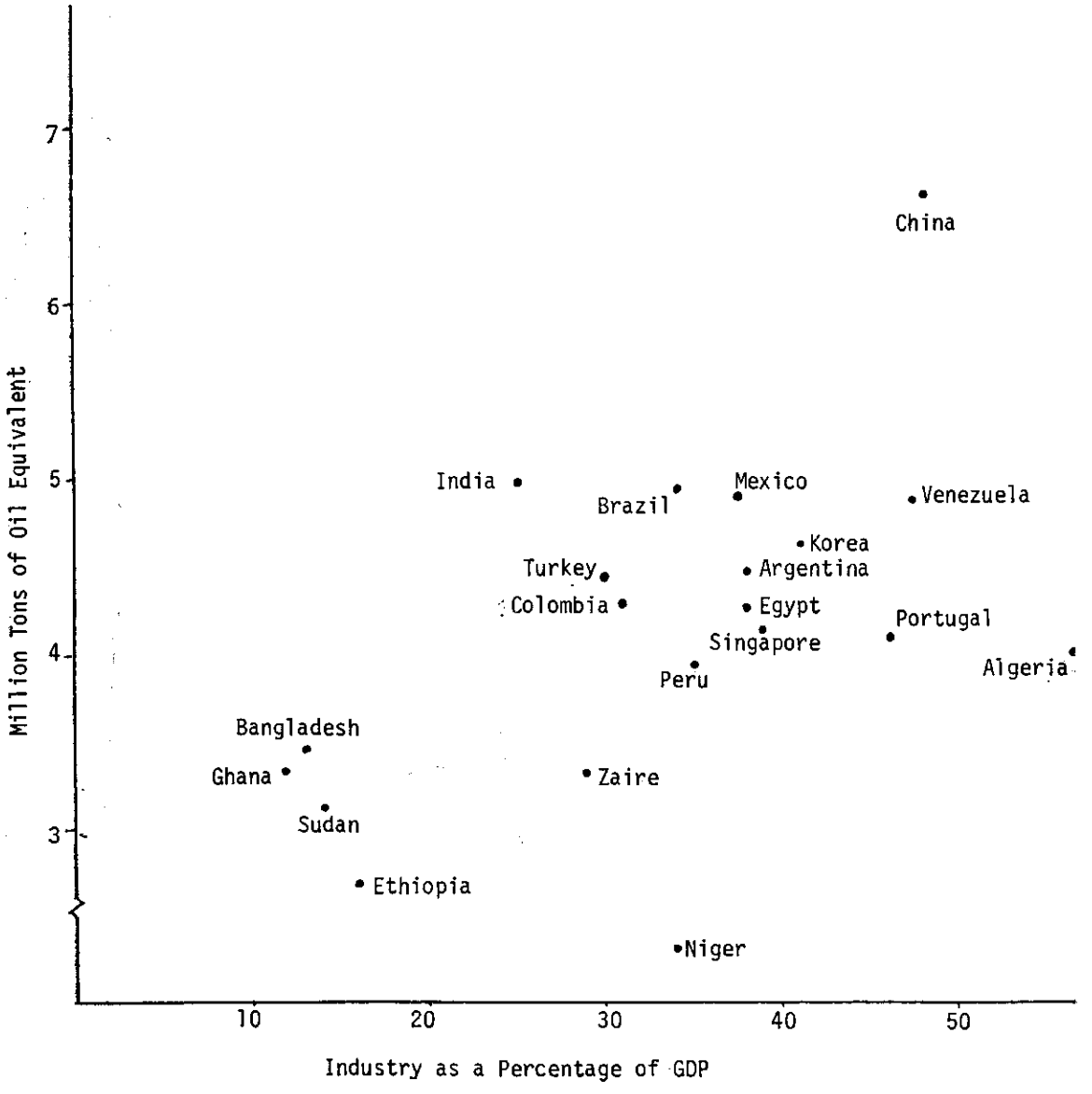

FIG. 2-2

The Relation Between Population and Energy Consumption
1980

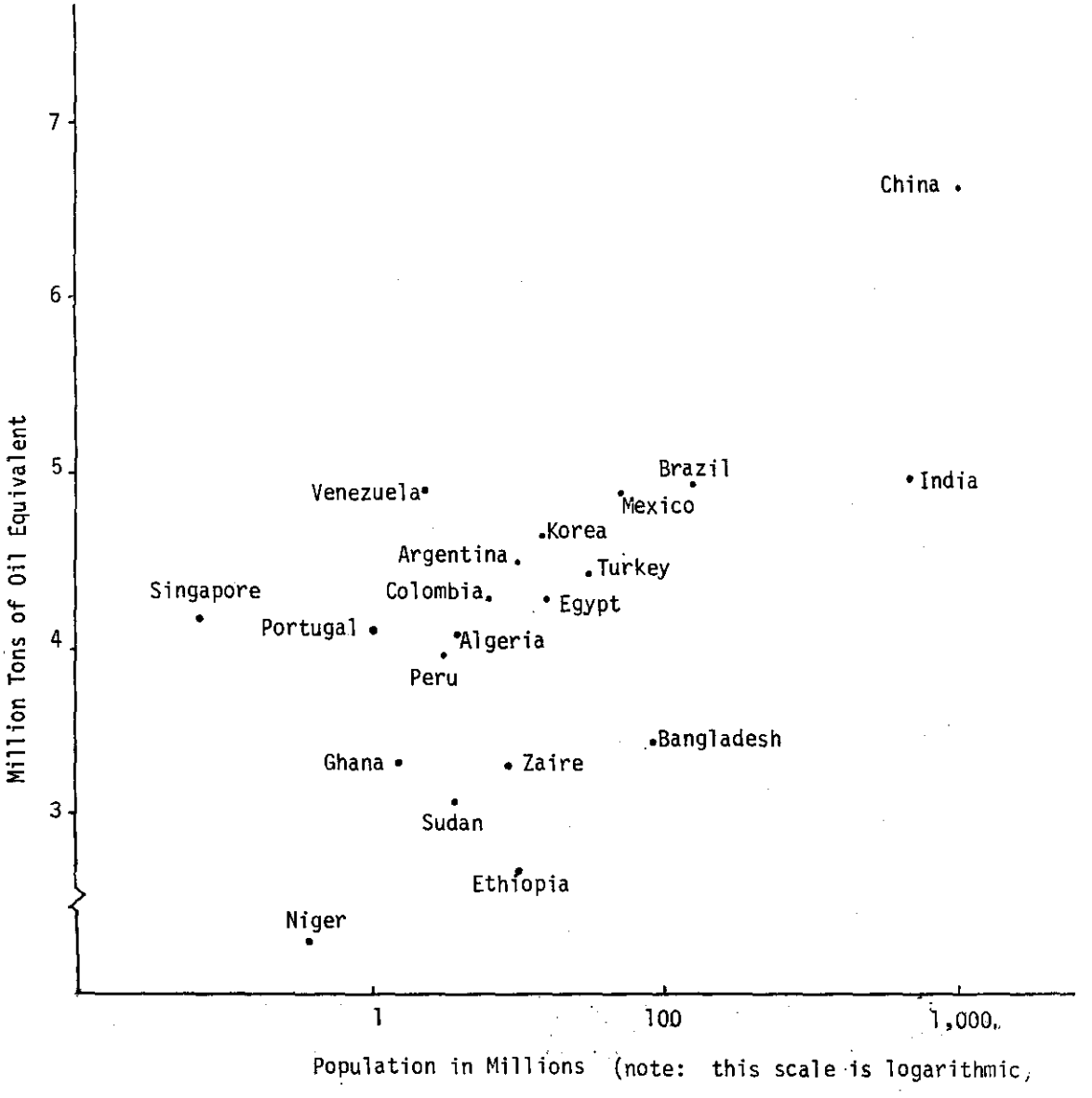

FIG. 2-3

3. The Demand Side

The consumption of commercial energy in developing countries has grown rapidly, at an average rate of 7.9 percent per annum from 1955 to 1978, compared to 3.8 percent for the industrial states. Oil in many cases accounts for 80 percent of total commercial energy consumption.([3]) The World Bank estimates that the growth in commercial energy demand will be 4.5 percent from 1980 to 1995, with the percentage share of oil dropping from 47 to 36 percent.([4]) Table 3-1 shows the energy consumption per 1000 population for the developing states, grouped on this basis by high, medium, and low consumption.

The per capita energy consumption obscures another dimension of demand, namely energy use in terms of oil equivalent per million US dollars of GDP. This indicator shows the energy intensity of economic activity, with high users consuming 500 tons of oil equivalents for every million US dollars of GDP. Only 14 countries demonstrate low energy intensity, in contrast to the 26 countries that demonstrate low per capita energy use. See Table 3-2.

3.1 *The Giants*

Again, aggregate figures simply distort the picture: these figures are shaped by four countries. China alone accounts for 30 percent of total commercial energy demand for developing states and 60 percent of their coal demand; Brazil, Mexico, India account for an additional 20 percent. A total of 12 countries consume more than two-thirds of all commercial energy in developing countries. Thus, if we exclude the largely coal-based consumption patterns of China and India, oil accounts for 61 percent of all commercial energy consumption of developing countries in 1980. The World Bank estimates a decline in oil utilization to 44 percent of all commercial use by 1995.

For oil-importing developing countries, 25 percent of the increase in commercial energy demand is expected to be met by an increase in oil consumption in the period 1980-1995. Net oil imports are expected to decline from 44 percent of total commercial energy consumption to 28

([3]) Joy Dundereley et al., *Energies Strategies for Developing Nations* (Washington, D.C.: Resources for the Future 1980), p. 9.

([4]) World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), p. 5.

TABLE 3-1 - *Energy Consumption (tons of oil equivalent per 1,000 people).*

High *(500 toe or More)*	Medium *(200-500 toe)*	Low *(200 toe or Less)*
Algeria	Bolivia	Angola
Argentina	China	Bangladesh
Brazil	Congo, P.R.	Benin
Chile	Dominican Rep.	Burundi
Colombia	Ecuador	Cameroon
Costa Rica	Egypt	Ethiopia
Gabon	El Salvador	Ghana
Greece	Guatemala	Haiti
Hong Kong	Honduras	India
Iran	Morocco	Indonesia
Iraq	Nicaragua	Ivory Coast
Jamaica	Papua New G.	Kenya
Korea	Paraguay	Malawi
Malaysia	Philippines	Mozambique
Mexico	Senegal	Nepal
Panama	Thailand	Niger
Peru		Nigeria
Portugal		Pakistan
Singapore		Rwanda
Trinidad and Tobago		Sierra Leone
Turkey		Somalia
Uruguay		Sri Lanka
Venezuela		Sudan
Yugoslavia		Tanzania
Zambia		Uganda
Zimbabwe		Zaire

Source: Based on World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

TABLE 3-2 - *Energy Consumption (tons of oil equivalent per million US dollars of GDP).*

High *(500 toe or more)*	Medium *(200-500 toe)*	Low *(200 toe or Less)*
Colombia	Algeria	Benin
Egypt	Argentina	Burundi
Indonesia	Bangladesh	Cameroon
Korea	Bolivia	Ethiopia
Pakistan	Brazil	Ghana
Panama	Chile	Guatemala
Portugal	Congo, P.R.	Ivory Coast
Senegal	Costa Rica	Malawi
Singapore	Dominican Rep.	Nepal
Sri Lanka	Ecuador	Niger
Trinidad and Tobago	El Salvador	Nigeria
Venezuela	Gabon	Paraguay
Yugoslavia	Greece	Rwanda
Zambia	Haiti	Sudan
Zimbabwe	Honduras	Tanzania
	Hong Kong	
	Indonesia	
	Iraq	
	Kenya	
	Malaysia	
	Mexico	
	Morocco	
	Mozambique	
	Nicaragua	
	Papua New G.	
	Peru	
	Philippines	
	Sierra Leone	
	Somalia	
	Thailand	
	Tunisia	
	Turkey	
	Uruguay	
	Zaire	

Source: Based on World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

percent by 1995.([5]) Again, these aggregate figures hide the fact that over half of all oil-importing developing states rely on external sources for well over 75 percent of their commercial energy requirements.

3.2 *Sectoral Consumption*

A detailed sectoral breakdown for commercial energy use in developing countries is not available, although it is clear that transportation and industry are major consumers. For example, the World Bank estimates that transportation consumes between 20 and 40 percent of all oil use in developing countries, with 65-80 percent by road vehicles, of which 60 to 80 percent is by trucks.([6]) The Economist Intelligence Unit estimates that of total commercial energy, 15-30 percent in mid-income and 10-20 percent in low income countries is consumed in the transportation sector, with 70-85 percent consumed by road vehicles, 5-10 percent by airplanes, and 3 percent by trains.([7]) Industry is estimated to consume 35 percent of total commercial energy, and its share of energy use is rising faster than any other sector. Dependence on oil or indeed any other commercial fuel is low in the residential sector — between 10 and 20 percent of the total, most of it in electricity. Finally, the agricultural sector consumes about 20 percent of all commercial energy.

The fact that both economic growth and total demand of energy in developing countries are growing faster than for the developed states points to a critical dilemma: growth by necessity entails greater energy consumption. See Figure 2-1. Thus, from 1980 to 1995, the World Bank forecasts that the developing states' share will rise from 20 to 25 percent of world total. Two factors are responsible for the dilemma: higher rates of population growth (about three times higher than in industrial states) and lower price elasticities of demand (due, to some extent, to government subsidy policies). Moreover, the demand for commercial energy will rise faster than the demand for traditional energy as economies expand their modern sectors with the concomitant industrialization and urbanization patterns.

([5]) World Bank (1983), pp. 5-6.
([6]) World Bank (1983), pp. 19-20.
([7]) Economist Intelligence Unit, Nr. 132, *Petroleum Investment in Developing Countries* (London: Economist Intelligence Unit, 1982), p. 4.

3.3 *Energy Imports*

The size of the oil import bill has been burdensome for almost every developing state. The imports of fuels for non-OPEC developing countries (excluding China) rose from 12 to 23 percent from 1973 to 1977 as a percentage of total imports.

In 1979 net oil imports represented between 8 and 14 percent of total imports in most non-oil exporting countries, but for 10 out of 61 countries (including Brazil, India, Turkey, Philippines, Thailand) oil imports represented over 20 percent of total imports. In the same year, nine countries had net oil imports equalling 5 percent of GNP or more, while in Cuba, Taiwan, Jamaica, Lebanon, Liberia, Jordan, Mauritania, Nicaragua, and Sudan the combination of rising oil prices and a stronger dollar meant that oil import payments represented more than 10 percent of GNP.

Net oil imports of all non-oil exporting countries increased from $ 19 billion in 1978 to $ 45 billion in 1981, a rise of 136 percent. Current account deficits rose from $11.6 billion in 1973 to $69 billion in 1981 in constant 1978 dollars. For low-income countries the deficit rose from 2.4 percent of GNP to 4.6 percent and for middle income countries the deficit rose from 1 percent to 6.1 percent in the same period. Brazil, Hong Kong, India, Pakistan, South Korea, Taiwan, and Thailand accounted for 80 percent of non-oil economies' imports of oil and 60 percent of the $69 billion 1981 current account deficit.([8])

The burden of energy imports is indicated in terms of energy imports as a percentage of total imports in Table 3-3. For ten countries, oil imports are 25 percent or more of their total import bill, while 25 countries show an energy bill of 10-25 percent of their total imports. For eight countries the import bill, and attendant burdens, are low despite the fact that several of them are highly dependent on external sources of energy.

Despite these figures and the estimates of GNP foregone noted earlier, it is important to stress that growth has not been as adversely affected by the oil imports bill as had been feared in the early 1970s. One decade after the events of 1973, we can observe that the developing states have fared rather well. Indeed, in Latin America, for example, there is no observable decline in the role of the transport sector as a

([8]) Based on a discussion in Economist Intelligence Unit, Nr. 125 (1982), pp. 20-30.

TABLE 3-3 - *Energy Importers.*

High *(25% of Total Imports or more)*	Medium *(10-25% of Total Imports)*	Low *(10% of Total Imports or Less)*
Brazil	Bangladesh	Argentina
Dominican Rep.	Chile	Benin
Hong Kong	Colombia	Burundi
Korea	Costa Rica	Hong Kong
Panama	El Salvador	Mozambique
Philippines	Ethiopia	Singapore
Thailand	Ghana	Somalia
Turkey	Greece	Zaire
Uruguay	Guatemala	
	Honduras	
	Ivory Coast	
	Kenya	
	Malawi	
	Morocco	
	Nepal	
	Pakistan	
	Paraguay	
	Portugal	
	Senegal	
	Sri Lanka	
	Sudan	
	Tanzania	
	Yugoslavia	
	Zambia	

Source: Based on World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

share of GDP. As transport is a major user of energy, this fact is of considerable significance.([9])

3.4 *Demand Management*

In the developing world there exists scope for both conservation and substitution, the two sides of demand management. Conservation strategies have been pursued actively and relatively successfully in Brazil, China, and South Korea, while substitution efforts have already been undertaken in Bangladesh, Bolivia, and Pakistan (to gas), Zambia (to coal), and Mauritius (to bagasse). Yet industrial plants continue to be inefficient compared to the international standards. In some developing states about 10 to 30 percent of energy is consumed per unit of output; in others, even more energy is used.([10])

Viable demand management strategies are tied to sectoral uses of energy. For example, the role of energy is especially critical in the transportation sector, a high energy user in all types of economies, where the impact of higher oil prices has been immediate. The transport sector's hold on the entire process of development may well be deeply circumscribed by new scarcities, in both the general economy and among individual sectors, providing new sets of problems for government and new concerns for public policy. The transport sector holds an important key to future change in patterns of energy use. Given the transportation sector's large share of petroleum consumption, transport-specific energy policies are particularly necessary.([11])

Renovation of industrial capital in many developing states has shown that there is scope for significant improvements in the efficient use of energy, particularly in industry, as the construction of plants coming on line can incorporate technological innovations for reduced energy use. There is, further, a range of low cost investments with paybacks over 10-20 months. Paybacks of larger conversions and investments in more

([9]) Choucri (1982). I am grateful to Fernando Bustamente for pointing out this unusual factor.

([10]) World Bank (1983), p. 14.

([11]) These entail better and more regular maintenance of engines; improved utilization of trucks in terms of loads; pricing, taxation, and import duties to encourage purchase of energy efficient vehicles; substitution of fuel such as alcohol, electrification, and LPG; and diversification of transport sector, e.g., railroads using coal and/or electricity and more efficiency in energy use per load.

efficient equipment would be 2-5 years. ([12]) Industrial projects with energy management programs are actively pursued in Brazil, Egypt, South Korea, and China.

With respect to electrical power systems, the World Bank has calculated that normal distribution and transmission losses account for 4-8 percent of total annual generation and 7-12 percent at peak hours. In half of the 76 countries reviewed, such losses were over 15 percent. Hence there is a potential for saving one half to one third of the losses normally incurred. Such reductions are important for it can be nearly 300 percent cheaper to reduce the loss of one kilowatt than to increase generation by an equal amount. Hence, reducing the total loss by 5-10 percent may save substantial amounts, for such a reduction should equal if not exceed the growth in demand.([13]) Losses in transmission and distribution of electricity have been estimated at 5 percent of total electricity output — a figure equivalent to one year's growth in demand.

These "losses" in energy, due to a variety of reasons, require two sets of responses: policies for reducing losses and policies for expanding supply possibilities. The following section looks at the supply side of the energy equation for developing and industrializing states.

4. The Supply Side

Worldwide production of commercial fuels in 1970-1980 increased by 3.6 percent per year and is expected to grow at 4.5 percent per year through 1995, despite the lower demand. During the 1970s developing states provided one fourth of total commercial energy supplies, with an anticipated increase to one third by 1995, thereby accounting for about 50 per cent of the total production increase.([14])

In 1980 the developing world accounted for 30 percent of global petroleum production, a figure that is anticipated to increase to 41 percent by 1995. Ninety percent of this production was concentrated in only eight countries. China and India alone accounted for 72 percent of coal production in the developing states. Overall, the developing countries are net oil and gas exporters and, by contrast, net coal importers.

([12]) World Bank (1983), p. 19.
([13]) World Bank (1983), pp. 22-23.
([14]) World Bank (1983), pp. 6-7.

At this writing, the crude oil reserves of developing countries (excluding OPEC members) are concentrated in nine countries. Five of these are estimated to have high oil reserves, i.e., 3000 million barrels or more: China, Egypt, India, Malaysia, Mexico. The remaining few — Angola, Brazil, Congo, and Tunisia — have more modest reserves, estimated at 1000-3000 million barrels.([15])

The natural gas situation is somewhat more encouraging in terms of potentials for a large number of developing states. Fourteen countries have high reserves (10,000 billion cubic feet or more), including several OPEC members. Nine countries appear to have 3000-10,000 billion cubic feet. See Table 4-1.

Gas development is less costly than had been believed earlier. And it is estimated that the expansion of natural gas infrastructure could lead to vastly greater gas utilization in developing countries. For example, current proven gas reserves, if developed, could cover almost half of these countries' commercial needs. As we note below, the development of gas infrastructure is critical if domestic price adjustments are to be made in the petroleum sector. Otherwise, the substitution possibilities cannot take place. Natural gas is used extensively in Algeria, Mexico, Pakistan, and Venezuela. Another five countries are on the verge of large scale utilization, namely Brazil, Egypt, India, Nigeria, and Thailand.

Coal, produced in thirty-five developing countries in varying quantities, is usually for domestic uses. As a fuel source it is 30-40 percent cheaper than oil in electrical power generation. Sixty percent of coal use in the developing world is concentrated in China and India. While coal reserves worldwide are enormous compared to oil (500 percent greater), there are several infrastructure and transport problems which constrain wider use. High initial investments, large gestation period for resource development, and high costs of transport place limitations on the benefits of this fuel source internationally. However, expansion of domestic uses for those countries with high imports can take place at relatively competitive prices. According to one estimate, the competitiveness of a coal mine is set at $100 a ton of delivered coal.([16])

On balance, increases in commercial energy production in new producers, that is, the conventional non-oil exporting countries, will exceed those of the less developed countries as a whole, with a growth rate of

([15]) World Bank (1983), p. 103.
([16]) Economist Intelligence Unit, Nr. 125 (1982), p. 34.

TABLE 4-1 - *Energy Reserves (Natural Gas).*

High *(10,000 billion cubic feet or more)*	Medium *(3000-10,000 billion cubic feet)*
Algeria	Bangladesh
Argentina	Bolivia
China	Cameroon
India	Colombia
Indonesia	Ecuador
Iran	Egypt
Iraq	Greece
Malaysia	Ivory Coast
Mexico	Tunisia
Nigeria	
Pakistan	
Thailand	
Trinidad and Tobago	
Venezuela	

Source: World Bank, *The Energy Transition in Developing Countries* (Washington, D.C.: World Bank, 1983), Appendix.

6.3 percent as opposed to 4.2 percent of all less developed countries. This means that a new group of industrializing countries joins the ranks of producers while remaining outside the frame of OPEC. In the following sections we highlight some of the implications of this new grouping.

4.1 *Exploring Activity*

Exploration for oil and gas in developing countries is generally undertaken through international (mainly World Bank) initiatives, through private ventures, or through a "mix" of both (as by the International Energy Development Corporation). Exploration has become a major policy priority for many of these countries. Although national governments themselves seldom make such investments, they are direct participants in the negotiation processes leading to concessions or contracts. A crowded development agenda almost by necessity precludes such allocations.

Fifty percent of all exploratory wells drilled from 1967 to 1976 were drilled in non-OPEC less developed countries. In other words,

exploration was made in 71 out of 113 countries, and seismic and other exploratory activities were undertaken in an additional 22 developing states. However, 5416 out of 6501 of these wells were sunk in 16 countries, all of which had pre-1967 discoveries. Of the remaining 55 countries, encouraging findings were located in 25. But the drilling trend has declined, however, with 324 exploratory wells in 1977 compared to 602 in 1972 and a density of drilling of 7 per 1000 m^2 compared to a world average of 109 per 1000^2 in 1977.([17])

Virtually all increases in exploration activity have occurred in countries already producing petroleum. For example, 60 percent of these increases are in Argentina, Brazil, and India alone. By contrast, exploration activity in the non-oil producing developing states has fallen considerably since 1972. This is due to a variety of reasons, including poor incentive systems, political risks and, more importantly declining prices for world oil in the early 1980s.

Few detailed analyses exist for the impact of investments on exploration and development for a "typical" non oil-rich developing country. In most of these states investments are foreign, from multinational oil companies, and production sharing agreements govern the oil-share of the government and of the company when (and if) oil is found. Such longitudinal analysis is helpful as it "maps" out relative gains for all parties over time. We discuss one such example, in section 5.3 below, undertaken at MIT, which provides an illustration of utility for other developing states.

4.2 *Reserve Generation*

Argentina, Brazil, and India have 79 percent of all proven oil reserves located in non-oil exporting developing countries, excluding China.([18]) The proven oil reserves located in these states amount to only one percent of the world total, but this figure represents 14 percent of non-oil exporting countries' ultimately recoverable reserves. On a worldwide basis, their reserves account for 37 percent of the total. Most known reserves for the non-oil exporting countries are in Latin America (14-35 billion barrels), although Africa also has a considerable potential (13.7 billion barrels).

([17]) See Dundereley et al. (1980), p. 138.
([18]) Economist Intelligence Unit, Nr. (1982), p. 28.

Eighty-eight percent of all Latin America's potential is believed to be in three countries: Argentina, Brazil, and Colombia.

In Asia the ultimate recoverable reserves are about 14 billion barrels, with 1.9 billion proven, of which 85 percent are in India alone. In Africa the onshore and offshore ultimately recoverable reserves are primarily oil, with some gas. Of the 20-38.5 billion barrels total, 75 percent is located in 30 countries, with Ghana, Somalia, Ethiopia, Sudan, Mauritania, Chad, Senegal, Mozambique, Mali, Kenya, and Madagascar having the most promising prospects.

Despite Africa's potential, only 148 wells were drilled from 1975 to 1978 and only 13 rigs were operational, eleven of which were located in the Ivory Coast, Niger, and Sudan. This number represents only seven percent of those rigs operating in Latin America. In Asia 100 rigs were operational, a figure which includes 44 in India.([19])

While exploration activity and reserves generation have not proceeded at the rate that has been expected, the scope for expansion is great. Yet several factors obscure this potential: declining world oil prices, prevailing risks in developing countries, insufficient incentives for foreign enterprises, and inability to expand national investments due to resource constraints, technical and skill shortages, political considerations, and competing priorities.

4.3 *Supply Management*

The interaction of energy and macroeconomic policy makes the organization of oil, gas, and coal industries difficult yet essential. The difficulties are due to the necessity of involving numerous agencies both public and private. The essentiality is created by the fact that macroeconomic goals are dependent upon energy policy, and success in the latter depends upon efficient macroeconomic policies.

In the past multinational oil companies dominated entire operations in fossil fuel development and management. In particular, the petroleum and natural gas sectors in developing countries have historically been established by international oil companies making essential calculations based on their assessment of profitability for their worldwide operations. With changes in the oil market, nationalization of the oil industry, and

([19]) Economist Intelligence Unit, Nr. (1982), p. 48.

government takeover of most operations, the management of the energy sector has adjusted accordingly.

The diversification of the supply of crude petroleum internationally coincided with the national governments' establishment of domestic price controls. This resulted in involvement of the various government agencies, invariably leading to centralized decision power in one agency. The underlying logic is to increase efficiency and rationalize regulation of proliferation of multiple demands on energy resources.

The near universal establishment of national oil companies to coordinate production and marketing contributed to the vertical integration of this sector. National oil companies are expected to control all facets of the sector and as such will be the locus of managerial and technical expertise. Their role is especially critical in the interface between national government and international oil companies. They are, however, almost universally understaffed, inexperienced, undercapitalized (due to price controls and subsidization) and lack of access to necessary technology. ([20]) The Latin American experience, examined in detail recently at MIT, illustrates both the potentials and the difficulties facing public sector energy enterprises in developing countries. ([21])

Because the technology, capital cost, and expertise involved in refining and marketing stages are less extensive than on the production side, the development of national downstream activities by national governments has been more pronounced (see Table 4-2). In some developing countries downstream operations are on a world scale. However, for most of these countries such operations have tended to be small and inefficient. Substantial improvements are needed to update facilities, reduce bottlenecks, and overhaul their operations. Yet there is scarcity both of capital and of technology. Substantial investments are required as most refineries were built to meet the requirements of the international operators and not those of the national governments in the country of operation. By contrast, controlling the marketing of a products industry is the least technologically demanding component of the oil-system. On balance, national companies have been rather effective in controlling distribution.

([20]) Economist Intelligence Unit, Nr. (1982), p. 30-34.
([21]) Choucri (1982), pp. 142-143.

TABLE 4-2 - *Variation in Local Petroleum Refining Capability in Oil-Importing Developing Countries.*

High *80,000 b/d or more*	Medium *20,000-80,000 b/d*	Low *Less than 20,000 b/d*
Argentina	Dominican Republic	Afghanistan
Brazil	Ghana	Bangladesh
Chile	Ivory Coast	Burundi
Colombia	Jamaica	Costa Rica
India	Kenya	Cyprus
South Korea	Morocco	Dominican Republic
Pakistan	Paraguay	El Salvador
Philippines	Senegal	Ethiopia
Singapore	Sri Lanka	Gambia
Taiwan	Thailand	Guatemala
Turkey	Tunisia	Guinea
	Uruguay	Guinea-Bissau
	Zaire	Guyana
	Zimbabwe	Honduras
		Lesotho
		Liberia
		Madagascar
		Malawi
		Mali
		Mauritania
		Mozambique
		Namibia
		Nicaragua
		Niger
		Panama
		Rwanda
		Sudan
		Tanzania
		Timor
		Togo
		Uganda
		North Yemen
		Zambia

Source: Economist Intelligence Unit, *Petroleum Investment in Developing Countries*, Report NR. 132 (London: Economist Intelligence Unit, 1982), p. 25.

5. Pricing Issues

Despite the highly regulated environment in many developing countries, prices continue to exert a strong influence on economic performance and on investment decisions. The world energy prices determine propensities to invest in exploration and in development (thereby potentially expanding sources of supply). Prices prevailing domestically, generally set in place by overarching social policies and priorities, condition internal consumption patterns and sectoral distribution. The disjuncture between domestic and international energy prices itself poses serious problems for rationalizing planning in this sector.

Domestic pricing of petroleum products and natural gas continues to be a critical issue in all developing countries. While some have increased petroleum and primary energy prices to reflect real scarcities, there remains considerable scope for change. Oil-exporting countries in particular are vulnerable to the distorting effects of unrealistic prices. Rapid growth in domestic consumption, pushed by low prices, cut into exports. This problem is particularly acute for Egypt, Indonesia, and Nigeria, among others.

Some adjustments have been made in non-oil exporting developing countries by passing energy price rises directly on to the consumer. The real domestic price increase of petroleum products in local currency between 1975 and 1981 was 40 percent in Korea, 60 percent in Brazil, Pakistan, Philippines, and Turkey; and over 200 percent in Yugoslavia and Colombia. Pakistan and Brazil illustrate well the impacts of price changes on energy consumption. Pakistan raised its diesel oil prices (which for a sample of non-oil exporting developing countries rose from 38 to 61 percent of gasoline prices from 1975 to 1979) and consumption dropped from 550 to 300 percent of its gasoline consumption in five years. Brazil decreased the price of diesel and correspondingly the consumption rose from 90-150 percent of gasoline use over the same period.([22])

The picture is more stark in the electricity sector of the non-oil exporting developing countries. Of the 33 countries surveyed by the World Bank, 18 increased tariffs in real terms since 1974, but only seven had prices equalling the marginal cost in the long term. An increasing number of countries have committed themselves to raising tariffs, including Bangladesh, Indonesia, Kenya, Nigeria, and Sri Lanka. Of course, prices do

([22]) World Bank (1983), pp. 16-17.

not operate in a vacuum, there are inevitable social adjustments to any effective pricing strategy.

5.1 *Prices and Demand Management*

One important policy instrument for containing demand growth, pressing for conservation and substitution, is raising domestic energy prices. In many developing states prices of fuels are maintained well below international standards, due to the social equity policies of the 1950s and the 1960s. While there is considerable scope for domestic price increases, it is generally feared that the social, political, and even economic costs of raising prices would be extensive. Many countries are hesitant to make this commitment.

For purposes of analysis, however, two issues need to be resolved: (1) determining precisely how energy is used in the economy in different sectors and in which forms; (2) determining the economy-wide effects as well as the sectoral effect of raising domestic energy prices as a key component of demand management strategies. Several constraints exist for making the necessary analysis. There are not enough data about sectoral use of energy, nor the analytical basis upon which to draw conclusions regarding price policies for demand management. Nonetheless, drawing upon detailed analysis for one developing country undertaken at MIT in collaboration with its governmental and energy organizations, we can draw some important conclusions. This is the case of Egypt, an industrializing society with a large petroleum export sector and dramatically expanding domestic consumption.

This analysis was undertaken in two stages: first, determining the precise energy uses in the economy (through the interindustry input-output table, which we expanded into a social accounting matrix to include the economy-wide flows); and second, constructing a 10-sector model of the economy to show the short-run, immediate effects of price policies.([23]) Our conclusions are presented here in this parallel fashion as well:

With respect to energy uses, we found that there have been substantial changes in patterns of energy use, and the role of energy sectorally in the two years we examined in detail, 1977 and 1979. In the space

([23]) Nazli Choucri and Supriya Lahiri, "Short-Run Energy-Economy Interactions in Egypt", *World Development.*

of two years, the internal shifts in energy flows were extensive. For example, in only two years, exports of crude petroleum expanded from 8.1 percent of all exports to 46.2 percent. Exports of refined products doubled: from 3.5 percent of all exports in 1977 to 7.7 percent in 1979. In 1981/82 exports contributed 2.76 billion to the country's balance of payments. The sector as a whole, between 1977 and 1979, made the following contribution to final demand, value added, and gross production.

The energy sector increased in importance in the economy from 1977 to 1979. For example, energy's share of final demand rose from 2.2 percent to 17.6 percent. Energy's contribution to gross production rose from 5.2 percent to 12.5 percent. The share of gross value added supplied by the energy sector rose from 5.3 percent to 17.5 percent. And, finally, inputs to the productivity of the energy sector increased from 4.5 percent of all industrial inputs to 7.2 percent.

Thus, we conclude that for Egypt, as perhaps for many other developing countries, economic growth and structural changes have had major impacts on energy uses domestically. It is therefore important to obtain better information about internal energy use. At this point we believe that, in the Egyptian case, for example, there have been even more changes from 1979 to 1984.

With respect to the impacts of demand strategies based on domestic pricing changes, we explored those impacts through a structural general equilibrium model of the economy that incorporates the essential features of this particular economy.[24] Current domestic price of petroleum in Egypt is about 20 percent of the internal market price equivalent. Almost 50 percent of energy used is petroleum based. Different sectors will respond differently to changes in energy prices, *and* price determination mechanisms differ from sector to sector. Thus, these new considerations provide the core of the problem. We wanted to know how the economy as a whole will adjust to higher prices, and how different sectors will respond.

The model draws upon the well-known linear expenditure system of demand equations to arrive at the sectoral consumption level. This set of equations, derived for utility functions, is the basis for calculating demand, or the consumption levels related to price and income variables for each sector. Given the different behavioral assumptions and the

[24] Ibid.

different identities built around a social accounting matrix, the solution is determined through several adjustment mechanisms. In this model, these mechanisms are the Keynesian output response in the quantity-clearing sectors, the "forced saving" mechanism via the rise in the prices of output relative to wage, adjustments in the trade deficit, and the surplus available in the government current account.

The conclusions are as follows: We found that the responses of the increase in the sectoral price levels will vary over the different sectors.

The changes in relative prices will lead to a rise in the level of profit income from the petroleum sector. A large proportion of this profit income will be going into the hands of the Egyptian government because of the large share of the government in the petroleum sector and in the other sectors of the economy. This increased government income will result in higher government savings leading to leakages in purchasing power.

One related effect is that real wages will fall. This will occur because of the short-run nature of predetermined nominal wages. Thus income will be redistributed away from wage and wage earners to profit recipients. A large amount of the increased profit will accrue to the government owing to the large share of the government in the public sector undertaking. (Of course, government can choose in turn to distribute profits back to wage-earners if it so chooses, but we do not examine this policy).

An *increase* in the domestic price of oil will lead to a *reduction* in the level of economic activity of the different sectors of the economy. Real value added will fall by approximately 2 percent and household consumption of petroleum products will decline by about 13 percent. Overall, the rise in domestic petroleum prices will create difficult adjustment problems in the short-run involving *increased inflation* (due to cost-push inflationary pressures originating in the petroleum sector) and *contraction of output* (brought about by a fall in aggregate demand). This will lead to the underutilization of capacity.

We undertook further analysis to identify the prospects for substitution from petroleum uses to natural gas. It became clear that in those sectors where natural gas can be used, substitution possibilities are inhibited if bottlenecks in the gas system are not removed. If the domestic supply of natural gas remains fixed, then the contractionary effects on the economy indeed have become more severe.

The above leads to one conclusion relevant for *all* demand man-

agement alone strategies for *all* developing countries: that energy demand management alone cannot bring about desirable impacts on the economy unless efforts are made to prevent cost increases which occur in other sectors of the economy.

The macroeconomic implications of domestic petroleum pricing strategies in Egypt are extremely important and should be considered carefully. Simply suggesting lifting of domestic subsidies, increasing domestic energy prices to world prices, will not have the intendend effects unless other measures are adopted as well. Treating the energy sector in isolation from the rest of the economy will be counterproductive and lead to adoption of measures that may even have detrimental effects. An overall energy/economy strategy is required in which adjusting domestic prices toward international prices is only one element.

5.2 *Prices and Expanding Supply*

The price of oil has two distinct impacts on producer countries: for the established producers it serves as a signal to moderate production and implement cutbacks as a means of sustaining prices. For new entrants in the market, price serves as a signal to allocate investment in exploration and development. Investment decisions, so critical for new producers, are closely tied to prevailing prices.

Developing countries with potentials for expanding energy generally rely on external sources of investments in exploration and development. This class of countries is different from the traditional OPEC producers as their reserve potentials are much more limited, and the financial basis more modest. Thus governments cannot easily divert resources for energy investments. As a result, adopting appropriate measures for attracting foreign investment is of major importance. In the petroleum sector production sharing agreements between government foreign companies are emerging as the norm for the 1980s.

In recognition of the reality, we have developed at MIT a simulation model to examine the impacts on production of investments in exploration and development — given basic geological information about the country in question. One essential intent of this model is to determine (1) the impacts of world prices and domestic prices on production and exports; (2) the distribution of oil produced — as between government and international oil companies — and then the allocation of govern-

ment share to domestic consumption vs. exports; and (3) impacts of energy investments on production capacity and additions to capacity.([25])

The Energy Development Model (EDM) is devised as an analytical tool to assist government agencies and investor companies to pull together relevant information from various fields — combined in a conceptual framework to produce simulations of future developments. The model integrates basic information useful for analyzing production possibilities and actual production for new oil exporting countries — the non-OPEC potentially important producers. For illustrative purposes, Figures 5-1 and 5-2 show two sets of results from a base case analysis for one such country, Egypt. This choice is made here to maintain consistency with the discussion of demand adjustments in section 4 above. The EDM model and simulation style is designed for this class of country, namely countries with strong export potential and relatively strong domestic consumption.

Figure 5-1 shows prospects for Egyptian oil production under two scenarios: one assumes that current reserves are more modest than estimated, as noted in official sources, and the other assumes that reserves are higher than those presently recorded. The base scenario rejects currently known reserves. The actual production of Egypt is also placed on the Figure for comparative purposes and tracks the base case as well.

Figure 5-2 shows the distribution of production under the existing production sharing agreement for the base case. It shows total Egyptian oil production under current conditions (and parameters) and how this production is allocated given existing contracts, and assuming no changes in the clauses over time. Thus we show the volume of cost recovery oil over time, the production-sharing oil, the foreign oil company share of production, and Egyptian share of production. This base case, allocating produced oil to the parties in question, will of course change significantly if we assure changes in the contract clauses. The characteristics of the base case are existing world prices, currently known reserves, and existing contracts with foreign oil companies.

The purpose of these illustrations is to indicate the "unfolding" of

([25]) See Energy Development Model (EDM), structured with Michael C. Lynch, based on the International Petroleum Exchange Model (IPE) as presented in Nazli Choucri (with David Scott Ross) *International Energy Futures: Petroleum Prices, Power, and Payments* Cambridge, Mass.: The MIT Press, 1981).

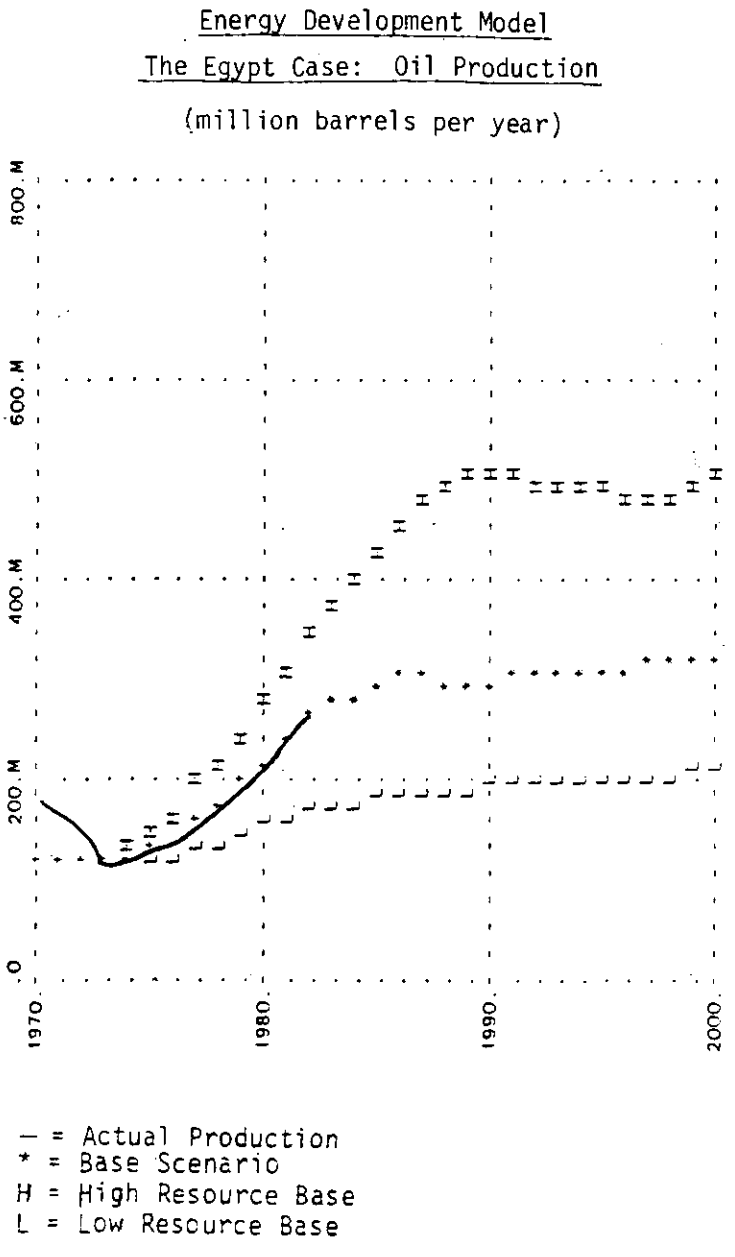

FIG. 5-1

Source: Nazli Choucri and Michael C. Lynch, *Energy Development Model: The Case of Egypt* (MIT Technology Adaptation Program, in press).

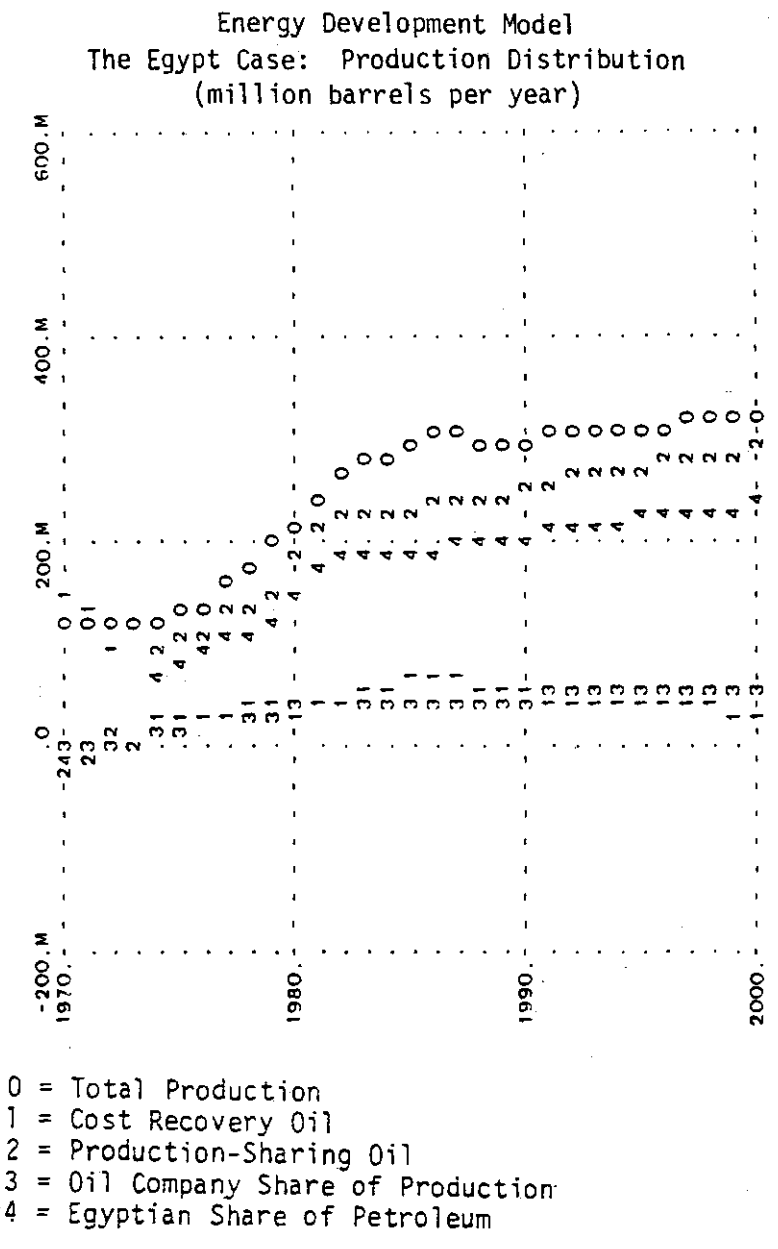

FIG. 5-2

Source: Nazli Choucri and Michael C. Lynch, *Energy Development Model: The Case of Egypt* (MIT Technology Adaptation Program, in press).

the oil sector and its performance for one of the new important oil producers. It would be extremely revealing to parameterize the Energy Development Model (EDM) to other countries, particularly their petroleum and natural gas potentials.([26]) Such an exercise would be very useful as a tool for policy, and for government policy assessment.

6. The Social-Political Dimension: Problems of Adjustments to Changing Energy Environments.

The changing energy environment has created new social strains in most developing countries. Social costs are mounting for everyone. For the oil-rich countries, the major oil-exporting countries, the combination of new wealth and new constraints creates new social tensions, and the revenue cuts due to lower oil exports and prices may create even greater pressures. For oil-importing countries, the oil-poor states, social strains have resulted from policy attempts to adjust to new scarcities. For everyone, there is evidence of strain and efforts to adjust to the changing energy environment. On balance, at least three types of social and political adjustments are becoming apparent and must be dealt with:

1. Adjustments to government attempts to respond to new constraints through new policies, regulations, and so forth;

2. Adjustments to new investment patterns and allocation for growth, such as those due to oil investments, or infrastructure projects related to availability of finance;

3. Adjustments changing conditions created by a changing international energy environment.

The convergence of these factors contributed to political pressures for many developing countries. The experience of countries with direct policy intervention in the energy sector is still fairly new. Nonetheless, domestic energy-related policies on both the supply and the demand sides are becoming intensely political. For example, when Brazil announced a set of policy measures in 1977 to curb demand and save about $120

([26]) See Nazli Choucri and M. Zaki Shafei, *Energy Policy Project in Egypt: An Overview*, TAP Report 83-20 (MIT Technology Adaptation Program, 1983).

million in the oil import bill,([27]) such policy interventions were not without their immediate social costs. Strikes and riots broke out in Brazil, Peru, and Santo Domingo specifically over increases in petroleum prices and shortages of supplies. In Ecuador, another example, the government has devised a variable petrol-pricing structure in the effort to ward off riots. In short, direct interventions in the petroleum sector created considerable unease.

On the supply side, there is yet another source of social strain, evidenced, for example, by the case of Mexico. In 1981 the government tried to abandon plans to limit oil production in order to help curb inflation. Some officials regarded any proposal to expand oil production to the limit as inflation-producing and likely to create further destabilization. Hence efforts to curb production were made (this before the advent of today's glut in the oil market). The complex economic process of reconciling a set of seemingly irreconcilable objectives — maximizing economic growth, reducing unemployment, curbing inflation, and so forth, — was all built around predicted levels of export earnings. However, irreconcilable objectives cannot be reconciled overnight, and social strains can become aggravated further.

Then, too, the perennial problem of unemployment which plagues most developing countries emerges at the forefront once again in oil-rich and oil-poor countries. The requirements of rapid industrialization tied to a strong energy sector almost invariably impose strong preferences for capital-intenisve investments. Untangling the causes of social strain is almost impossible to do, given the scanty information available. Despite protests and social unrest, there is some evidence of positive adjustment to energy policies, as noted earlier. Yet, the situation in many countries is still transitional: there is a search for appropriate policies for both the supply and the demand sides.

In the Gulf region of the Middle East and the exporting countries of Latin America, patterns of investment appear to be distorting the process of economic growth and aggravating structural dislocations. Agricultural production specifically was low, partly out of neglect. Oil wealth is being used in larger shares of the national budget. The sudden in-

([27]) See *IMF Survey*, February 1977, and Cloraldino Soares Severino, "The Energy Problem and Transport: The Brazilian Experience", December 1980. Prepared for the Seminario, "Impacto del Costo de la Energía en el Sector Transporte", 1-3 December 1980, Bogota, Colombia. Translation available at the Department of Political Science, Massachusetts Institute of Technology, Cambridge, Mass.

creases in the oil revenue in oil exploring states had unleashed a new pattern of domestic investments.

In some developing countries the social and economic impact of oil exploration and development has contributed to the disruption of agricultural development plans through erratic and unplanned economic changes. The "pull" of labor has accentuated "squatter settlements" and contributed further to migrant flows from rural areas. At the same time large public sector energy enterprises suffer from labor shortages of both skilled and semiskilled labor.

Some countries, like Venezuela, have considered establishing financial mechanisms for regulating investments and oil income. The government had declared it would place half of its total oil income in the Venezuelan Investment Fund as a means to reduce inflationary pressures and control the developmental process. The fund is designed to finance a new petrochemical industry and infrastructural projects such as shipbuilding, a massive steel complex, and a long-range agricultural program designed to help Venezuela attain self-sufficiency.([28])

Changes in oil prices and massive oil income in the 1970s resulted in transformations in internal power relations in almost all oil exporting countries. Four trends stand out: the rapid expansion of the bureaucracy and government agencies, the growing importance of technological investments as one of the strongest and most coherent trends, the importance of the banks, and, last, the clear growth and predominance of public enterprises related to petroleum and energy.

Among observers of developing countries, it is said that the oil-rich states in the 1970s developed a "petroleum syndrome". The relationship between growth, equity, and social change has been seriously disturbed, and the traditional patterns of social and political relations changed significantly. The emerging importance of technocrats and entrepreneurs in the political system changed more traditional patterns of power and wealth. The basis of the new power had become the country's depletable resources, and not expansion of its productive capacity. Hence the impacts of energy investment patterns transcend conventional economic concerns, and bear directly upon a country's political arrangements, and the evolution of its social structure.

The distribution of benefits tied to key economic decisions is render-

([28]) George W. Grayson, *The Politics of Mexican Oil* (Pittsburgh: The University of Pittsburgh Press, 1981), p. 118.

ing energy related decisions synonymous with decisions bearing on the viability of the society itself. In several potential energy exporters, the public sector is held accountable for lack of success. For example, in Brazil the apparent lack of success of Petrobras to make any significant strikes borders sometimes on becoming a political issue. "Why wouldn't God have conceded this present to us?" lamented the company's first president. ([29]) Large sectors of the country's public have occasionally expressed anger at Petrobras' apparent inactivity domestically, especially in view of its success in Iraq. "If we can discover oil abroad, why can't we do so in our own country?". ([30])

These reactions are all symptomatic of increasing expectations far in excess of actual performance. States everywhere are becoming cognizant of the pressures created by a changing energy environment. The nature of the pressures differs, as do the political responses. In the international arena, there is evidence of collaboration. Although observers of development tend to stress the dislocating effects of the energy environment, caution and a modicum of optimism may well be in order. Indeed, the most favorable adjustments have occurred in the ability of most countries to weather the pressures of the 1970s. The challenge now is to adjust to the demands of the 1980s and the changing international energy environment.

([29]) *New York Times*, September 21, 1979, pp. D1, D12.
([30]) Ibid.