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OIL AND GAS EXPLORATION AND DEVELOPMENT IN OIL IMPORTING DEVELOPING COUNTRIES

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ABSTRACT

The rapid rise in oil prices and supply shortfalls during the 1970s did not bring a concomitant increase in oil and gas exploration and development to the oil importing developing countries (OIDCs). To be sure, total exploratory activity in the OIDCs, as measured by the number of seismic party-months and the number of exploratory wells drilled, did in fact increase in the 1970s, but relative to the rest of the world exploratory activity actually declined. The number of seismic party-months increased worldwide by about 20%; however, the percentage of the world total attributable to the OIDCs declined by about 50%. Further, the number of exploratory wells drilled increased worldwide by over 60% while the number of wells in OIDCs as a percentage of the world total fell by over 15%. The increase in exploratory activity that occurred became more concentrated in the developed countries and in particular the United States and Canada. Moreover, in the OIDCs, exploratory activity became more concentrated in petroleum producing countries, especially Argentina, Brazil, and India.

The consensus among many investigators indicates that exploration and development in OIDCs was inhibited by a combination of factors. First, the geologic prospects for oil and gas were not conducive to exploration. The high cost, small-sized fields that are characteristic of OIDCs limit profit potential, increases risk, and provides for limited prospects of exportable surpluses, which are necessary to supply downstream operations. Second, the lack of infrastructure in many nonpetroleum producing OIDCs deterred oil and gas exploration. Third, restrictive contracts provided for an insufficient amount of risk sharing to attract foreign capital. Fourth, host government taxation policies discriminated against high cost, small-sized fields. Fifth, political risk and government instability did not encourage foreign investment, considering the usual 10- to 15-year petroleum exploration and development period. Finally, U.S. taxation policies following the oil embargo were designed to encourage domestic exploration and development.

The 1980s have seen a substantial decline in real prices for petroleum, high interest rates, a developing country debt crisis, and a worldwide economic recession. As expected, these forces have reduced the cash flows of the international oil companies through lower revenues and higher costs of capital, and have caused them to seek higher risk-adjusted rates of return on exploration projects. Consequently, the international oil companies have reduced their exploratory and development activity in OIDCs. Further, the debt crisis now experienced by many oil producing OIDCs has had an impact on the amount of exploration their own national oil companies can accommodate. The 1980's conditions are likely to cause an absolute decline in exploratory activity in OIDCs that are considered high risk, and where the probability of finding oil and gas is low. In the oil producing OIDCs where large reserves have been discovered, the impact on exploratory incentives will be less severe. These trends are already evident in the recent exploratory and development data. Reversal of these trends will require (1) a general improvement in economic conditions favorable to

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exploration and development and (2) removal of host government obstacles and more favorable contracting and taxation policies that are commensurate with risks. The activities of The World Bank may prove to be effective in stimulating exploration by national oil companies; however, to date they have not attracted private firm participation.

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1. INTRODUCTION

The energy problems of oil importing developing countries (OIDCs) are characterized by a commercial sector heavily dependent on imported oil and a traditional sector heavily dependent on woodfuels and agricultural and animal wastes. Although most of the total energy consumed in OIDCs is derived from traditional sources, imported oil provides nearly all of the energy for transportation, industry, and power generation. The rapid increases in world oil prices of the 1970s created massive oil import bills and debt for many developing countries, robbing them of badly needed foreign exchange essential for economic development.

In the 1980s oil prices declined in real dollar terms, but in many OIDCs the appreciation of the U.S. dollar relative to local currencies led to an increase rather than to a decrease in the price of oil. For example, in U.S. Agency for International Development (AID) supported countries, the price of Saudi crude oil was four times as high in 1984 as in 1980 (Vogt, et al., 1985). Besides certain renewable options, it is now widely accepted that there are economically recoverable oil and gas deposits in many developing countries, and exploiting these resources is seen as one longer term energy solution (World Bank, 1983). Unfortunately, it is conceded that the increase in world oil prices of the 1970s did not bring about an increase in exploration and development activity in the OIDCs, and the conditions of the 1980s do not offer much encouragement.

The purpose of this paper is to review the evidence of exploration and development and the factors responsible for the low level of

activity in the OIDCs. A review of exploratory and development activity in the 1970s and the 1980s is presented in the next section of this paper. The third section then discusses the obstacles to oil and gas exploration and development in the OIDCs. The catalytic efforts of the World Bank in promoting exploration and development are described in the fourth section. The final section provides some conclusions.

2. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY

2.1 The 1970s

The consensus among many investigators quite clearly shows that the substantial increase in world oil prices that occurred in 1973 and 1974 ($3.01 to $11.65/bbl, Curlee, 1985) did not bring about a concomitant increase in oil and gas exploration and development in OIDCs. To be sure, exploratory and development activity did increase in absolute terms, but relative to the rest of the world, exploratory and development activity actually declined (Blitzer et al., 1983; The World Bank, 1983; Broadman, 1983 and 1984; Parra, 1981; and The National Petroleum Council, 1982).

As shown in Fig. 1, exploratory seismic activity increased worldwide by about 20% and became much more concentrated in the developed nations. Total seismic activity in the Asian, African, and Latin American oil exporting and importing countries declined. In a study of 47 oil producing and nonproducing developing countries, Broadman (1984) found that nearly one-half of them experienced a decline in seismic and exploratory activity between 1970 and 1982. Moreover, seismic activity declined significantly in Papua New Guinea and Senegal, but remained high in Argentina, Brazil, and Colombia, and increased substantially in Bangladesh, Cameroon, and Pakistan.

Another, and perhaps better measure of exploratory activity, the number of wells drilled, increased worldwide by over 60% as depicted in Fig. 2. The increase was largely confined to the developed countries, which accounted for over 70% of the 1972 to 1980 increase. Although the number of wells drilled increased by 37% in the OIDCs, its share of the

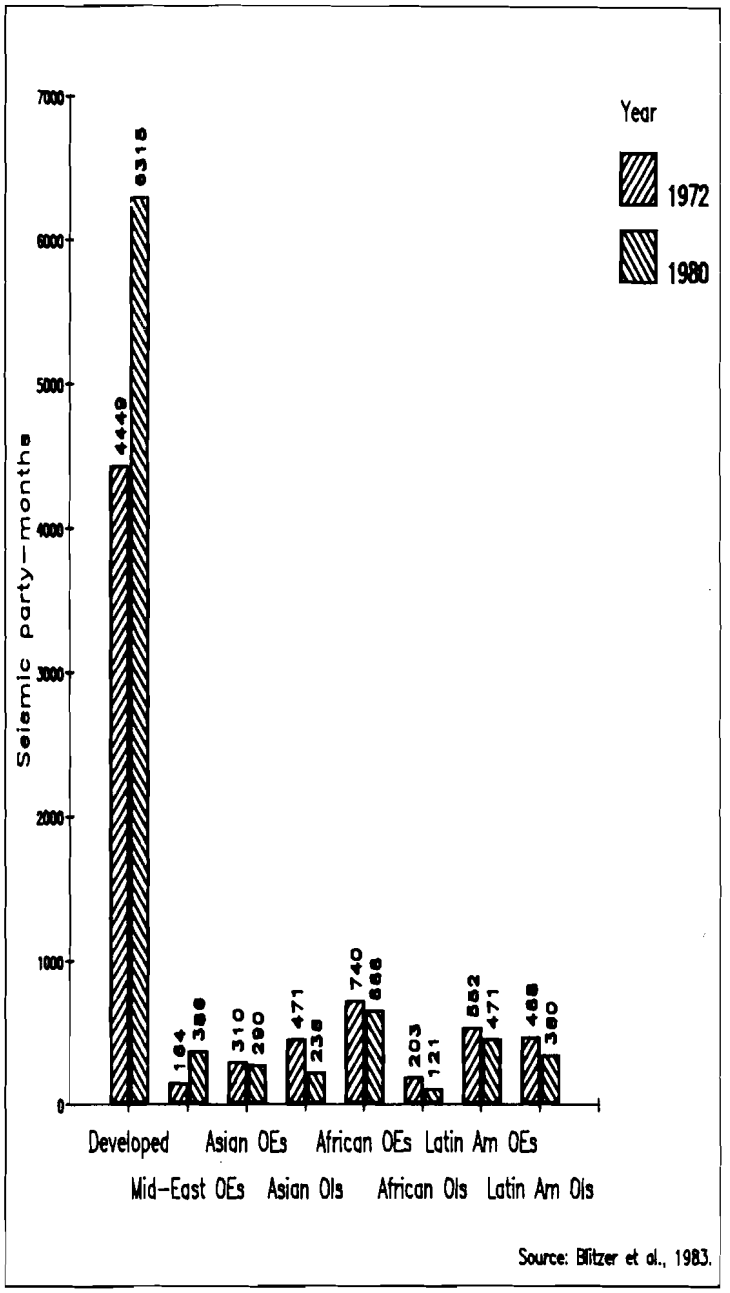


Fig. 1. Exploratory seismic activity, 1972-1980

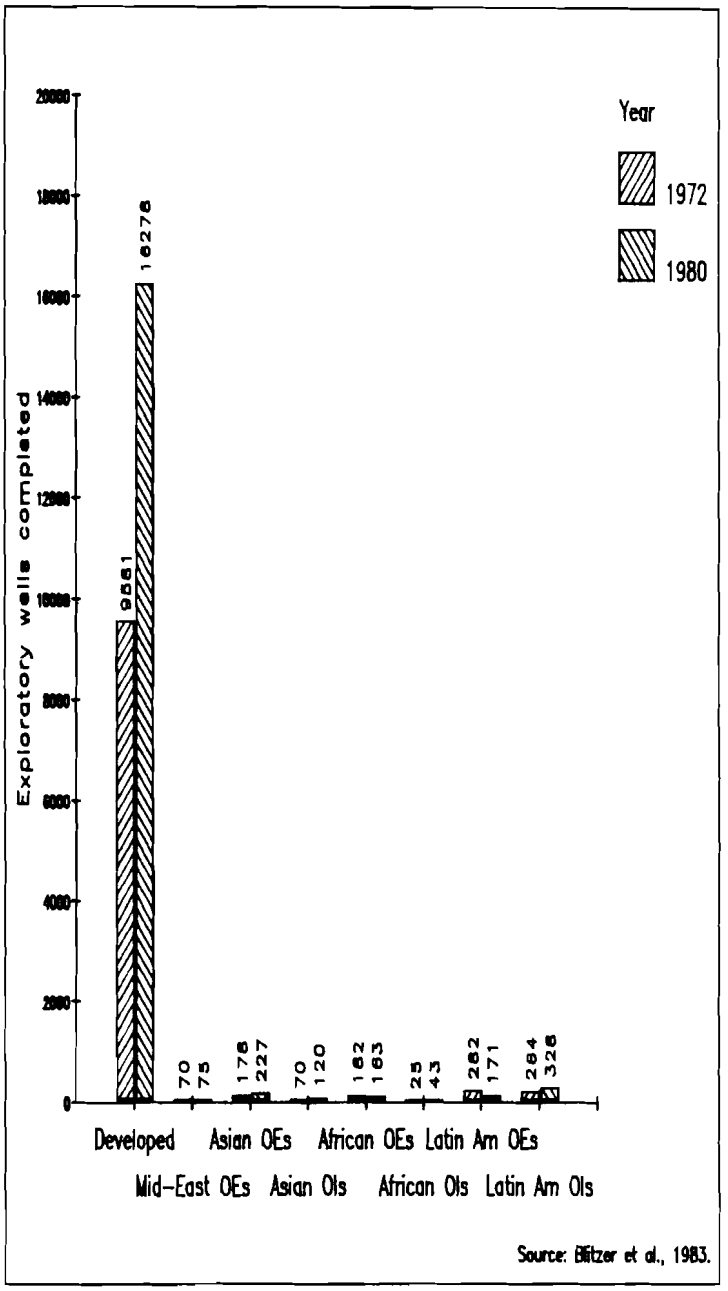


Fig. 2. Exploratory wells completed, 1972-1980

world total fell from 3.4 to 2.8%. Exploratory drilling declined in Turkey, remained constant in Argentina and Brazil, and increased significantly in Colombia, Taiwan, Thailand, and the Philippines (Broadman, 1983). Similar conclusions about exploratory activity can be drawn from still another measure of activity -- the number of rigs active at year end (Fig. 3). The data indicate that only in the African OIDCs was there a share increase in active rigs at year end relative to the rest of the world between 1972 and 1980. All regions reported an increase in numbers of active rigs.

The overwhelming dominance of the developed countries in all three measures of exploratory activity is surprising, considering the success rates for exploratory drilling. Figure 4 shows that between 1972 and 1980, success rates increased dramatically in OIDCs for crude oil and natural gas. For an individual well, the probability of an oil discovery was much higher during this period in the developing countries relative to the developed world. By 1980, only in the Asian oil importing countries were crude oil success rates lower than those for the developed countries. Success rates for natural gas were highest in the developed countries reflecting perhaps more of a concerted effort for discovering and developing alternatives to oil.

Development well drilling more than doubled between 1972 and 1980, and, like exploratory activity, most of the increase occurred in the developed countries. In 1980 the developed countries accounted for nearly 93% of the world total as depicted in Fig. 5. In absolute numbers, development drilling increased in all regions except for the African oil exporting developing countries (OEDCs). The share of world development drilling increased in the Asian OEDCs and the Asian and

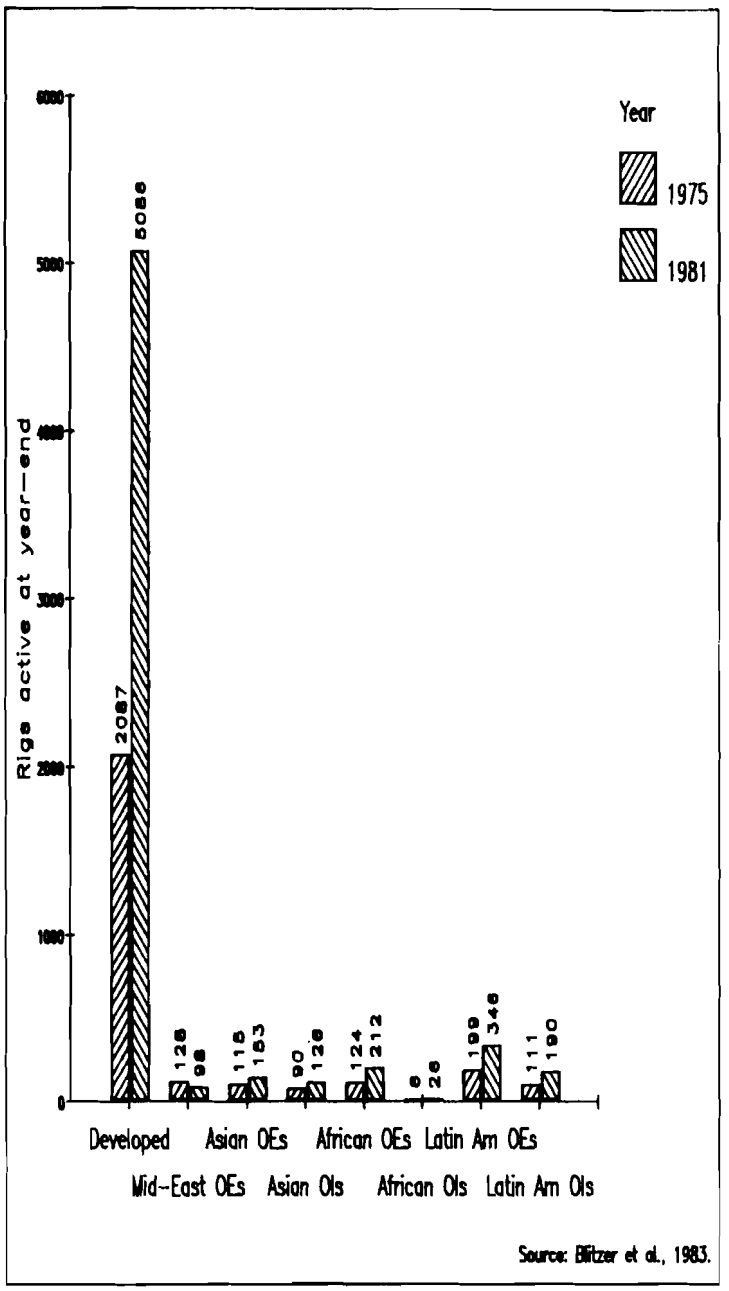
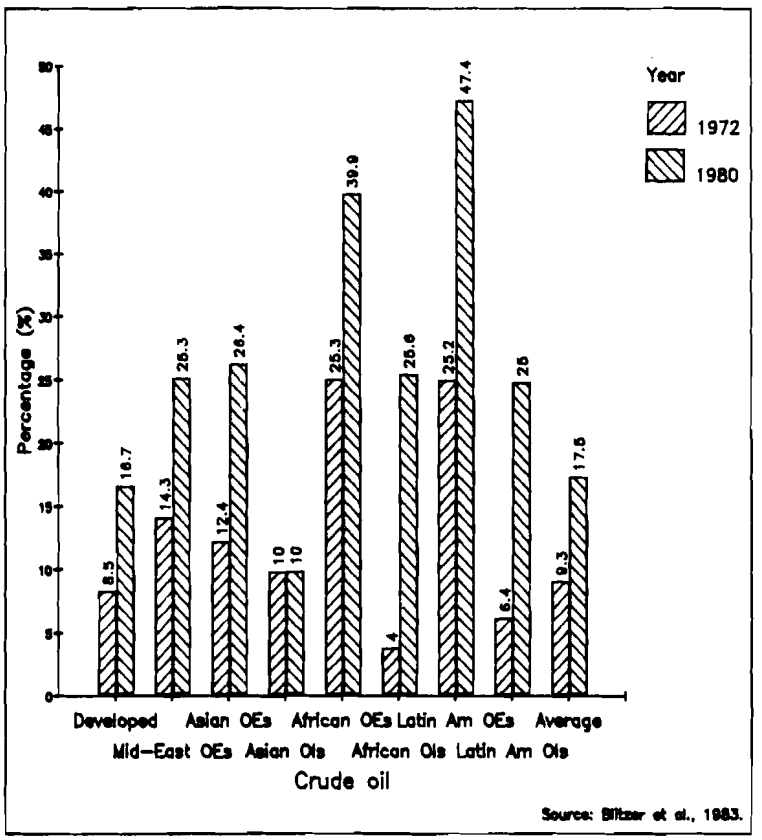


Fig. 3. Exploration rigs active at year end, 1975-1981



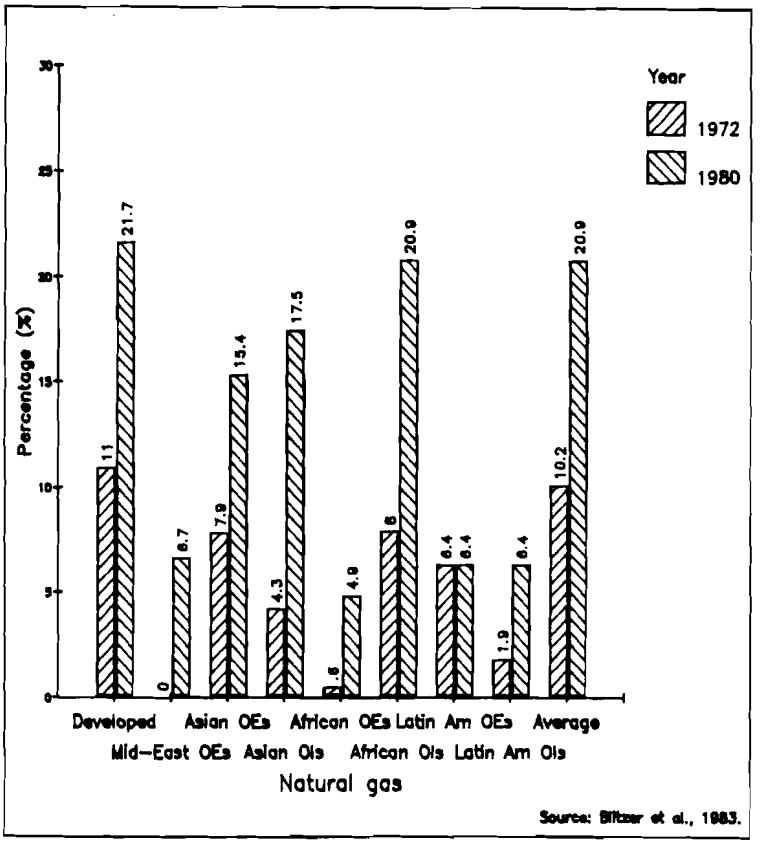


Fig. 4. Exploratory drilling success rates for crude oil and natural gas, 1972-1980

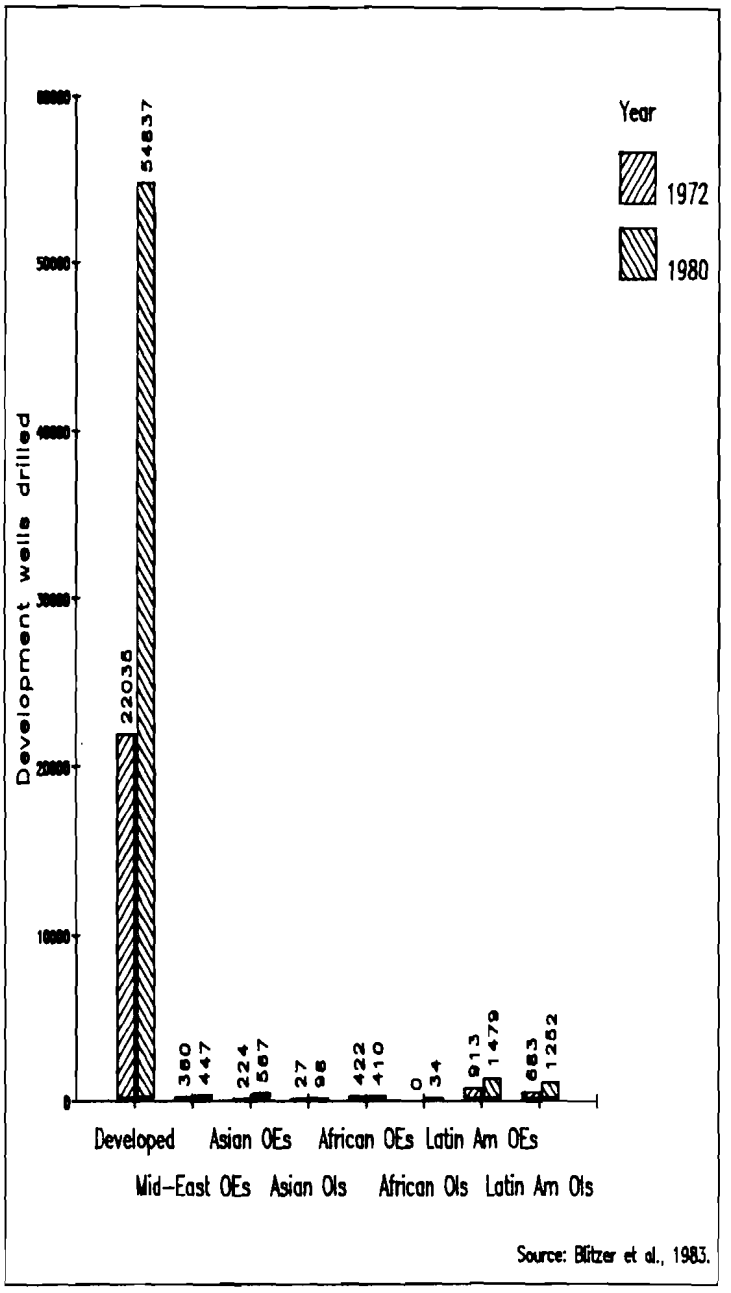
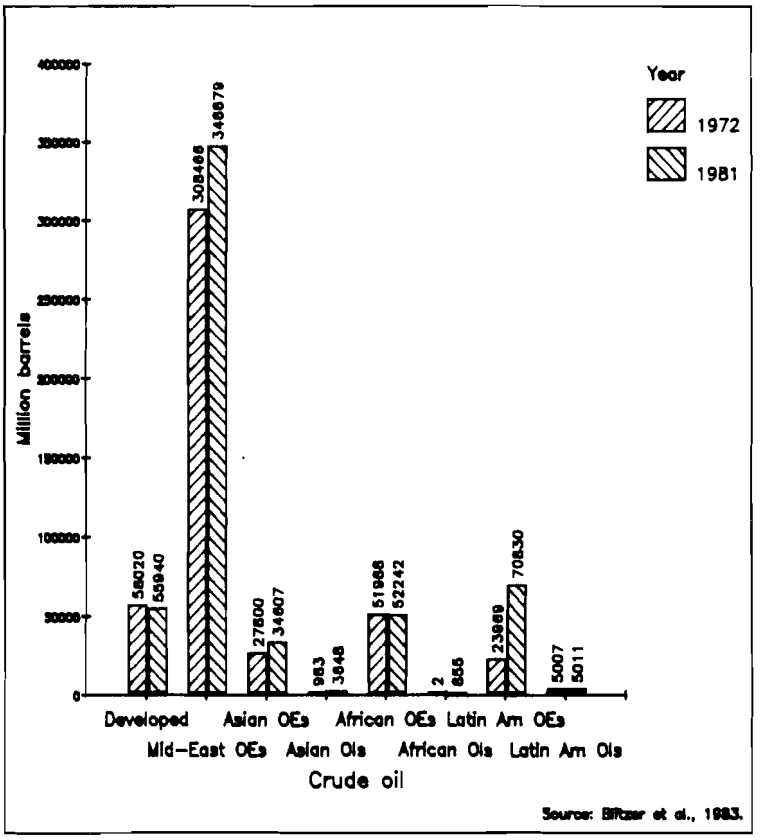


Fig. 5. Development wells drilled, 1972-1980

African OIDCs. The resultant changes in proved crude oil and natural gas reserves from development drilling between 1972 and 1981 are shown in Fig. 6. Unlike exploration and development data, oil and natural gas reserves are heavily concentrated among the OEDCs. There was a decline in the share of the reserves held by the developed countries despite their record levels of exploration and development activity. The largest percentage increases in reserves occurred in the OIDCs; however, their share remained relatively meager compared to the world total. As shown in Fig. 7, oil production increased everywhere except for the Middle East and African exporters between 1972 and 1980. The largest percentage increase occurred in the Asian exporting countries. A similar situation is found with natural gas, except that the share of production in the developed countries declined by about 14%.

Exploration and development expenditures are, perhaps, the most unequivocal measure of activity. Unfortunately, comprehensive expenditure data are unavailable for developing countries. To overcome this deficiency, Blitzer et al. (1983) employed three alternative techniques for extrapolating investment cost functions from known areas, such as the United States, into other countries based on drilling activity reports. The results from application of these methods show, as expected, that investment expenditures are also highly skewed toward developed countries. In 1980, based on an average of the three methods, the developed countries accounted for over 70% of all investment expenditures. The Asian OEDCs and OIDCs accounted for 9% and 3.6%, respectively. In Africa, the share of total expenditures was 3.6% for the OEDCs and only 0.5% for the OIDCs. The share of expenditures among the Latin American OEDCs and OIDCs was 5.4% and 3.0%, respectively.



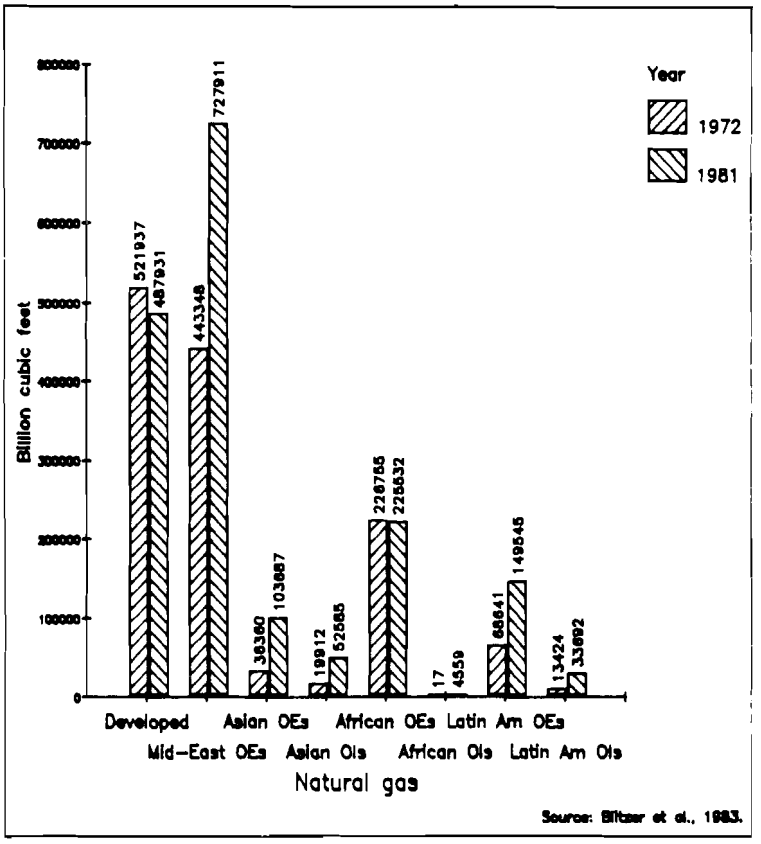
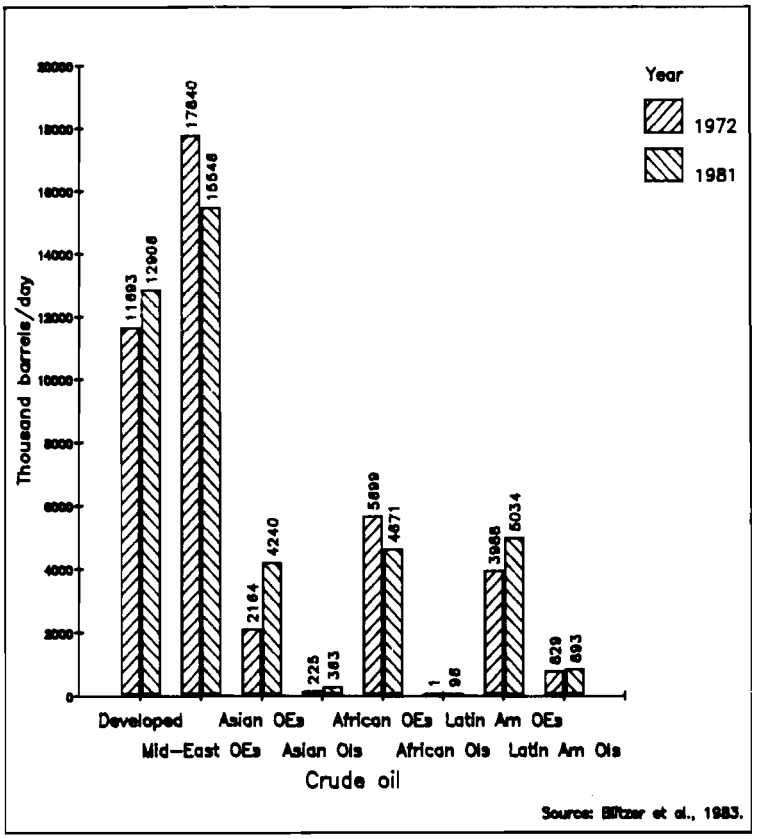


Fig 6. Estimated proven reserves of crude oil and natural gas, 1972-1981



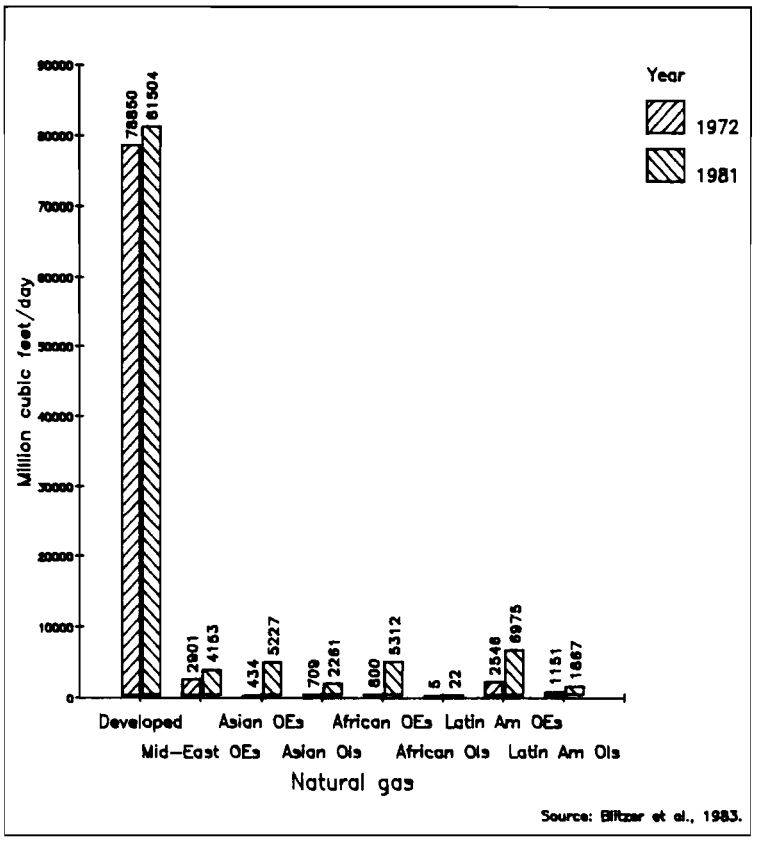


Fig. 7. Estimated daily crude oil and natural gas production, 1972-1981

Since the expenditure shares are higher in developing countries relative to the number of exploratory and development wells, expenditures per well drilled are also higher.

The data and analyses show a clear but perverse relationship. Exploration and development activity and expenditures are highly concentrated in the developed nations, and oil and gas reserves and production is concentrated in the developing nations. Figure 8 displays this inconsistency by showing the percentage distribution of gross additions to hydrocarbon reserves and the percentage distribution of exploratory wells drilled. To further illustrate the inefficiency in exploration and development, Blitzer et al. (1983) constructed a number of statistics to measure the effectiveness of exploratory and development activity during the 1972 to 1980 period. Figure 9 shows two of these -- millions of barrels of crude oil discovered per exploratory well drilled and barrels of new oil production per development well drilled. Exploration effectiveness was highest for the Mideast oil exporters followed by the Latin American, African, and Asian OEDCs. The OIDCs had the lowest effectiveness in exploration among the developing countries, but it was significantly higher than that reported for the developed countries. Development effectiveness was highest in the African oil importers and Asian oil exporters. Only in the Latin American oil importing countries was development effectiveness lower than that for the developed countries.

Although the data unambiguously indicate that the OIDCs did not participate in the surge of exploratory and development activity, the activity that did occur was overwhelmingly concentrated in a few oil producing OIDCs, and the share of activity in the nonproducing OIDCs

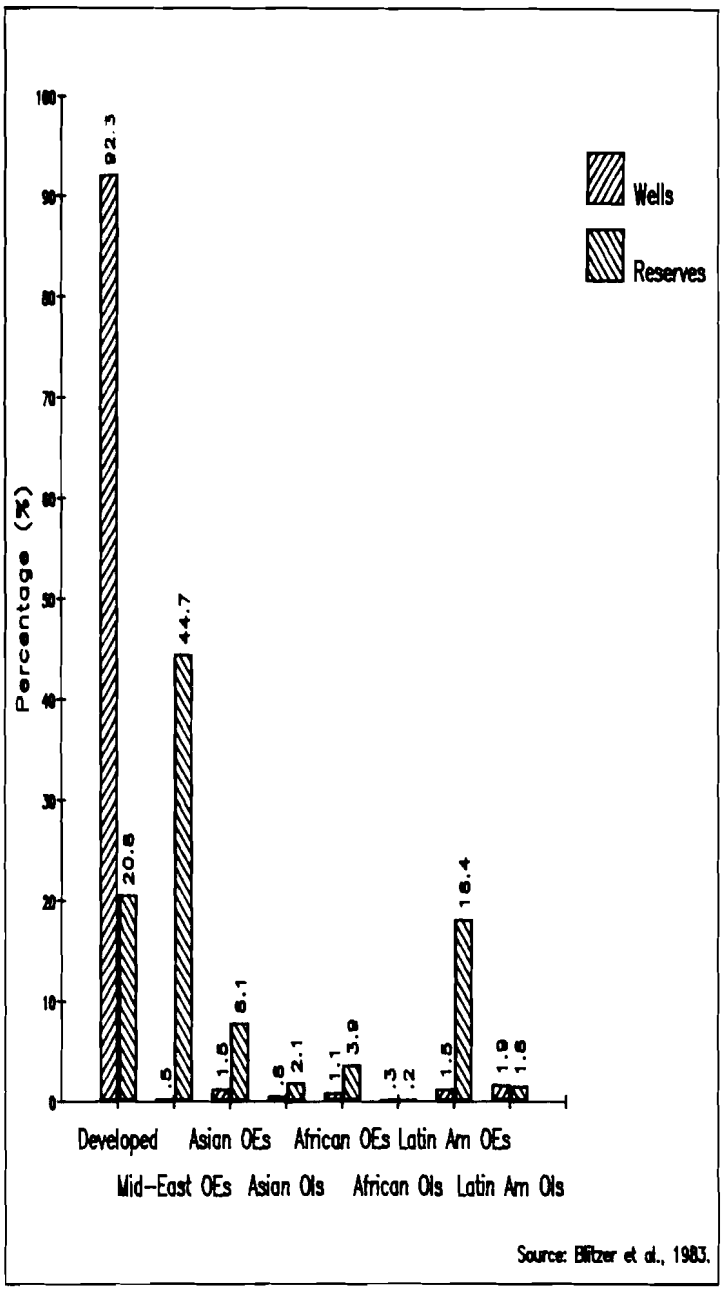


Fig. 8. Percentage distribution of gross hydrocarbon reserve additions and exploratory wells completed from 1972 to 1980

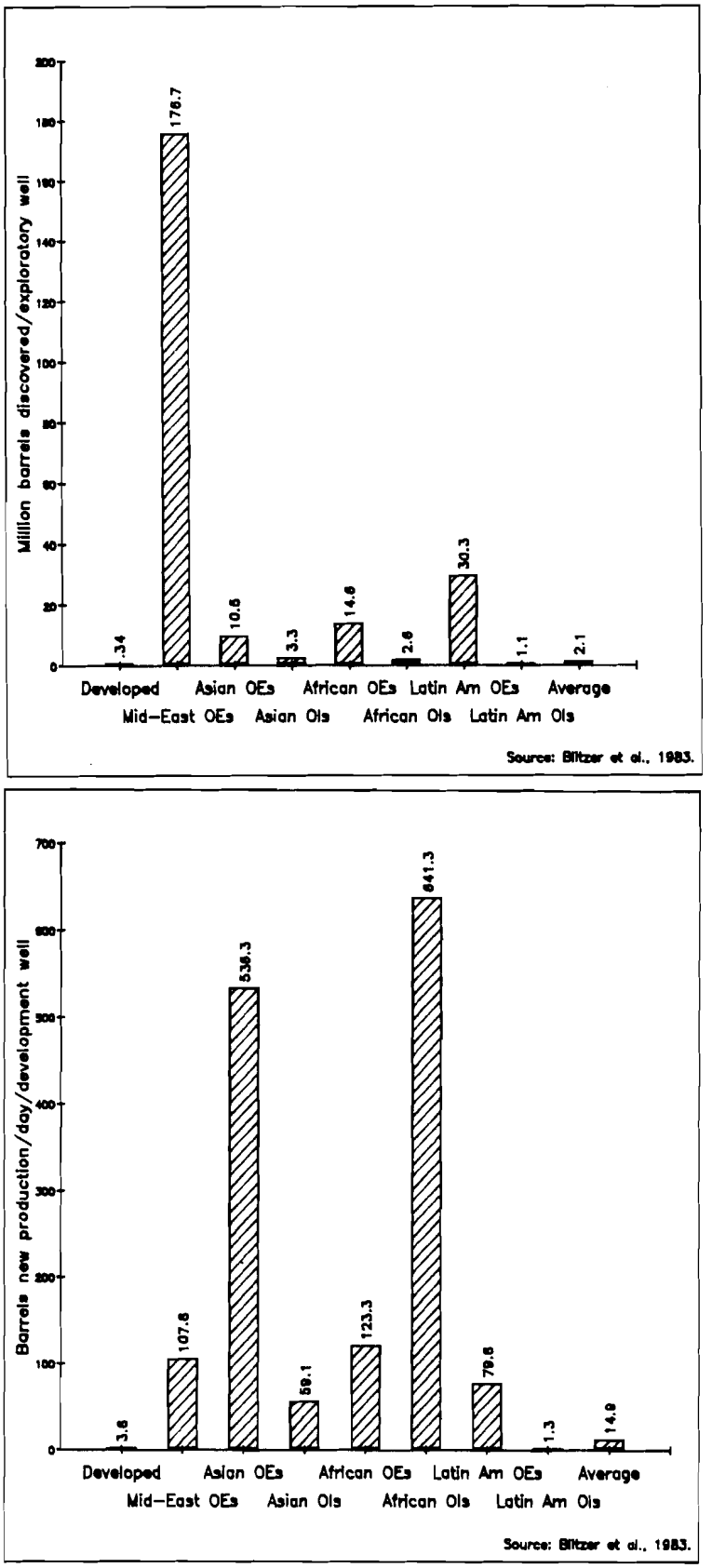


Fig. 9. Effectiveness in exploratory and development drilling from 1972-1980

declined considerably relative to the world total (World Bank, 1983). Within the oil producing OIDCs, the majority of the activity was carried out by the national oil companies of Argentina, Brazil, and India. Between 1972 and 1980 over 90% of the exploratory wells in the OIDCs were drilled in the countries that were already producing oil, and in 1980 the percentage was over 93%. In the OIDCs, the national oil companies (NOCs) drilled about 73% of the wells with the majority of these limited to three country NOCs -- Argentina, Brazil, and India. The seven international majors accounted for about 17% of the exploratory wells.

2.2 The 1980s

Between 1978 to 1979 there was a second major world oil price increase ($12.70 to $32.00/bbl, Curlee, 1985). This stimulated an increase in exploratory activity in OIDCs in the early 1980s that reached record levels in 1982. The data for this period show that relative to all the OIDCs, there was a slight increase in the share of wells drilled in the nonproducing countries from 1980 through 1982 (Table 1). Although the total number of wells drilled in the OIDCs were at record levels, the activity was highly skewed and limited to a relatively few countries in each region. The Cameroon and the Ivory Coast accounted for over 67% of the exploratory wells drilled in Africa. In Latin America, 77% of the exploratory wells were drilled in Argentina and Brazil. The Sudan and Turkey had 67% of the exploratory wells among the North African and Middle East OIDCs. And, Burma, India, Pakistan, Philippines, and Thailand accounted for nearly all of the exploratory activity in Asia. Other measures of activity show trends that are similar to those of the 1970s.

Table 1. Exploratory wells drilled in OIDCs, 1978-1983

	1978	1979	1980	1981	1982	1983
AFRICA--OIL PRODUCERS						
Cameroon	21	25	17	18	11	4
Ghana	1	2	0	1	1	0
Ivory Coast	5	3	2	10	14	4
Zaire	5	1	0	3	4	4
Subtotal	32	31	19	32	30	12
AFRICA--NON PRODUCERS						
Chad	5	1	0	0	0	0
Equatorial Guinea	0	0	0	0	4	0
Gambia	0	1	0	0	0	0
Guinea	0	0	0	1	0	0
Kenya	1	0	0	1	1	0
Mali	0	1	0	0	1	0
Mauritania	0	0	1	0	1	0
Niger	0	3	3	0	2	1
Senegal	0	0	0	0	1	0
Sierra Leone	0	0	0	0	1	0
Somalia	0	0	1	1	3	0
Tanzania	0	1	0	0	2	1
Subtotal	6	7	5	3	16	2
TOTAL AFRICA	38	38	24	35	46	14
NO. AFRICA & MIDEAST--OIL PRODUCERS						
Israel	5	7	10	7	14	8
Morocco	4	7	10	14	11	8
Turkey	24	20	29	29	39	21
Subtotal	33	34	49	50	64	37
NO. AFRICA & MIDEAST--NON PRODUCERS						
Jordan	1	0	0	0	2	4
Sudan	4	6	8	14	17	24
Yemen	0	0	2	1	0	0
Subtotal	5	6	10	15	19	28
TOTAL NO. AFRICA & MIDEAST	38	40	59	65	83	65
ASIA--OIL PRODUCERS						
Burma	0	NA	11	17	19	NA
India	66	65	14	17	NA	NA
Pakistan	6	10	9	13	10	14
Philippines	18	23	23	17	13	4
Thailand	8	10	14	21	30	38
Subtotal	98	108	71	85	72	56

Table 1. (continued)

	1978	1979	1980	1981	1982	1983
ASIA--NON PRODUCERS						
Bangladesh	2	NA	NA	5	2	1
Korea	0	0	0	1	0	1
Nepal	0	0	0	1	0	0
Sri Lanka	0	0	0	2	0	0
Subtotal	2	0	0	9	2	2
TOTAL ASIA	100	108	71	94	74	58
LATIN AMERICA--OIL PRODUCERS						
Argentina	88	71	110	127	107	130
Barbados	0	0	0	3	0	0
Bolivia	13	12	6	19	18	8
Brazil	89	134	166	245	334	275
Chile	14	22	16	62	41	17
Colombia	29	30	34	75	73	36
Guatemala	0	1	2	6	9	5
Subtotal	233	270	334	537	582	471
LATIN AMERICA--NON PRODUCERS						
Dominican Republic	0	3	0	0	1	0
Guyana	0	0	0	1	2	0
Honduras	2	1	1	0	0	1
Jamaica	0	0	0	2	4	0
Nicaragua	3	0	0	0	0	0
Panama	2	0	0	0	0	0
Paraguay	3	1	0	1	1	0
Subtotal	10	5	1	4	8	1
TOTAL LATIN AMERICA	243	275	335	541	590	472

Source: AAPG Bulletin, Worldwide Report Issues.

Notes: Only offshore wells drilled are reported for Bangladesh in 1978, Burma in 1978, and India in 1980 and 1981.

The change in oil reserves and daily production and gas reserves in the OIDCs are shown in Table 2. Proved oil reserves increased significantly in all regions. There were also significant increases in oil production and proved gas reserves in all areas except for the North African and Middle East OIDCs.

Beginning in mid-1981, there were a number of complex and interrelated factors that caused a precipitous decline in exploratory activity in 1983 and thereafter (Table 1). A worldwide economic recession, and to some extent the lagged addition of more fuel-efficient capital stock as a result of the 1978-79 price increase, sharply reduced the demand for oil. For example, world oil consumption was under 58 million barrels per day in 1983, down from the record level of 65.1 million barrels per day in 1979, and for the largest consumer, the United States, demand dropped by 20% from 1978 to 1982 (Curlee, 1985). The expected results were a reduction in oil production and a decline in world prices. Oil production among OPEC countries had fallen from 31 million barrels per day in 1979 to 17.3 million barrels per day in May 1984 (Curlee, 1985). And in March 1983, OPEC reduced its benchmark price by $5 per barrel and imposed an output ceiling of 17.5 million barrels per day. The effect of this soft energy market and declining oil prices on the international oil companies was as expected -- a reduction in cash flows, and hence, smaller exploration budgets. Further, the high interest rates that prevailed only led to increases in already high exploration and drilling costs. There is evidence that in response to the recession, OIDCs became more anxious to tax energy projects in order to stimulate their own faltering economies (Blitzer et al. 1983).

Table 2 . Proved oil and gas reserves and daily oil production in OIDCs, 1980 and 1984

Region/Country	1980 Oil 1,000 bbl	1980 Gas 10^9 cu ft	1980 Oil Production 1,000 bbl/d	1984 Oil 1,000 bbl	1984 Gas 10^9 cu ft	1984 Oil Production 1,000 bbl/d
AFRICA						
Benin	-	-	-	100,000	-	6.9
Cameroon	140,000	-	57.0	550,000	4,150	125.0
Ghana	7,000	-	2.0	3,800	4	0.6
Ivory Coast	-	-	3.0	108,000	3,000	22.0
Zaire	135,000	50	22.0	110,000	30	27.0
Subtotal	282,000	50	84.0	871,800	7,184	181.5
NO. AFRICA & MIDDLE EAST						
Israel	1,000	100	0.7	750	8	0.1
Morocco	100	25	0.2	250	-	0.2
Sudan	-	-	-	300,000	-	-
Turkey	125,000	500	42.0	294,000	600	41.0
Subtotal	126,100	625	42.9	595,000	608	41.3
ASIA						
Bangladesh	-	8,000	-	-	7,000	-
Burma	25,000	135	30.0	28,000	170	30.0
India	2,600,000	9,300	185.0	3,500,000	15,000	543.0
Pakistan	200,000	15,800	10.0	82,000	15,760	18.0
Philippines	25,000	-	14.0	16,300	12	12.0
Thailand	-	8,000	-	156,000	5,900	19.0
Subtotal	2,850,000	41,235	239.0	3,782,300	43,842	622.0
LATIN AMERICA						
Argentina	2,400,000	15,200	490.0	2,266,000	24,628	467.0
Barbados	1,500	-	1.0	600	-	1.7
Bolivia	150,000	5,400	30.0	158,000	4,270	20.0
Brazil	1,200,000	1,500	190.0	1,976,000	2,840	437.0
Chile	400,000	2,500	30.0	736,000	2,360	38.0
Colombia	710,000	5,000	125.0	624,000	3,786	165.0
Guatemala	16,000	-	3.0	500,000	30	5.2
Subtotal	4,897,500	29,600	869.0	6,260,600	37,914	1133.9
TOTAL OIDCs	8,155,600	71,510	1234.9	11,509,700	89,548	1978.7

Source: Oil and Gas Journal, Worldwide Reports 1979, 1980, and 1985.

Another significant manifestation of the 1980s was the debt crisis experienced by most developing countries. The crisis affected their borrowing ability, and, since over 60% of exploratory activity is carried out by NOCs, it undoubtedly affected exploration budgets (Mikesell, 1984). The last year of data on exploratory wells drilled shows a significant decline in activity in all regions except for the Asian oil producers. The number of wells drilled in oil producing OIDCs fell by about 20% (Table 1). However, the number of wells drilled in the nonproducing regions declined by nearly one-half.

The available data show, for both the 1970s and 1980s, that the OIDCs did not participate as a group in the worldwide expansion of exploratory and development activity concomitant with their potential. It is clear that on the basis of the available evidence (i.e., success rates and effectiveness in exploration and development), more activity should have taken place in the OIDCs. In the most comprehensive investigation of exploratory activity in developing countries, Blitzer et al. (1983) assert that although exploration, development, and production costs are higher in OIDCs, and discoveries are likely to be of smaller size, the data indicate that exploration in developing countries is neither more risky geologically, nor more expensive per barrel of reserve additions, than the average elsewhere. In the following section some of the nongeologic factors that might explain the lack of exploration and development in OIDCs are discussed.

3. OBSTACLES TO OIL AND GAS EXPLORATION AND DEVELOPMENT

The majority of oil and gas exploration and development in OIDCs has been undertaken by national oil companies, and it has been conceded that not enough is undertaken by private petroleum companies. [Even the National Petroleum Council (1982) admits to the low level of activity by U.S. petroleum companies in OIDCs.] The World Bank (1983), Broadman (1983), and others have identified a number of obstacles that may have deterred or limited petroleum company participation. These constraints include (1) geological prospects, (2) the extent of infrastructural development, (3) contractual arrangements and taxation, and (4) political risk. Each of these deterrents is discussed in the remainder of this section.

3.1 Geological Prospects

The global distribution of oil and gas reserves is highly skewed, with 57% of proven reserves now held by the Middle East nations. The countries in Asia and the Pacific, Western Europe, Africa, and the Western Hemisphere currently hold about 2.6%, 3.5%, 8.0%, and 16.8% of world proven reserves, respectively. Between 1980 and 1985 total world proven reserves increased by nearly 9.0%; however, the distribution of these reserves changed very little (Oil and Gas Journal, 1979 and 1984).

The World Bank (1979) reported that of 70 developing countries evaluated, 23 had very high (over 1,500 million barrels) or high (750 to 1,500 million barrels) petroleum prospects, and an additional 15 had fair (100 to 750 million barrels) prospects. While there are good prospects for economically recoverable oil and gas deposits in OIDCs,

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there is a high probability that the fields discovered will be small-sized. It is widely acknowledged that the major international oil companies seek large oil and gas fields, and have no particular interest in oil fields under 50 million barrels and gas fields under 3 to 5 trillion cubic feet (Palmer, 1983). In general, the lack of interest in small-sized fields by large oil companies results from the fact that exploration and development costs per unit output are much higher and that small-sized fields are less likely to produce an exportable surplus, which is desired in order to secure supplies for downstream refining operations and to assure access to foreign exchange. The smaller independents could effectively exploit small-sized fields according to Palmer (1983); however, they have not been active because they have been constrained by cash flows, have taken advantage of domestic tax advantages, and have limited ability to spread risk among multiple ventures.

To be sure, prospective field size is a characteristic of exploration that depends critically on world oil prices. For example, the percentage of fields abandoned in the United States having less than 1 million barrels of oil declined from 24% between 1947 and 1969, to 6.1% between 1970 and 1972, and dropped to 0% between 1973 and 1975 (Wolstadt, 1983).

3.2 Infrastructural Development

It is conceded that exploration and development in OIDCs is more expensive, and the lack of infrastructure is one contributing factor. Broadman (1984) found in an econometric analysis of exploration in developing countries that infrastructure was a highly significant factor in determining activity in the oil producing developing countries. The

American Petroleum Institute (Wolstadt, 1983) notes that countries without infrastructure are likely to be at an exploration disadvantage regardless of the prospects of the geology. Furthermore, any infrastructure required to begin exploration and development reduces the total amount of risk capital available. And because infrastructure has many 'public good' characteristics, the private sector is unlikely to provide it. The National Petroleum Council (1982) argues that this is an appropriate area for third party, particularly the World Bank, financing involvement.

3.3 Contractual Arrangements and Taxation

There are four types of contractual arrangements that have been used in developing countries. These include (1) concessions, (2) production-sharing contracts, (3) non-risk and risk service contracts, and (4) joint ventures (see Broadman, 1983, Mikesell, 1984, Gillis, 1982 and the National Petroleum Council, 1982, for more detailed discussions). Concession arrangements essentially give the oil company ownership in the oil produced. The host government typically receives a portion of the production as a royalty and levies a tax on the revenue from the balance of the production. The oil company provides all of the exploration and development capital, and hence assumes all the risk. Under production-sharing contracts, the oil company provides all of the exploration and development capital and receives a portion of the output to recover its costs. The balance of production is shared between the host government and the oil company according to some prescribed rate. The host government shares directly in the development risk. Under non-risk service contracts, the oil company provides exploration and/or development services in return for a fixed fee. All exploration and

development risks are borne by the host government. The risk service contract is a variant whereby the oil company provides for exploration, and, if a discovery is made, the host government compensates the oil company with a fee to cover exploration and development costs. Here the oil company assumes the exploration risk and the host government assumes all of the development risk. The last form of contract, the joint-venture, is an arrangement in which the host government provides equity, usually in the development stage, along with the oil company. The oil company's exploration costs are recovered first and then each party shares in the returns in proportion to their respective equity interests.

In recent years there has been shift away from concessionary agreements to production-sharing contracts. Broadman (1984) found in a study of 47 OEDCs and OIDCs that 77% were using exclusive concessions in 1970, and, in 1980, this percentage had dropped to 34%. This trend clearly shows an increasing involvement by host governments in petroleum related activities, and, more importantly, a greater willingness to accept some of the risks, although in most cases only development risks. Further, in the 1970s state oil companies held exploration rights on acreage far in excess of what they could hope to explore. Since then prospective acreage has become more available to private firms.

The evolution of contracting arrangements has also led to a gradual blurring and changing of the fiscal provisions embodied in each type of agreement. There are three distinct forms of taxes prevalent in the various contracting arrangements: (1) signature bonuses, (2) royalties, and (3) profit taxes (again, see Broadman, 1983 and 1984, Mikesell, 1984, and Gillis, 1982 for more discussion). A signature bonus is

essentially a front-end lump sum tax that is paid by the oil company for the right to explore, and is usually associated with competitive bidding for exploration rights. In situations where there is considerable geologic information, and where the prospects for a discovery are good, bonuses provide a mechanism for increasing the share of economic rents going to the host government in early years. However, competitive bonus bidding may fail to attract prospective oil companies and be counter productive when there is little geologic information; a case in point is provided by Guatemala (Mikesell, 1984).

The main revenue generating fiscal instruments used by developing countries are the royalty payment and the profit tax. Unlike bonuses, the key feature of these fiscal instruments is that they are paid in the future and only payable upon discovery and production. Further, the bonus payment has the effect of decreasing the expected rate of return of a lease as compared to the royalty and profit tax, which when discounted to the present has a lower net present value. The difference between the two fiscal instruments is that royalties are fixed payments levied on each unit (or gross revenue) of oil produced, and the profit taxes are levied on net revenues and are not paid until the oil and gas development begins making a profit. Relative to the other fiscal measures, the profit tax results in more risk-sharing; however, profit taxes have the disadvantage of delaying revenues to the host government. Profit taxes may also show up as windfall, excess profit, and resource rent taxes, which are designed to capture the windfall, excess profit, or rent when the rate of return on the investment to the oil company exceeds some specified level.

From the perspective of the oil company, the major distinction between the royalty payment and the profit tax is that the tax is usually creditable against the oil company's government income taxes, while the royalty is considered a deductible expense. Quite naturally, there has been a tendency for oil companies to encourage foreign governments to label royalties as taxes. In the United States, determining whether a particular tax is an income tax, and therefore creditable, is a very contentious issue. In 1975 Section 907 of the Internal Revenue Code was enacted to provide clarification. The code provides that the tax a U.S. company pays on foreign oil and gas extraction income qualifies to the extent of a credit of up to 48% (i.e., highest U.S. rate). Taxes above 48% could not be credited or deducted. Further, the IRS position was now to restrict creditable taxes to those that bear a strong resemblance to the structure of the U.S. income tax. The 1975 tax code also provided that losses generated by petroleum operations could be used to reduce foreign oil and gas nonextraction income. This single-country loss rule effectively raised the level of foreign income, thereby allowing a greater use of foreign tax credits. The impact of the single-country loss rule would be to stimulate exploratory drilling abroad; however, the restrictions on the use of foreign tax credits in addition to other legislation, notably The Foreign Corrupt Practices Act, The Export Administration Act, and The Tax Reform Act, have burdened the operations of U.S. petroleum firms operating abroad (NPC, 1982). Although not conclusive, the data on the number of exploratory wells drilled by U.S. firms in OIDCs declined significantly after 1975 (Fig. 10). Moreover, in 1982 the

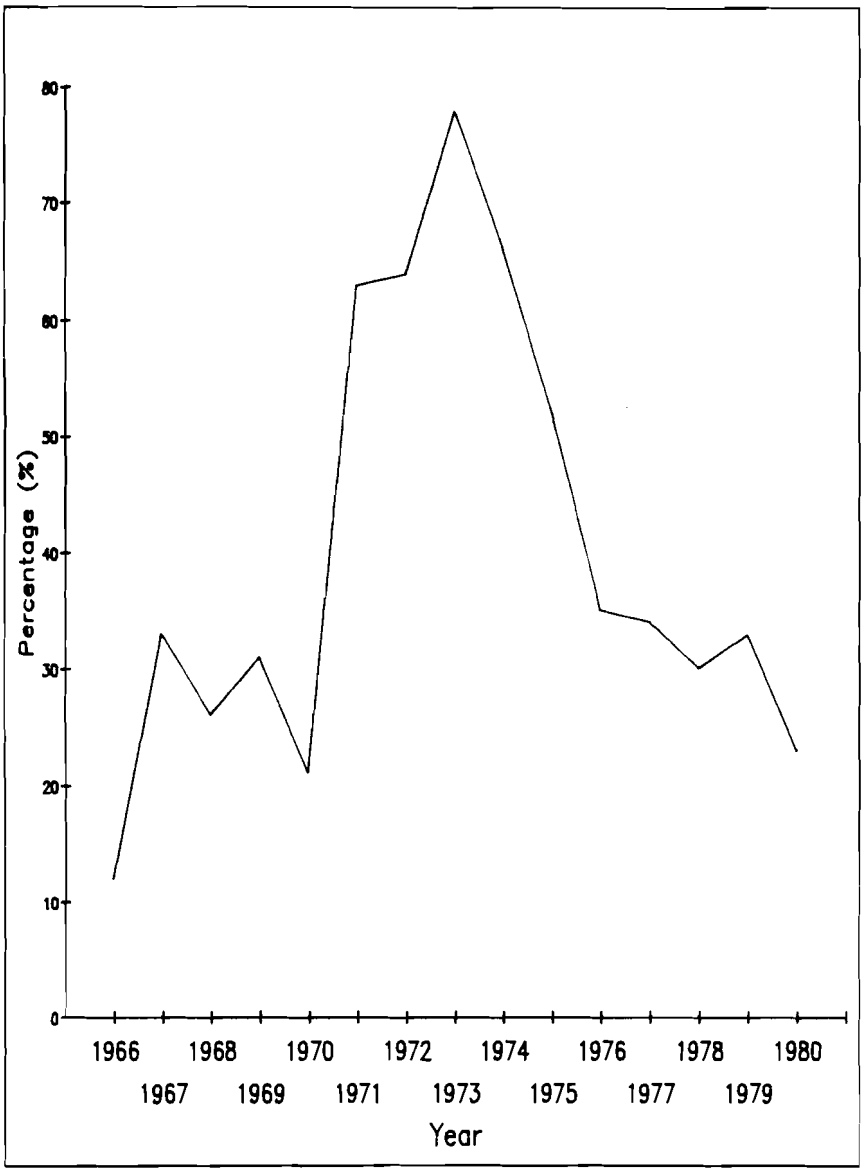

Fig. 10. Percentage of exploratory wells drilled in developing countries by U.S. companies, 1966-1980

single-country loss rule was repealed with the passage of the Tax Equity and Fiscal Responsibility Act (TEFRA) in 1982. Moreover, the existence of special tax benefits, such as drilling funds for individual investors and percentage depletion allowances for certain oil companies, further discourages U.S. firms from operating abroad.

As reported by Broadman (1983 and 1984), the last decade has seen an increase in yields accruing to host governments as a result of higher levels of taxation and a change in the mix of fiscal instruments. Specifically, a shift away from royalties to the use of more profit taxes. Still, in most developing countries, the use of high royalties, large host government production shares, bonuses and competitive bidding, high income taxes, windfall taxes that are not commensurate with risk, and tax systems that do not allow for foreign tax credits, have not encouraged exploration and development (Mikesell, 1984). Further, fiscal instruments, in particular profit taxes, are generally applied uniformly across fields and thus tend to be regressive. That is, the host government's share of profit bears no resemblance to field size. Palmer (1983) states, "In response to the large oil price increases, countries raised substantially the government share of project revenues from royalties, taxes, production shares, and so on to obtain a larger share of the resource rent and to limit the 'windfall gains' made by investors. However, the structure of the fiscal terms in many cases not only limited windfall gains but also made it unprofitable for investors to explore for small fields."

The World Bank (1983) notes that a number of countries have made conditions more attractive to oil firms in recent years. Increasing progressivity in tax structures will undoubtedly make high cost, small

fields more appealing to potential investors. In a simulation of the progressivity of tax structures, Kemp and Rose (1982), found that despite recent improvements at increasing progressivity, tax structures still discriminate against oil and gas fields characteristic of developing countries. Broadman (1984) gives two reasons for the reluctance on the part of host governments to adopt more progressive contract and tax structures. Progressivity would shift a higher degree of risk to the host government and tax revenues would not accrue until the project is well underway.

3.4 Political Risk

Political risk from the perspective of the oil firm is usually characterized by expropriation, nationalization, restrictions on access to foreign exchange, property damage, and any other changes in the business environment associated with political events (Broadman, 1983). To paraphrase Palmer (1982), although there is wide contention that political risk is an impediment to oil and gas exploration, the evidence suggests that the major international oil companies do not view it as a serious problem. Like geologic risk, the large oil firms have alternative strategies to mitigate risk, the smaller firms having fewer options.

Oil firms can minimize political risk by adopting risk averting and market diversification strategies. Risk averting strategies could include adding risk premiums to required expected rates of return on oil and gas investments or by requiring shorter payback periods on investments. To be sure, these political risk aversion strategies require higher minimum acceptable selling prices and detract from the economic viability of exploration and development programs.

Alternatively, risk can be offset by engaging in oil exploration in a number of countries simultaneously (i.e., risk spreading). Political risk can also be transferred to the extent that the host government participates on an equity basis in exploration joint ventures. Perhaps the most comprehensive measure available to minimize risk is to purchase political risk insurance offered to U.S. firms through the Overseas Private Investment Corporation (OPIC). This political risk insurance program was enacted in 1969 to facilitate the participation of U.S. companies in the economic and social progress of developing countries. OPIC insurance provides coverage for expropriation, contract alterations, damage, interference, and inconvertibility of currency. However, the insurance program is restricted to countries that have a special insurance agreement with the U.S. government.

Large international oil companies have many options for dealing with political risk; smaller firms that cannot spread risk can engage in joint ventures and purchase insurance. As discussed in the next section, the World Bank is making a presence in oil and gas exploration and development, and the mere presence of the Bank can help to reduce the perception of political risk.

4. THE WORLD BANK CATALYTIC EFFORTS

Many countries have experienced an absolute decline in exploratory activity, and in still other countries, apparently rich in potential, there has been no exploratory activity whatsoever. In an effort to promote exploration and development in OIDCs, various multilateral and bilateral assistance programs have been formulated. The most important and comprehensive of these is the World Bank's program to accelerate petroleum production in developing countries.

In 1977 the World Bank approved and initiated a program calling for expansion of lending in the development of fuel and non-fuel mineral resources of member countries [World Bank, 1979]. The focus of the program was to be on countries that have good prospects for producing petroleum, but do not have the experience to do so without technical assistance. Moreover, priority was to be given to those countries that are poor, have large populations, are heavily dependent on oil, and have the greatest need for technical assistance [World Bank, 1979].

The World Bank (more specifically the International Bank for Reconstruction and Development and the International Development Association) lending program from July 1977 through June 1984 is summarized in Table 3. The program grew steadily each year from $150 million in fiscal year 1978 to over $1 billion in fiscal year 1983. In 1984 oil and gas lending declined appreciably. The data reveal that oil and gas loans were primarily directed at existing oil producing countries. As a group they received approximately 86% of total loans approved, and within this group there were a number of oil exporting nations -- China, Congo, Egypt, Nigeria, Peru, and Tunisia. The oil

Table 3. World Bank oil and gas lending projects, 1977-1984

Country	Amount	Project Type
Fiscal Year 1978		
India	$150.0	Oil Development
	150.0	
Fiscal Year 1979		
Thailand	4.9	Gas Development
Turkey	2.5	Oil Development
Pakistan	30.0	Oil Development
Egypt	75.0	Gas Development
	112.4	
Fiscal Year 1980		
Thailand	107.0	Gas Development
Congo	5.0	Exploration Promotion
Peru	32.5	Oil Development
Morocco	50.0	Exploration Support
Madagascar	12.5	Exploration Promotion
Bolivia	16.0	Exploration Support
Egypt	50.0	Gas Development
Honduras	3.0	Exploration Promotion
Tunisia	37.0	Gas Development
Somalia	6.0	Exploration Promotion
Tanzania	30.0	Exploration Support
Argentina	27.0	Exploration Support
South Yemen	9.0	Exploration Promotion
	385.0	
Fiscal Year 1981		
Liberia	5.0	Exploration Promotion
Turkey	25.0	Exploration Support
India	400.0	Oil Development
Turkey	62.0	Oil Development
Egypt	25.0	Exploration Support
Bangladesh	85.0	Gas Development
Guinea-Bissau	6.8	Exploration Promotion
Panama	6.5	Exploration Promotion
Mali	3.7	Exploration Promotion
Jamaica	7.5	Exploration Support
Portugal	20.0	Exploration Support
Costa Rica	3.0	Exploration Promotion
	649.5	

Table 3. (continued)

Country	Amount	Project Type
Fiscal Year 1982		
Argentina	200.0	Oil Development
Argentina	100.0	Oil Development
Mauritania	3.0	Exploration Promotion
Gambia	1.5	Exploration Promotion
Kenya	4.0	Exploration Promotion
Tanzania	20.0	Exploration Support
Guyana	2.0	Exploration Promotion
Egypt	90.0	Gas Development
North Yemen	2.0	Exploration Promotion
Peru	5.3	Oil Development
India	200.0	Oil Development
Romania	101.5	Oil Development
Nepal	9.2	Exploration Promotion
Thailand	90.0	Gas Development
Ivory Coast	101.5	Oil Development
	930.0	
Fiscal Year 1983		
China	162.4	Oil Development
China	100.8	Oil Development
Equatorial Guinea	2.4	Exploration Promotion
Ethiopia	7.0	Exploration Promotion
Ghana	11.0	Exploration Promotion
Guinea-Bissau	13.1	Exploration Promotion
India	165.5	Exploration Support
India	222.3	Gas Development
Madagascar	11.5	Exploration Support
Morocco	75.2	Exploration Support
Pakistan	43.0	Gas Development
Papua New Guinea	3.0	Exploration Promotion
Peru	81.2	Oil Development
Philippines	37.5	Exploration Support
Senegal	9.5	Exploration Promotion
Turkey	55.2	Exploration Support
	1,000.6	

Table 3. (continued)

Country	Amount	Project Type
Fiscal Year 1984		
Bangladesh	23.0	Exploration Promotion
Benin	18.0	Oil Development
China	100.3	Exploration Support
Guinea	8.0	Exploration Promotion
Hungary	90.0	Oil Development
India	242.5	Oil Development
Nigeria	25.0	Gas Development
Pakistan	51.5	Exploration Support
Pakistan	30.0	Oil Development
Somalia	18.0	Exploration Support
Zaire	4.5	Exploration Promotion
	610.8	
Total Exploration Promotion		163.7 (4.3%)
Total Exploration Support		735.2 (19.1%)
Total Oil Development		2,110.2 (55.0%)
Total Gas Development		829.2 (21.6%)
TOTAL ALL PROJECTS		3,838.3 (100.0%)

Source: World Bank Annual Reports and National Petroleum Council

exporting countries received nearly $790 million dollars in loans or about 20% of the total program. The bulk of the lending was also directed to a relatively few countries, India in particular. The three largest recipients, India, China, and Egypt, accounted for nearly $2 billion in loans or over 50% of total program lending. Table 3 also summarizes lending by type of project. Given the countries involved, it is not surprising to find that over 75% of the lending was to oil and gas development projects with only 14% to exploratory related activities.

The World Bank oil and gas lending program has been heavily criticized by the American Petroleum Institute (1983) and by the National Petroleum Council (1982). They note that the bulk of the lending has gone to state-owned oil companies, the effect of which was to merely displace private participation without increasing the overall level of hydrocarbon supplies. Their contention is supported by a U.S. Treasury study that claims that there were no instances through 1981 in which financing by the World Bank had been supplemented by a private oil firm. Moreover, the NPC and the API fear that since World Bank resources are limited, diversion of funds to petroleum projects would inhibit the development of badly needed infrastructure improvements, which in the long term may do more to attract private industry.

The API recommends that funds should be restricted to supplying support for geophysical surveys, development of oil and gas infrastructure, technical assistance, and financing a host country's share of development costs when alternative financing is not available. The NPC holds a similar position, except that it goes a bit further by recommending that the World Bank only become involved in organizing

existing geologic information. (A particularly scathing critique of the views of the API and the NPC is put forward by Zakariya, 1983).

Regardless of the criticisms, the World Bank program in oil development has had some successes. For example, in India, where the bulk of the lending has gone, proven oil reserves have increased by 35% since 1980 and oil production has increased by nearly 300%. However, the program has not been successful in attracting private investment nor in exploration. Recently, the World Bank approved a number of exploratory drilling loans targeted at specific opportunities rather than as part of a broad exploration program (World Bank, 1983). These loans have in common (1) geologic areas with known potential (2) an absence of international oil company participation, and (3) a national oil company with technical expertise. Given the dominance of national oil companies in exploratory and development drilling in OIDCs, it is likely that they will continue to receive the financial support of the World Bank. Hopefully, the presence of the Bank will also add an additional degree of stability and encourage smaller private oil companies, who perhaps have less concern for obtaining exportable surpluses to supply downstream operations and are attracted to small-sized fields. Underwriting risk to attract small firms and emphasizing exploration promotion and support loans at the expense of development and production may stimulate additional activity, especially in nonproducing OIDCs.

5. CONCLUSIONS

The exploration and development data strongly indicate that the developing countries, and in particular the nonproducing OIDCs, did not fully participate as a group in the resurgence of worldwide activity from the first major oil price increase. The evidence also suggests that the second oil price increase of 1978 and 1979 did bring more exploration to the OIDCs in 1980 to 1982, but then exploration declined drastically under pressure from falling real prices of oil. Moreover, the available evidence shows a highly skewed distribution of activity in the OIDCs. In each major region there are only a handful of countries that have had meaningful exploration activity, and fewer still in oil and gas development.

There is also a wide consensus in explaining the almost total absence of exploratory and development activity. The geology in OIDCs as a group tends to have high cost, small-sized field characteristics, which does not encourage investment by the large international oil companies seeking assured exportable supplies. On the contrary, the data show that success rates and exploration and development effectiveness is higher in the OIDCs relative to the developed countries. Because of the location of sedimentary basins, the size and flow characteristics of the fields, and particularly the lack of infrastructure, exploration and development costs tend to be higher in OIDCs, but not too high to warrant activity. All investigators of the exploration problem in developing countries agree that more private participation will be forthcoming if host governments make two concessions. First, that they offer contracting arrangements that

provide for more risk sharing, and second, include progressive fiscal terms in contracts that do not discriminate against small deposits and take advantage of foreign tax credits of the oil companies' home country. Investigators also agree that political risk is present, but they acknowledge that there are ways to spread and transfer risk.

The recent developments in oil markets (i.e., the soft demand and declining real prices) has reduced the cash flows of prospective exploration investors. Further, the consensus of many oil analysts is for a continuation of a rather soft energy market at least for the remainder of the decade followed by a slight upward trend in real prices. The expected market conditions in the near future do not appear to offer an environment conducive for oil companies to make major investments. It is likely that private participation will be relegated to those countries with proven potential and to those countries who are in a position to offer attractive incentives. The debt crisis now experienced by many OIDCs has exacerbated an already desperate problem. For some OIDCs, the World Bank multilateral assistance program may be an effective catalyst.

REFERENCES

Blitzer, C.R., P. E. Cavoulacos, D.R. Lessard, and J. L. Paddock, Overcoming the Oil Exploration Gap in Developing Countries, prepared for the U.S. Agency for International Development, Washington, D.C., October 1983.

Broadman, H. G., Determinants of Oil Exploration and Development in Non-OPEC Developing Countries, Resources for the Future, Discussion Paper D-114, Washington, D.C., October 1983.

Broadman, H. G., "Incentives and Constraints on Exploratory Drilling for Petroleum in Developing Countries: An Econometric Analysis," presented at the Annual Meeting of the American Economic Association, Dallas, Texas, December 1984.

Curlee, T. R., Future World Oil Prices: Modeling Methodologies and Summary of Recent Forecasts, ORNL/TM-9521, Oak Ridge National Laboratory, April 1985.

Gillis, M., "Evolution of Natural Resource Taxation in Developing Countries," Natural Resources Journal, 22:619-648, July 1982.

Kemp, A., and D. Rose, "Four Oil Fiscal Systems in Need of an Overhaul," Financial Times Energy Economist, 6:9-12, April 1982.

Mikesell, R. F., "Petroleum Exploration in Non-OPEC LDCs," Energy Policy, March 1984.

National Petroleum Council, Third World Petroleum Development: A Statement of Principles, U.S. Department of Energy, Washington, D.C., 1982.

Palmer, K., "Private Sector Oil Exploration in Developing Countries," OPEC Bulletin, June 1983.

Parra, F. R., "Exploration in the Developing Countries: Trends in the Seventies, Outlook for the Eighties," OPEC Review, 5(2), 22-38, Summer 1981.

Vogt, D. P., T. R. Curlee, and R. B. Shelton, The Implications of World Oil Market Conditions for Developing Countries, Oak Ridge National Laboratory, ORNL/TM-9793, in press, 1985.

Wollstadt, R.D., Oil Exploration in Less Developed Countries: The Activities of Private Oil Companies, American Petroleum Institute, Washington, D.C., August 1983.

World Bank, A Program to Accelerate Petroleum Production in Developing Countries, Washington, D.C., January 1979.

World Bank, The Energy Transition in Developing Countries, Washington, D.C., August 1983.

Zakariya, H. S., "The World Bank and Petroleum Development in the Third World," Natural Resources Forum, 8(1), 5-23, 1984.

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