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Oil Supply Disruptions: Frequency and Impact [redacted]

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An Intelligence Assessment

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An Intelligence Assessment

Information available as of 26 April 1982 has been used in the preparation of this report.

This assessment was prepared by [redacted] of the Office of Global Issues, [redacted] of the Office of East Asian Analysis, and [redacted] of the Office of Current Production and Analytic Support. Comments and queries are welcome and may be directed to the Chief, Energy Markets Branch, OGI [redacted]

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The paper was coordinated with the National Intelligence Council. [redacted]

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Oil Supply Disruptions: Frequency and Impact [redacted] 25X

Key Judgments

The consensus forecast of a soft world oil market over the next two to three years is causing complacency within major oil-consuming countries. Several forecasters have even predicted a collapse in oil prices, as well as the demise of the OPEC cartel. While we expect considerable market softness because of stagnant demand and adequate supplies, the frequency of supply disruptions in the past gives little reason to place much faith in a "no surprises" forecast.

Given present market conditions, only a major disruption of output from Saudi Arabia would have significant impact on oil prices during the next two to three years. After the mid-1980s, however, the production-capacity cushion that now exists is likely to shrink as OECD economic growth rebounds from the current recession. We are uncertain about how fast the change would occur, but oil market vulnerability to moderate supply disruptions could greatly increase. To avert panic buying normally associated with a significant supply disruption, consumers must be convinced that adequate energy supplies will be available from surplus productive capacity in other producing countries, from alternative fuels such as coal or gas, or from stockpiles. Our analysis indicates that a release of oil stocks at the onset of a crisis would sharply cut the runup in oil prices.

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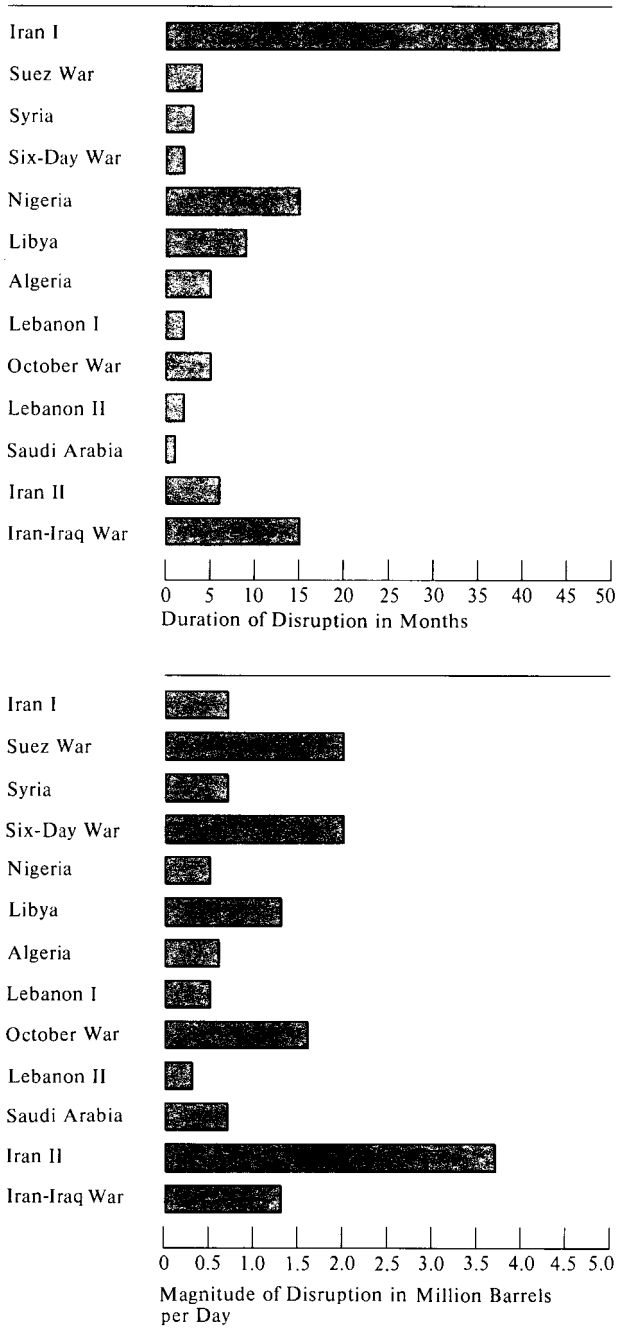
Figure 1

Disruptions of World Oil Supplies, 1951-81



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Oil Supply Disruptions: Frequency and Impact [redacted] 25X

Introduction

Most forecasters generally agree that over the next two to three years the oil market will remain stable, with a significant decline in real oil prices and the possibility of erosion in nominal prices. Given the importance of oil and energy use in Western economies, such predictions imply that economic recovery can safely proceed at a fairly rapid pace, unconstrained by concern over further shocks from oil price hikes. These forecasts also assume that oil supplies are not disrupted by political unrest in key exporting countries or damage to key oilfield and export facilities. A review of recent supply disruptions, however, suggests that such events occur rather frequently. [redacted]

The Historical Record

Since 1950, oil supplies from major exporting countries have been interrupted on 13 occasions (table 1 and figure 1). The duration of these disruptions ranged from one month (a 1977 fire at a Saudi Arabian gas-oil separation plant) to 44 months (nationalization of Iranian oilfields in 1951). Supply losses ranged from 300,000 barrels per day (b/d) in the case of the 1976 Lebanese civil war, to 3.7 million b/d as a result of the Iranian revolution in 1978-79. [redacted]

In most cases, the disruption to supplies had little or no measurable impact on prices. Oil companies were able to switch to alternate sources with relative ease because of the ample surplus capacity that existed worldwide and the considerable flexibility companies maintained in their distribution systems. Indeed, the lesson learned from early disruptions—such as the closings of the Suez Canal in 1956 and 1967—reemphasized the need for large supply overhangs and redundant distribution systems. [redacted]

By the early 1970s, however, several changes had occurred to make the oil market increasingly vulnerable to supply disruptions:

- Growth in oil consumption began to outpace increases in productive capacity; non-Communist use of oil more than doubled from about 19 million b/d in 1960 to almost 40 million b/d by 1970, while productive capacity grew by less than 80 percent.
- Oil trade expanded in line with the growth in consumption; inventory requirements grew faster.
- US oil production peaked in 1970 and imports, which had doubled in the 1960s, began to grow even more rapidly.
- Producing country governments increased control over oil liftings through such actions as nationalization, reducing major oil companies' flexibility in managing production and exploration. [redacted] 25X 25X

Libya's move to reduce the authorized production level of foreign oil companies in 1970, coincident with major pipeline sabotage in Syria, marked the first instance in which a supply disruption caused a sharp rise in oil prices. The loss of about 1.3 million b/d for a nine-month period resulted in a 25-percent rise in oil prices. [redacted] 25X

In the 11 years since the 1970 Libyan dispute, seven additional disruptions have occurred. Only two had an impact on the oil market, but the effects of both were severe: 25X

- The 1973 Arab oil embargo following the October Arab-Israeli war caused a loss of 1.6 million b/d in oil supplies, more than tripled oil prices, and contributed to the abrupt curtailment of gross national product growth in the Organization for Economic Cooperation and Development economies from 6.1 percent in 1973 to a negative 0.4 percent by 1975. 25X
- Supply losses resulting from the Iranian revolution more than doubled oil prices between late 1978 and early 1980. Moreover, OECD/GNP growth fell from 3.6 percent in 1979 to 1.3 percent in 1980. [redacted]

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Table 1

Past Disruptions of Oil Production

Dates		Duration *(Months of Lost Production)*	Magnitude of Supply Shortfall *(Million b/d)*
March 1951–October 1954	*Mossadegh and the Anglo-Iranian Oil Companies.* Iranian oilfields were nationalized on May 1, following two months of unrest and strikes in the Abadan area. Major oil companies boycotted Iranian oil on the world oil market and instituted court actions to deter potential buyers.	44	0.7
November 1956–March 1957	*Suez War.* Nasser closed the Suez Canal in the wake of the Anglo-French-Israeli incursion. At the same time, the Iraqi Petroleum Company (IPC) pipeline was damaged in Syria, and Saudi Arabia embargoed oil shipments to the United Kingdom and France.	4	2.0
December 1966–March 1967	*Syrian Transit Fee Dispute.* Syria imposed new transit taxes on the IPC pipelines to the Mediterranean. IPC stopped the flow of oil, refusing to pay the higher taxes. Iraq demanded full revenues from the oil companies operating there, despite the diminished production.	3	0.7
June 1967–August 1967	*Six Day War.* Suez Canal closed, and IPC and Tapline pipelines shut down following the Israeli strike into the Sinai. Oil exports were embargoed to Western Europe—particularly to the United Kingdom and West Germany—and the United States.	2	2.0
July 1967–October 1968	*Nigerian Civil War.* Oil terminals were blockaded by the Nigerian Federal Navy, choking off exports. Shell and BP ceased production in the country during most of the war.	15	0.5
May 1970–January 1971	*Libyan Price Controversy.* Libya gradually reduced the authorized production by selected oil companies, claiming potential damage to the oilfields. At the same time, the Tapline was damaged in Syria, forcing a shutdown until Syria authorized repairs. Production cuts were restored, and the pipeline in Syria was quickly repaired once Libya obtained higher oil prices from the companies.	9	1.3
April 1971–August 1971	*Algerian-French Nationalization Struggle.* Algeria nationalized 51 percent of the oil companies and pipelines—all French owned—operating within its borders and announced compensation plans. The Algerians then unilaterally raised oil export prices to French firms, leading the companies to seek a worldwide embargo against Algerian oil. Algeria retaliated by suspending oil deliveries to French tankers, claiming that the companies owed back taxes. Oil flows resumed in August after a CFP-Algerian agreement in July. All other companies accepted the Algerian terms by December.	5	0.6
March 1973–May 1973	*Lebanese Political Conflict.* Unrest in Lebanon disrupted the flow of oil from Iraq and Saudi Arabia. Following a Lebanese takeover of IPC facilities near Tripoli, Iraq cut off oil exports to Lebanon and was denied use of Lebanon's transit facilities. In April, a storage tank and parts of the Tapline facility at Sidon were destroyed by sabotage.	2	0.5

Table 1 (continued)

Dates		Duration *(Months of Lost Production)*	Magnitude of Supply Shortfall *(Million b/d)*
October 1973–March 1974	*The October Arab-Israeli War.* OAPEC embargoed oil shipments to selected Western countries and reduced oil production. Transit through the Suez Canal was halted, further delaying shipments to the United States and Western Europe. OPEC production returned to the level of October 1973 in the first quarter of 1974. Saudi Arabia finally ended the embargo on 18 March 1974.	5	1.6
April 1976–May 1976	*Civil War in Lebanon.* Political instability in Lebanon led Iraq to reduce oil exports via the pipelines through Lebanon to the Mediterranean.	2	0.3
May 1977	*Damage at a Saudi Oilfield.* Fires damaged a gas-oil separation facility at Saudi Arabia's Abqaiq field. Repairs took nearly one year, but other Saudi production quickly offset the loss.	1	0.7
November 1978–April 1979	*The Khomeini Revolution in Iran.* Unrest in the oilfields shut down production during the fourth quarter of 1978 and the first quarter of 1979. Output was gradually restored to around 4 million b/d starting in May 1979.	6	3.7
October 1980–December 1981[a]	*Iran-Iraq War.* The Iraqi-initiated regional conflict sharply curtailed oil exports from both countries, particularly through the Persian Gulf. There were intermittent air attacks and sabotage damage to export terminals, processing facilities, and pipelines in both countries.	15	1.3

[a] For analytical purposes, we assumed that this ongoing conflict ends with the conclusion of our sample period, December 1981.

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Current Vulnerabilities to Supply Disruptions

The continued slide in oil consumption since the 1979-80 price runup has forced OPEC producers to lower output sharply. Total OPEC production in March 1982 was about 20 million b/d, or roughly 8 million b/d below available capacity in these countries, even with the continuation of the Iran-Iraq war. Some of this surplus capacity—perhaps as much as 3-4 million b/d—will be eroded once the ongoing inventory adjustment process is completed and demand for OPEC oil rebounds. Resolution of the Iran-Iraq war, however, could result in an increase of 2-4 million b/d in production capacity within a year. As for oil inventories, stocks in non-Communist countries at the end of 1981 totaled 4.4 billion barrels, or roughly 93 days, of forward consumption. Some 300-500 million barrels of these stocks were considered excess—an amount equal to 6 to 11 days of forward consumption.

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The present combination of surplus productive capacity, excess stocks, and declining consumption affords OECD countries considerable protection against an oil supply disruption. Indeed, the market may be vulnerable only to a major disruption in Saudi oil

production over the next three to four years. Excluding Saudi Arabia, it would take simultaneous disruptions in at least two other countries to cause a supply loss of 3 million b/d. In the unlikely event that such disruptions occurred, the Saudis probably would use their own surplus capacity to offset the bulk of the lost supplies.

The cushion of surplus stocks and excess capacity will be gradually eroded once OECD economic recovery gets under way and oil use rebounds. The stock surplus probably will be depleted later this year, while excess productive capacity will still be available beyond 1985. The level and duration of the excess in productive capacity will depend on several factors:

- The pace of economic growth and the effect of structural changes in the economy on oil use.
- The magnitude of decline in oil production in the OECD as a result of the expected drop in US production.
- The rate of growth in oil consumption in LDC economies, especially within OPEC.
- The level of exports from Communist countries.

On balance, these factors will lead to an increase in the demand for OPEC oil and cause producers to approach the level of available capacity later in the decade, leaving the market once again vulnerable to even a moderate supply disruption. Throughout the decade, the market will be more vulnerable to disruptions during the upswing of the business cycle because of changes in inventory patterns and the rapid surge in oil use.

Disruption Analysis

If the historical record of major exporting countries is indicative of future activity, there is a good chance that some type of shortfall will occur in any given year. In fact, disruptions may occur with even greater frequency:

- Five of the major exporting countries are located in the volatile Persian Gulf region.
- Five other exporters—Mexico, Algeria, Nigeria, Indonesia, and Venezuela—could face social turmoil that would disrupt oil production should the present soft market conditions persist for a year or more.
- Libya is subject to internal and external threats to its ability to produce oil, given the present government.

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By superimposing the historic pattern of oil supply disruptions on oil market conditions that we think might materialize between 1982 and 1990, we were able to simulate possible market conditions during disruptions.[1] The simulations allowed for an inventory buildup and liquidation in response to a supply shortfall as well as for a supply response from oil producers or strategic reserve drawdowns by consumers.[2] The baseline scenario used for oil market conditions in the absence of supply shortfalls enabled us to measure the impact of supply disruptions.[3] (See appendix for details.)

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Given the record, consuming countries should be prepared to deal with disruptions of various sizes and duration. We used the historic incidence of disruptions to calculate the frequency, size, and duration of potential supply disruptions between 1982 and 1990. The results of our simulation analysis are as follows:

- Forty percent of the simulated disruptions entailed losses of less than 500,000 b/d.[4]
- Twenty percent entailed losses between 500,000 b/d and 1 million b/d.
- About 15 percent resulted in disruptions of 1-1.5 million b/d.
- About 10 percent resulted in disruptions of 1.5-3.0 million b/d.
- Only 15 percent of the potential disruptions involved losses of more than 3 million b/d.

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[1] The possibility of supply disruptions was addressed for the 10 LDC oil exporters that we expect will be producing at least 1 million b/d by 1990.

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[2] Inventory building in the simulations occurs at the rate of 50 percent of the oil lost in the shortfall in the first year and 10 percent of the shortfall in the second year, to a maximum of 1 million b/d. These shortfall-induced additions to inventories are liquidated in the year following the end to the disruption.

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[3] Assumptions used in the baseline scenario include:

- OECD economic growth averaging 2.5 percent annually between 1982 and 1990.
- Constant nominal oil prices through 1984, an increase in the nominal price of less than $3 per barrel by 1985, and market-clearing prices from then onward.
- Nonoil supplies increase an average of 1.3 million b/d annually.

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[4] Our simulations express oil disruptions and supply responses in annual rates.

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Supply Offsets

Assessing the size of potential disruptions was only part of the analytical process. Another key element was the extent to which these disruptions can be offset by production increases in nonaffected countries. The historic record shows that most supply disruptions have been associated with substantial offsets. Indeed, these offsets largely account for the absence of a price runup during most supply disruptions in the past. 25

Production offsets could reduce or eliminate the impact of most disruptions likely to be encountered over the next few years (figure 2). The magnitude of these offsets could be substantial:

- Over the next two to three years, the supply response to a disruption could be perhaps as much as 6 million b/d.

- The Saudi production response alone could be the difference between 10 million b/d and the level of Saudi production before a disruption. Over the next two to four years, this difference could exceed 3 million b/d. Beyond 1986, however, the difference probably will equal 1.5 million b/d or less.

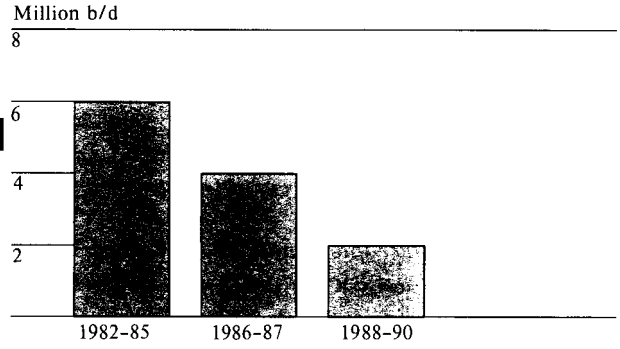
- Non-Saudi production responses are likely to be limited to a maximum of 1.5 million b/d throughout the decade.

Our analysis does not identify the specific source of the disruption. As a result, the supply response during a real disruption is not likely to be as automatic as we have assumed and could be somewhat less. For example, a disruption that involves Saudi Arabia would obviously reduce the amount of the available supply response.

Later in the decade, growth in the demand for OPEC oil, coupled with erosion of productive capacity in some OPEC countries will reduce the size of the potential production response during a disruption. Most analysts agree that oil prices remain stable if there are 2-3 million b/d of spare capacity available. By 1988, however, the production response could be limited to less than 2 million b/d, leaving the market vulnerable to even a moderate supply disruption. 25

Figure 2

Potential Production Offsets, 1982-90[a]



[a] Based on Saudi Arabian capacity at 10 million b/d and combined capacity in Iran and Iraq reaching 5.5 million b/d in 1984 and remaining at this level for the remainder of the decade.

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Nonoil supplies, especially of coal and natural gas, can also make a significant contribution to offsetting oil losses during a disruption. In the United States, for example, gas consumption surged 4 percent immediately following the Iranian revolution after several years of stable demand. The impact these supplies have on lessening pressures on oil prices probably will increase over time: 25

- More oil using industries and power stations are developing a dual-fuel capability.
- New pipeline systems are increasing gas supply flexibility and further development of gas reserves could provide added surge capacity.
- Expansion of coal-handling facilities, especially in the United States, are eliminating constraints to the expansion of coal supplies. 25
- Growing nuclear power capacity will provide some surge capacity. 25

Some Policy Issues

One factor in dampening the impact of any disruption is the timely drawdown of consumer nations' stocks. Indeed, stock levels and stock behavior have been key factors in shaping market reactions during the last

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Nonoil Supply Disruptions

Natural Gas

Rapid growth in natural gas trade and growing OECD reliance on gas imports from non-OECD sources will make gas supplies increasingly vulnerable to disruptions. International shipments of natural gas have more than doubled since 1973, with a growing volume coming from Algeria and the USSR. Both countries have curtailed gas shipments in the recent past:

- *Moscow has interrupted supplies to Western Europe on several occasions during the peak winter demand period for technical reasons and to meet domestic needs.*
- *Algeria suspended gas shipments to France and the United States and has delayed startup of deliveries to Italy over pricing disputes.*

Western Europe will be particularly vulnerable to gas cutoffs because reliance on imports from these two suppliers and other non-OECD sources is expected to increase to 35 percent of total gas needs by 1990.

Coal

Coal supplies are also susceptible to disruption, as recent events in Poland have indicated. A more likely cause for a disruption of coal supplies in the future, however, is a labor dispute such as occurred in the United States in 1977. Japan could be particularly vulnerable to a coal supply disruption because Tokyo relies heavily on imported coal.

[redacted]

three major supply disruptions (table 2). Price runups following the Arab oil embargo and the Iranian revolution were due in large part to demand pressures resulting from stockholder efforts to rebuild and add to inventories. In both cases, consumption was increasing and stocks were at about normal levels prior to the disruption:

- During the Arab embargo, stocks were initially depleted at an above-normal rate in late 1973. Oil stocks were then drawn down at only half the normal rate in the first quarter of 1974, and companies continued to build inventories at above-normal rates through the third quarter. From late 1973 through the third quarter of 1974, average OPEC official sales prices rose from $5.18 per barrel to $11.34 per barrel.
- During the Iranian revolution, oil inventories were drawn down at an above-normal rate during the first quarter of 1979 and then accumulated at rapid rates during the remainder of the year. The OPEC average official sales price rose from $12.91 per barrel to $23.55 per barrel during this period.

In contrast, the oil market remained fairly stable during the supply disruption caused by the Iran-Iraq war in September 1980. The market calmness was

Table 2

Major Supply Disruptions: Impact on Oil Stocks and Oil Prices

	Primary Oil Stocks Rate of Change (million b/d)		Oil Prices [a] (US $ per barrel)
	Actual	Normal	
Arab oil embargo			
1973 4th qtr.	−1.5	−1.0	5.18
1974 1st qtr.	−0.9	−1.5	11.36
2nd qtr.	4.5	2.0	11.25
3rd qtr.	3.8	3.2	11.34
Iranian revolution			
1978 4th qtr.[b]	0.1	−0.3	12.91
1979 1st qtr.	−4.4	−3.1	13.79
2nd qtr.	2.6	2.1	17.08
3rd qtr.	4.3	3.4	20.14
4th qtr.	0.9	−0.6	23.55
Iran/Iraq war			
1980 3rd qtr.	2.5	2.6	31.74
4th qtr.	−2.2	−0.9	32.61
1981 1st qtr.	−1.8	−3.6	34.84
2nd qtr.	1.8	2.0	34.64

[a] OPEC: Average crude oil official sales prices.
[b] Government-owned stocks increased by 600,000 b/d.

due in large part to the existence of about 400 million barrels of excess stocks that stockholders were willing to deplete. In addition, consumption was falling and the International Energy Agency (IEA) was urging members to refrain from spot market purchases. Oil stocks fell at about the normal rate throughout the winter period (October-March), and the inventory buildup during the second quarter remained at about the normal seasonal rate of 2 million b/d. The OPEC average official sales price rose only from $31.74 to $34.64 per barrel during the period despite a loss of 4 million b/d in supplies from Iran and Iraq.

If oil users anticipate a fairly quick release of oil from stockpiles or can readily switch to alternate fuels, the initial scramble to build and hoard inventories may be toned down or averted. As a result, the sharp escalation in spot prices and the ensuing rise in official prices may be dampened considerably. Our simulations indicate that if oil stocks or available nonoil supplies were used at the onset of a crisis to offset a 1-million-b/d supply shortfall, the disruption-induced runup in real oil prices would be sharply curtailed. Holding down disruption-induced real oil prices by $5 per barrel (1980 dollars) would, on average, avert a loss of some $350-400 billion in GNP for the OECD over the 1982-90 period.

Commercial stocks represent the bulk of oil inventories held in consuming countries. The majority of commercial inventories are operating stocks needed to ensure the smooth operation of the distribution system. Because costs are involved in holding inventories, companies will not maintain stocks at above-normal levels unless appropriate economic incentives are provided or governments mandate such action. Most West European governments have adjusted for this normal market behavior by requiring companies to maintain stocks at specified levels. West Germany, through the Oil Stockpiling Corporation, EBV, enables companies to share the financial burden of holding excess commercial inventories.

Sizable strategic stockpiles—oil purchased and owned by governments as opposed to inventories held by commercial firms—are located only in the United States, Japan, and West Germany. The Strategic Petroleum Reserve in the United States now contains about 250 million barrels of oil stored in underground salt caverns. Japan has a strategic reserve of about 70 million barrels, mostly held in floating tankers offshore. The West German stockpile contains about 50 million barrels of oil. 25X

At present, these foreign governments have not indicated clear plans regarding the disposition of these strategic stockpiles during an oil supply disruption, although the stocks are viewed as a last resort. In both Japan and West Germany, the level of stocks is still below the announced stockpile goal. Even so, the potential for sizable releases of stockpiled oil could have a significant price-dampening effect during a disruption, if buyers refrain from panic purchases on the spot market in anticipation of the availability of oil from strategic stocks. 25X

Some other factors that consuming nations have considered or implemented to cope with a supply disruption include:

- Removal of controls on crude and product prices to allow market forces to allocate supplies.
- Use of the IEA oil-sharing scheme.
- Standby legislation to allocate oil supplies.
- Maintenance of dual-fuel capacity in industry and electric power facilities; the Dutch, for example, can reduce oil use by 10 percent by switching to gas. 25X
- Surge capacity for domestic production of oil and natural gas.
- Stockpiles of alternative fuels such as coal and natural gas. 25X

Altogether these measures provide consuming countries with some protection against small oil and gas disruptions through the mid-1980s. Beyond this period, the measures now in place will provide less protection because the production-capacity cushion will diminish and leave the market more vulnerable to any size disruption. By that time—the late 1980s—some consuming countries, especially in Western Europe, will also become increasingly vulnerable to gas supply disruptions. 25X

Appendix

Disruption Methodology

Probability of Disruptions

To estimate the likelihood, duration, and magnitude of possible future oil disruptions, we examined the historical instances of disruptions to oil production between 1951 and 1981. Oil research focused on those cases where oil production declined for nonmarket reasons such as damage to oil facilities, nationalization of companies, or political decisions about production levels.

Thirteen cases constitute the historical data base. These disruptions ranged in length from one month to 44 months and the magnitude ranged from 300,000 to 3.7 million b/d. In calculating the magnitude for our simulations, the amount of oil lost was expressed as a percentage of oil production in significant exporting countries over an average of three months prior to the disruption. The largest percentage loss—32 percent—resulted from the 1956-57 closure of the Suez Canal.

We assumed that a disruption was equally likely to occur in any future year as in the past, and we calculated the estimate of the yearly probability of a disruption of any size to the oil production of significant oil-exporting countries to be 0.42 (13 divided by 31).[5] Probability distributions for the duration and magnitude of oil disruptions were also constructed, with equal weight given to each historical case.

Generating Disruptions

Scenarios of the occurrence of market disruptions between 1982 and 1990 were created by combining random selections of the likelihood, length, and magnitude of a disruption in each year. To generate each scenario:

- A random number between 0 and 1 was drawn for each year and matched against the estimate of the likelihood of a disruption. Where a random number was less than or equal to the estimate of the probability of a disruption—0.42—a shortfall in oil production was recorded. Should the random number exceed 0.42, oil production follows a baseline oil scenario.
- Once a disruption was recorded for a particular year, two additional random numbers were drawn to pick from the probability distributions calculated for the duration and magnitude of past disruptions.
- As a third step, duration times magnitude times the baseline estimate of oil production was calculated to obtain the oil lost in each disruption. For example, a hypothetical disruption of six months (duration = 0.5), shutting down 3 percent of the oil produced (magnitude = 0.03) in a year in which our baseline production projection for the group of 10 countries would otherwise be 24 million b/d, implies a loss of 360,000 b/d in oil on the world market.[6]

The method of randomly selecting from the individual probability distributions constructed from the data base allows for combined results that exceed any of the historical disruptions. A random pairing of the longest disruption with the largest percentage of oil lost over any period would yield a disruption that exceeds any recorded case. Conversely, smaller than historically observed disruptions can also result from the random selection.

The Baseline Scenario

A "no surprises" scenario in the CIA energy model was used to calculate benchmarks for energy demand, GNP growth, and oil prices for the 1982-90 period. The underlying characteristics of the model included:

- Oil and nonoil supplies are exogenous with the exception of Saudi Arabia's oil output; Saudi production is endogenous up to the limit of the Saudis' preferred ceiling of 8.5 million b/d.

[5] Disruptions to the combined production of the 10 OPEC and non-OPEC LDC oil exporters that we expect to be producing at least 1 million b/d in 1990 were considered in our baseline estimates—Indonesia, Iran, Iraq, Kuwait, Libya, Mexico, Nigeria, Saudi Arabia, the United Arab Emirates, and Venezuela.

[6] Because disruptions can extend more than one year, the longer disturbances were treated by reducing the amount of production in one year and a fraction of the amount in the following year(s). For example, a 3-percent disruption that lasts for 18 months would result in a loss of 720,000 b/d in the first year and a loss of 360,000 b/d in the second year.

- Income elasticity of energy demand is 1.0 with no lags.
- Price elasticity of energy demand is 0.12 in the first year, with a cumulative impact of 0.5 through the ninth year.

Energy prices in the model are determined in the following manner:

- The cost of crude oil is determined by the OPEC price, subject to price controls on domestic production, where applicable.
- Prices for petroleum products are determined from costs of crude oil, refining, and transportation.
- Natural gas prices move with petroleum product prices, subject to national controls on end-use prices.
- Coal prices move with the GDP deflator.
- Electricity prices are obtained from prices on fossil fuels, weighted by shares of the fuel used to produce final electricity.
- The end-use price for total energy is built up from prices for individual fuels, weighted by the demand for each fuel, and based to a common year.

Given these relationships, the model is solved for a market-clearing OPEC price.

The energy model summarizes the macroeconomic impacts of higher energy prices through reaction functions derived from simulations with the CIA linked econometric model. The model is an ISLM model with a small supply side and is composed of medium-size models for major industrialized countries. It estimates total demand for energy and ties energy and macroeconomic sectors together through prices.

Simulation of Oil Disruptions

As a first step in assessing the impact of disruptions on the oil market and OECD economies, 100 scenarios of oil-production disruptions for each year between 1982 and 1990 were generated. Of a total of 900 possible disruption-years, 451 cases were obtained in the first simulations; 63 of these, however, were the result of multiyear disruptions. The average disruption was 1.3 million b/d, and the largest exceeded 10.9 million b/d:

- Forty percent of these disruptions involved a loss of less than 500,000 b/d in a single year.
- Another 20 percent involved a loss of less than 1 million b/d.
- Nearly 75 percent of the disruptions resulted in a loss of less than 1.5 million b/d in oil production. 25

Stock Behavior and Supply Responses

Historical experience since 1970 indicates that oil consumers typically build inventories in the months following a disruption in oil production. To capture this behavior pattern, a three-year inventory cycle was developed in which stocks increase by 50 percent of the disruption in the first year and 10 percent of the disruption in the second year, to a cumulative total of 1 million b/d. Stocks are liquidated by an amount equal to the buildup in the third year, or in the case of a multiyear disruption, in the year after it ends. 25

In past disruptions, a number of OPEC countries have responded with increased production. To approximate the amount of additional production forthcoming, the productive capacity of each OPEC member was examined, as well as their recent responses during the 1978/79 Iranian revolution. Production from OPEC states (excluding Iran) rose by 3.3 million b/d on a year-over-year basis in that period; 90 percent came from Saudi Arabia, Iraq, Kuwait, and Nigeria. 25X1 25

Three alternative rules were employed to simulate the supply response from unaffected producers and consumers. One set of simulations provided as much as 1.5 million b/d in additional supplies from countries other than Saudi Arabia. Given the continuing erosion of productive capacity among some of the OPEC states, this amount represented an upper limit (figure 3). The Saudis were assigned a maximum production of 10 million b/d, with a production response equal to the difference between this amount and Saudi production in our baseline scenario. Because of growing requirements for Saudi production in our baseline scenario, the combined OPEC supply response was limited to 3 million b/d after 1986 (figure 4). 25

A more optimistic supply response allowed for an additional 1 million b/d to be added in the event of a disruption. Such supplies could be forthcoming from strategic oil stocks in the consuming countries. The third supply response assumption allowed for additional supplies only to the extent that inventory demand was countered (figure 5). 25

Figure 3
Comparision of Market-Clearing Prices for Oil: Assuming Optimistic Supply Response and Stock Behavior

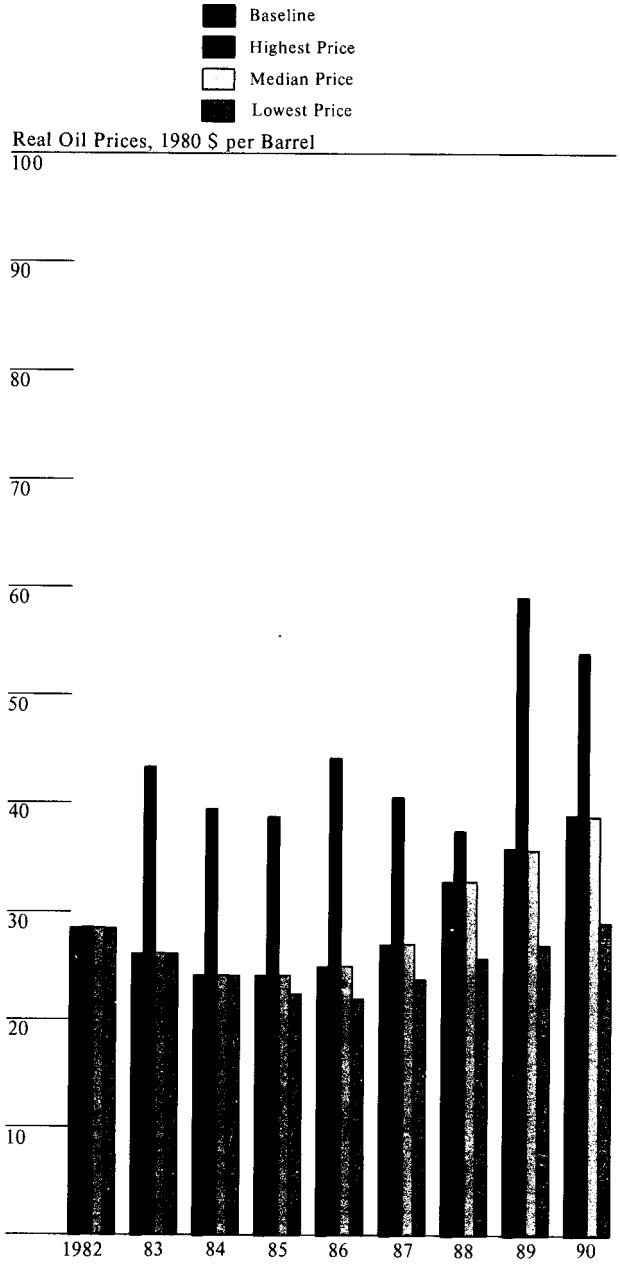

Figure 4
Comparison of Market-Clearing Prices for Oil: Assuming Pessimistic Supply Response and Stock Behavior

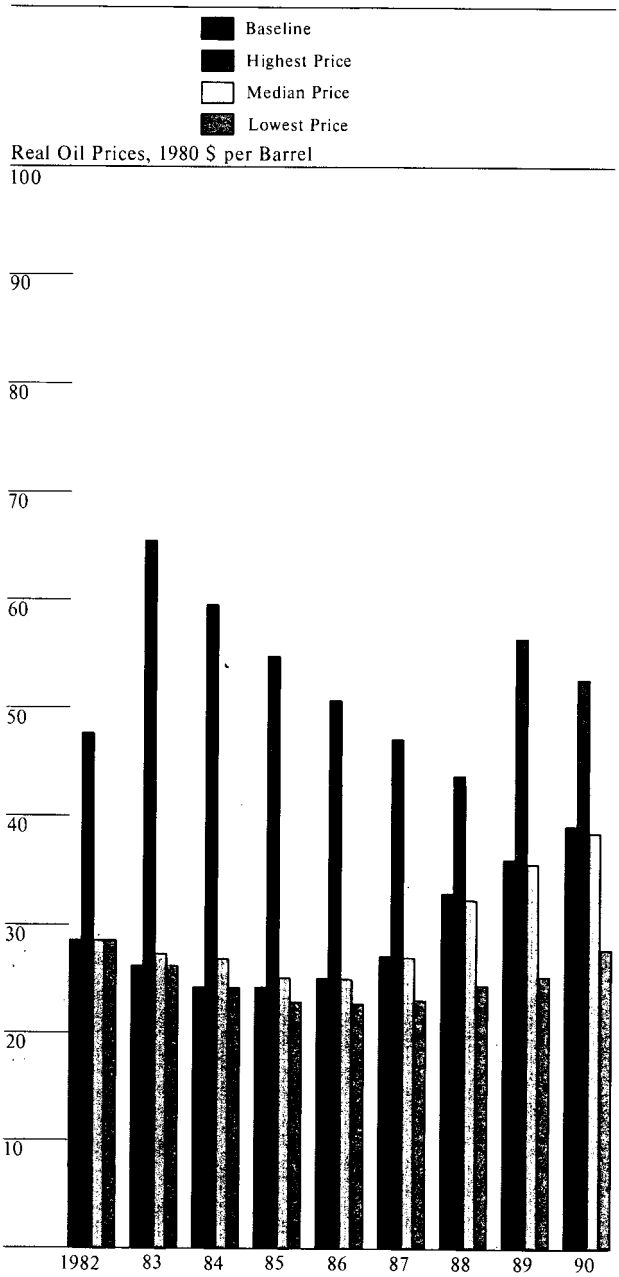

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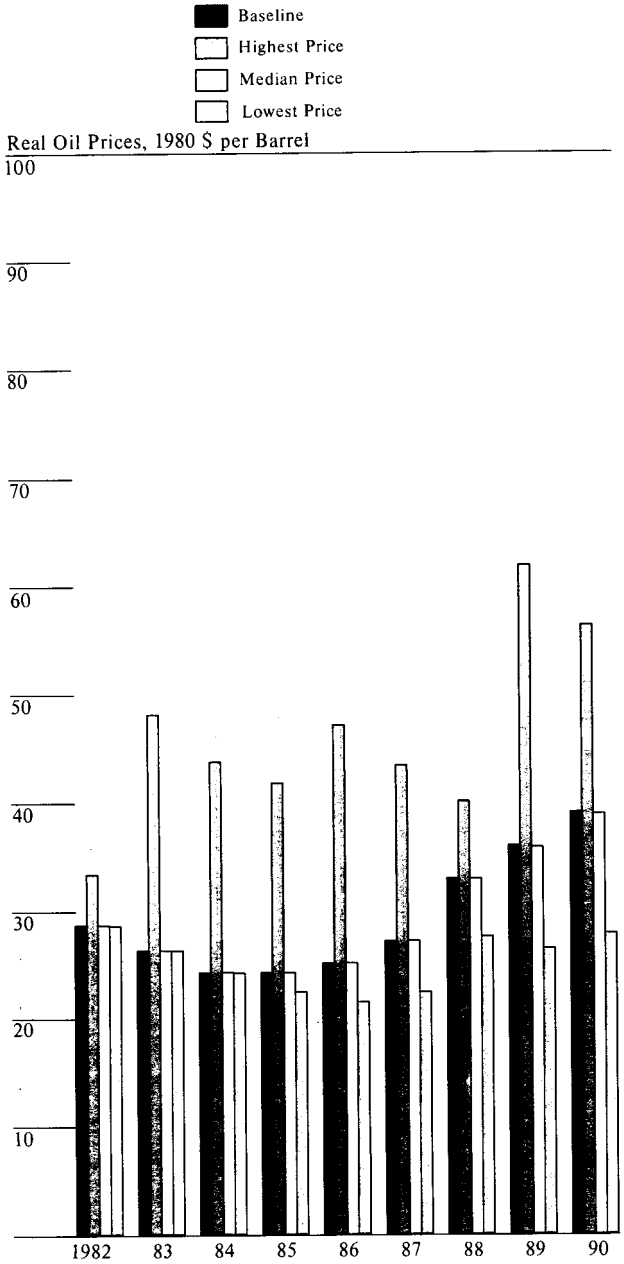
Figure 5
Comparision of Market-Clearing Prices for Oil: Assuming Most Likely Supply Response and Stock Behavior



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