BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Chairman, Subcommittee On Fossil And Synthetic Fuels, Committee On Energy And Commerce, House Of Representatives

Oil Supply Disruptions: Their Price And Economic Effects

Large disruptions of 10 and 19 millions of barrels of oil per day could double or triple oil prices and have serious effects on inflation, economic growth, and employment--even under conditions of substantial unused production capacity such as those present during the past year. However, under these slack market conditions, GAO's analysis shows that a small disruption of 3 million barrels per day would have little effect.

Under tighter market conditions like those before the Iranian oil cutoff of 1979, there is less unused production capacity to make up for lost production, and disruptions result in larger price increases.

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

RESOURCES, COMMUNITY, AND ECONOMIC DEVELOPMENT DIVISION

B-209176

The Honorable Philip R. Sharp
Chairman, Subcommittee on Fossil
and Synthetic Fuels
Committee on Energy and Commerce
U.S. House of Representatives

Dear Mr. Chairman:

In your May 21, 1982 letter, you asked that we determine the consensus, if any, on the oil price and economic effects of supply disruptions in the absence of U.S. Government intervention. You also asked that we assess the adequacy of research in this area. This report responds to that request.

Sincerely yours,

J. Dexter Peach
Director

REPORT BY THE UNITED STATES GENERAL ACCOUNTING OFFICE

OIL SUPPLY DISRUPTIONS: THEIR PRICE AND ECONOMIC EFFECTS

D I G E S T

Oil supply disruptions, such as the 1973-74 Arab oil embargo and the 1979 Iranian production shutdown, suddenly remove oil from the world market and cause oil prices to rise. The administration is committed to letting the world oil market determine the price of oil during supply disruptions, permitting the price to rise without restraint by the Federal Government. Expressing concern about how high these prices may go in possible future disruptions, Representative Philip R. Sharp, Chairman of the Subcommittee on Fossil and Synthetic Fuels, House Committee on Energy and Commerce, asked GAO to determine the consensus, if any, on the oil price and economic effects of supply disruptions and to assess the adequacy of research in this area.

GAO's analysis showed that disruptions invariably raise oil prices. If oil prices happened to be falling before the disruption, they would rise or at least fall less rapidly. Oil prices increase in a disruption because production is reduced. This shrinking of oil supplies allows producers to charge more for their oil. The price increase in the 1979 Iranian oil disruption demonstrates that oil prices may increase steeply even if there is enough excess capacity to replace most of the lost production. As experienced in past disruptions, inventory accumulation exacerbates the shortage and price increase.

SCOPE AND METHODOLOGY

GAO used the only three currently available models which focus on the behavior of oil prices in a disruption. These models were developed by Knut Mork of the University of Arizona; Glenn Hubbard and Robert Fry of Harvard University; and GAO, based on principles and estimates of Philip K.

Verleger's model. The models were used, in combination with GAO's analysis of past disruptions and other research, to assess the price and economic effects of world production capacity losses of (1) 3 million barrels per day, a small case, (2) 10 million barrels per day, a moderate case representing the loss of Saudi Arabia or several smaller producers, and (3) 19 million barrels per day, a shutdown of the entire Persian Gulf. Disruptions were assumed to last one year and to take place during a period of modest economic growth.[1] GAO examined these effects under both slack (abundant excess production capacity) and tight (little excess production capacity) market conditions as well as with and without drawdown of the U.S. Strategic Petroleum Reserve.

HOW HIGH MAY PRICES GO?

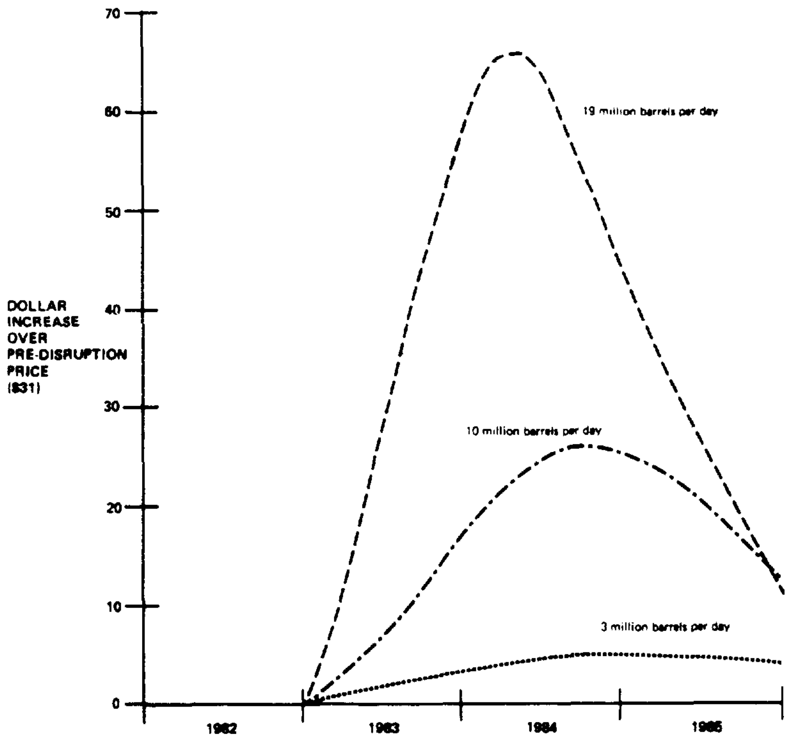
The models show that disruption size (amount of lost production), market tightness (the percent of available production capacity in use), and what happens to oil inventories govern the severity of oil price increases in disruptions. The figure on page iii shows what happens to contract oil prices (the price charged for oil sold under long-term contract) in a 1983 disruption. Prices rise swiftly and generally reach their peak after the disruption is over. Increases are temporary as long as lost production is fully restored and no other production cutback occurs. Because of the similarities in models' oil price results, those presented here are primarily from the GAO model. However, any significant differences in the other two models' results are noted.

Disruption size

The disruption size (amount of lost production) is the single most important factor determining price increases. Prices rise more than proportionally as disruption size increases. This is shown in the figure on page iii. In a moderately slack market, the GAO model produced the following price increases over the $31 per barrel base:

[1]Economic growth in the base case ranged from 2.6 to 4.1 percent, depending on the model.

CONTRACT PRICES IN 3, 10 AND 19 MILLION BARRELS PER DAY
DISRUPTIONS UNDER SLACK MARKET CONDITIONS



--A 3 million barrels per day disruption results in modest price increases, temporarily raising contract crude oil prices by up to $6 per barrel at the peak. Spot prices (the prices paid for oil exchanged on a day-to-day basis) could rise by more than $7 per barrel at the peak.

--A 10 million barrels per day disruption could temporarily raise contract oil prices by about $27 per barrel, while spot prices could rise by about $37 per barrel at the peak.

--A 19 million barrels per day disruption could raise contract oil prices by about $70 per barrel, while spot prices could temporarily rise by more than $100 per barrel.

Caution is called for in interpreting the results of the 19 million barrels per day disruption, however. Market relationships may break down under such severe conditions, making models inappropriate for measuring price effects.

Market tightness

Tighter oil markets lead to higher prices in all disruption scenarios. In GAO's 10 million barrels per day case, increasing the production-to-capacity ratio (that is, the degree of market tightness) from 65 to 75 percent raised spot prices at their peak by an additional $16 per barrel or 50 percent. The larger the disruption, the greater the price rise.

Oil inventories

How oil companies utilize their oil inventories

Examination of past disruptions reveals that oil companies accumulate inventories--a key factor pushing prices up. Inventory buildup is caused by expectations of rising prices and uncertainty over whether the disruption may worsen. The volume of inventories accumulated accelerates steeply with the disruption size. For example, in the 10 million barrels per day disruption case, private inventory buildup increased prices by nearly $8 per barrel.

Strategic Petroleum Reserve drawdown

Drawing down the U.S. Government's oil inventory (the Strategic Petroleum Reserve) can reduce price increases somewhat. In GAO's 10 million barrels per day disruption, drawdown at its current maximum rate made an 8 percent or $5 per barrel price difference. The Reserve's current size and maximum drawdown capability of 1.7 million barrels per day limits its leverage over prices in large disruptions. However, when the Reserve reaches a level of 540 million barrels, maximum drawdown capability will more than double. In a 10 million barrel per day disruption, drawdown at the maximum rate would lower the average spot price increase for 1983 by 17 percent.

CONSUMER OIL PRICES

Consumer oil prices respond sluggishly to disruptions, peaking more than 6 months after the disruption's end. Heating oil price increases are generally the same as those for gasoline.

--Gasoline prices could rise by as much as 25 cents per gallon at their peak in a 3 million barrels per day disruption.

--In a 10 million barrels per day disruption, gasoline prices could temporarily rise by as much as $1.28, depending on the market tightness at the disruption's onset.

--A 19 million barrels per day disruption could raise gasoline prices by $2.20 per gallon at their peak, representing an increase of about 170 percent.

MACROECONOMIC EFFECTS OF SUPPLY DISRUPTIONS

Oil price shocks accompanying supply disruptions hurt the U.S. economy. GAO's research shows that macroeconomic effects would be modest in small disruptions and severe in a 19 million barrels per day or Persian Gulf disruption. The adverse economic effects are temporary with one exception. There would be a permanent, one-time loss in the gross national product (GNP). The models' economic results are not as similar as their oil price results. Thus, depending on which is more appropriate, either ranges of model results or the maximum effects are presented here.

Inflation

Many researchers have cited oil disruptions as one cause of increased inflation in the last decade. All models showed small inflation increases by one-half a percentage point or less in the 3 million barrels per day disruption. In the 10 million barrels per day disruption, the inflation rate could increase by as much as 2.6 percent at the peak. The Persian Gulf disruption causes severe inflation increases from about 3 to 11.4 percent (depending on the model) at the peak.

Economic growth

Oil price shocks reduce economic growth during the disruption year and the year following. Much of the economic literature considers oil supply disruptions to have contributed greatly to the recessions in 1975 and 1980. The three models show that small disruptions have modest effects, with the 3 million barrels per day case reducing the economic growth rate by no more than 0.4 percentage points at its peak. The 10 million barrels per day disruption could temporarily reduce real GNP growth by as much as 3 percentage points, representing a loss of about $99 billion. The 19 million barrels per day disruption would have severe impacts. The real GNP growth rate could be temporarily reduced by over 13 percentage points, according to the model showing the largest economic effects. This would mean, for example, that if GNP would have grown at an annual rate of 3 percent without the disruption, it would decline at a rate of 10 percent with the disruption. This growth reduction represents a peak annual GNP loss of $415 billion. Although the growth rate generally catches up within two years of the disruption's end, a permanent loss in GNP remains due to lost investment.

Unemployment

The models show that oil price increases will generally raise unemployment by less than one percentage point in the 3 and 10 million barrels per day disruptions. However, a one percentage point increase represents a loss of over one million jobs. In the Persian Gulf disruption, peak increases in the unemployment rate range from about 1 to 6 percentage points, depending on the model.

POLICY IMPLICATIONS

GAO's research shows that market tightness and oil inventory behavior are important factors determining the size of the oil price increase in a disruption. U.S. Government actions in these areas could help moderate disruption-induced price increases. In advance of a disruption, the Government could help maintain market slackness and encourage the industry to hold adequate oil inventories. During a disruption, the Government could encourage private inventory drawdown or could draw down the Strategic Petroleum Reserve.

KEY AREAS WHERE ADDITIONAL RESEARCH IS NEEDED

Key areas for additional research concerning the effects of disruptions include: (1) the effects of large disruptions such as a loss of the entire Persian Gulf, (2) the effects of and ways to reduce private stock buildup during disruptions, and (3) government policies to minimize the economic costs of disruptions. GAO's current emergency preparedness research includes an assessment of the costs and benefits of government options for encouraging private companies to hold emergency stocks. Private stockpiling before disruptions would help reduce stock buildup during disruptions.

Contents

ABBREVIATIONS

CPI	Consumer Price Index
GAO	U.S. General Accounting Office
GNP	Gross National Product
MBD	Thousand barrels per day
MMBD	Million barrels per day
OPEC	Organization of Petroleum Exporting Countries
SPR	U.S. Strategic Petroleum Reserve

CHAPTER I

INTRODUCTION

BACKGROUND AND OBJECTIVES

Oil supply disruptions in the 1970s dramatically increased oil prices and hurt the economies of the United States and other oil-consuming nations. In the year following the drop in world oil production resulting from the 1973-74 Arab oil embargo, official crude oil prices for Arab light nearly tripled. In the two years following the 1979 Iranian oil disruption, the price of imported crude oil more than doubled. By increasing inflation and unemployment and lowering economic growth, both of these price shocks severely damaged the U.S. economy.

Current slackness in the oil market, with the associated oil price decline, reduces the consequences of a disruption, but under most circumstances it does not reduce the likelihood of a disruption occurring. Crude oil supply disruptions can result from a wide variety of circumstances, including politically inspired embargoes or intentional production cutbacks as well as production shutdowns due to internal political problems, terrorist activities, or regional wars. Declining oil prices and thus oil revenues could destabilize third-world oil-producing nations, thereby increasing the likelihood of a disruption. In addition, while non-OPEC (Organization of Petroleum Exporting Countries) production continues to rise, over one-quarter of the world's oil supply is still produced in the politically volatile Middle East and North Africa. Thus, the probability of disruptions to the world's oil supply remains high.

U.S. oil imports have dropped dramatically in the last few years, but we still import nearly one-third of our oil, so the Nation remains vulnerable to periodic supply disruptions. Also, in an uncontrolled market, oil prices are set at the world level. Thus, even if we imported no oil, the Nation would still be subject to a disruption's price effects. Furthermore, U.S. allies continue to rely on imported oil and remain vulnerable to supply disruptions.

By vetoing legislation renewing emergency oil allocation authority (S.1503), the administration re-emphasized its commitment to rely on the free market to allocate and price oil during supply disruptions. Reliance on the free market means that oil prices would rise until demand for oil fell to a level equal to the diminished oil supply. What is unclear is how much U.S. oil prices would increase using that strategy.

In his May 21, 1982, letter to us, the Chairman of the Subcommittee on Fossil and Synthetic Fuels, House Committee on Energy and Commerce, expressed concern about how high oil prices would rise during oil supply disruptions in the absence of any government intervention (see Appendix III). He requested that we do the following in the context of free market pricing:

--Identify and assess the adequacy of research on oil price effects of supply disruptions;

--Determine the consensus, if any, on the effect that shortages have on U.S. oil prices both during and after a disruption;

--Determine the consensus, if any, on the effects of price shocks on the U.S. economy; and

--Identify any key questions that remain in addressing how high prices may rise during shortages.

This report is our response to the Chairman's request.

METHODOLOGY AND SCOPE

The study was divided into three phases: (1) identifying relevant research, (2) identifying and using models to measure the oil price effects of disruptions, (3) using models to determine the economic effects of shortages.

The first phase of the study entailed a literature search and numerous interviews with staff of government agencies, private organizations, and academia. We also attended a major industry conference on modelling the effects of oil supply disruptions. We identified numerous studies on the economic impacts of supply disruptions. However, rather than explicitly determine the oil price effects, most of them assumed a price increase and measured its economic effects.

In the second phase of the study, we identified and used the only three models that explicitly measure oil price effects of supply disruptions. After assessing these models' technical adequacy and the validity of important assumptions, we asked the model authors to run their models with our disruption scenarios and assumptions. Two of the authors responded to our request. The third model did not exist in a form where it could be easily rerun, so we formulated our own model based on the author's principles, some of his estimates, and his advice. This model consists of seven equations and is based on statistical relationships between elements in the oil market. It appears in Appendix I and is referred to as the GAO model. After obtaining comparable results, we varied assumptions on initial oil market conditions to determine how they affect the size of the price shock. Since the models estimate world crude oil prices, we converted these estimates into U.S. crude and product prices. Our conversion method is described in Appendix II.

The third phase of the study used the three models to measure the economic effects of the price shocks. Two of the models have the rest of the economy built in, while the third contains only the oil sector. To measure economic effects of the prices predicted by the third model, we entered our prices into Data Resources Inc.'s U.S. macroeconomic model. Our audit work was conducted in accordance with generally accepted government auditing standards.

The models

The models we used to measure oil price effects were developed by:

(1) Knut Mork of the College of Business and Public Administration at the University of Arizona;[1]

(2) Glenn Hubbard/Robert Fry of the John F. Kennedy School of Government at Harvard University (referred to here as the Hubbard model); and

(3) GAO, based on principles and estimates from Philip K. Verleger's model developed at Yale University (referred to here as the GAO model).

All three models are built on the statistical relationships between various energy and economic variables over the last decade. The models are computerized for ease of changing assumptions and disruption scenarios.

Models measure price effects through the relationship that prices have with either the ratio of production to production capacity, or the ratio of expected to actual production. The former relationship models a disruption by lowering production capacity. The resulting higher ratio increases prices. The latter lowers actual production, increasing the ratio and thus prices.

There are important differences among the models. (1) Both Mork's and Hubbard's models have linking macroeconomic sectors. Since GAO's does not, it is missing the feedback effect of lower economic growth caused by the price shock, which lowers oil demand and then prices. (2) The three models produce results for

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[1]Mork, Knut. "What If We Lost the Persian Gulf?" Crisis in the Economic and Financial Structure. Edit. Paul Wechtel. (Lexington, Mass.: Lexington Books, 1982).

different time periods. Mork's model is annual, Hubbard's is quarterly, and GAO's is monthly. (3) Hubbard and GAO explicitly model private oil stock behavior during supply disruptions. Mork's model does not do so and must be adjusted for inventory buildup to avoid understating the size of the shock.

Mork's model produces a larger price shock in 1983 than the other two models. Since Mork's model is annual, we would have expected it to have the lowest price shock, because averaging the shock over a year reduced the price peak. However, his 1983 price shock is higher because price effects are concentrated in the disruption year.

The above-mentioned factors account for some of the differences in model results. Each model represents a unique view of how and the extent to which numerous factors affect the movement of oil prices during a disruption.

Limitations on using models to measure the effects of supply disruptions

Some cautionary words about using models to predict the effects of future supply disruptions are in order. Every supply disruption is different, and it is impossible to model the effects of every possible combination of circumstances. Model results apply to a given disruption only insofar as the assumptions about the size and duration of the disruption, and the oil market and economic conditions at the outset, are comparable.

Another caution about using models to predict effects of future supply disruptions is that one cannot be certain that past relationships in the oil market, which have been used to estimate the models, are still present. Model results will be good predictors only if future relationships are like those in the past. In fact, we state later that the models may not be appropriate for measuring the effects of severe disruptions because oil market relationships, upon which the models are based, may change under these circumstances.

Models also do not take into account factors that cannot be quantified such as government responses to disruptions. Thus, they cannot fully explain the price response in any given disruption.

Because of these limitations, model results should be interpreted as indicating the direction and magnitude of effects rather than their precise size. Wherever possible, we relate model results to analysis of others' research and past disruptions. Furthermore, since certain assumptions can greatly influence results, we modelled additional scenarios to test how sensitive the results were to alternative assumptions. These alternatives included variations in market tightness and use of the U.S. Strategic Petroleum Reserve (SPR).

THE DISRUPTION SCENARIOS

Disruption sizes

The three world disruption scenarios we modelled were:

(1) 3 million barrels per day (MMBD) production capacity loss, a small case,

(2) 10 MMBD capacity loss, a moderate case, and

(3) 19 MMBD capacity loss, representing a shutdown of the entire Persian Gulf.

A 3 MMBD capacity would be equivalent to the shutdown of two small producers such as Qatar and the United Arab Emirates. This scenario, a fairly small loss in today's glutted market, is the most probable of the three.

The 10 MMBD capacity loss could occur with the shutdown of either Saudi Arabia or a number of smaller producers, such as Iran and Iraq, Kuwait, and the United Arab Emirates. This scenario is less likely than the 3 MMBD loss but is plausible.

The 19 MMBD capacity loss implies the complete loss of Persian Gulf oil. This scenario is the least probable since it would require a total loss of production in the Gulf or the closing of all straits and pipelines. A plausible scenario for this loss would be a major Middle East war.

In all disruptions, capacity or production (whichever the model uses) for the disrupted countries was removed from the world oil market. Thus, we are modelling a true production loss rather than an embargo against the United States, where some of the oil could be sold elsewhere.

Timing and duration

The disruptions were assumed to occur on January 1, 1983, and last for one year. The occurrence in 1983 is incidental in that we did not attempt to predict and simulate energy and economic conditions for this time. We assumed market conditions were similar to those in mid-summer 1982. We chose a one year disruption since Mork's model is annual and could not accept a shorter disruption. At the disruption's end, capacity or production was regained in equal increments over the following two years.

SPR drawdown

Oil price effects of disruptions could be influenced by using the SPR. We made the following assumptions about average SPR fill and drawdown during the disruption year:

(thousand barrels per day)

Disruption case	Average fill rate	Average maximum drawdown
no disruption	200	0
3 MMBD	0	0
10 MMBD	0	0
10 MMBD	0	673 a/
19 MMBD	0	673 a/

a/The maximum quarterly drawdown rates during the disruption year are: 1st quarter-1.7 MMBD, 2nd quarter-900 MBD, and 3rd quarter-90 MBD. These are the maximum rates now possible. Drawdown stops after three quarters due to stock depletion. The normal SPR fill rate was assumed in the year after the disruption.

Prior to modelling, we asked the Department of Energy's Deputy Assistant Secretary for Energy Emergencies to enunciate the agency's policy on SPR fill and drawdown during disruptions. He stated that these policies had not yet been decided.[2] In the absence of any explicit administration policy at that time, we chose to discontinue fill during all disruptions. The last administration stopped filling the SPR during the 1979 Iranian oil disruption.

We also assumed that the SPR would not be drawn down in the 3 MMBD disruption and would be drawn down at the maximum rate in the 19 MMBD disruption. Since it is most uncertain what would be done in the 10 MMBD case, we modelled both no drawdown and maximum drawdown. Selecting the two extremes demonstrates the maximum difference SPR use can make. The maximum drawdown rate is set at the highest rate physically possible. This rate changes

[2]Subsequent to our modeling efforts, P.L. 97-229 was passed and required a fill rate of 300 MBD unless the President found that such a rate was not in the national interest. The minimium required fill rate, subject to the availabilty of appropriated funds, is 220 MBD. As long as the maximum drawdown rate remains at 1.7 MMBD, the higher fill rate would only modestly increase the price effects of SPR drawdown. As of the four week period ending December 17, 1982, the SPR was being filled at 192 MBD, a level which is closer to our assumed 200 MBD rate.

over the course of drawdown, which is reflected in the monthly and quarterly models. The average drawdown over the course of the disruption year was assumed to be 673 MBD, while quarterly drawdown ranges from 1.7 MMBD for the first quarter to 0 in the fourth quarter.

Private oil stocks

Private stock behaviors are determined within Hubbard's and GAO's models. Mork's model was at first run without any stock changes, and was run again with the stock changes produced by Hubbard's model.

OIL MARKET AND ECONOMIC CONDITIONS AT THE OUTSET OF DISRUPTIONS

Market tightness

We chose to model our disruption scenarios under both loose and tight market conditions. The tighter the market, the lower the availability of replacement oil, and the larger the price shock. Market tightness is defined as the level of oil demand or production[3] relative to production capacity. The larger the ratio, the smaller amount of unused capacity, and the tighter the market. Our loose market conditions reflect the mid-summer 1982 market since that was the most current data available. At the outset of the disruption, OPEC was assumed to be producing at about 65 percent of maximum sustainable capacity.[4] Thus, substantial unused capacity was available to replace disrupted production. Our tight market case assumed that OPEC was producing at about 75 percent capacity at the start of 1983. To put this assumption in perspective, prior to the 1979 Iranian oil cutoff, OPEC was producing at over 80 percent of maximum sustainable capacity, which experts consider an unusually tight market.

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[3]In the models, production is set to equal oil demand, which is defined as oil consumption plus inventory change. Both production and demand are used, depending on the model, to measure how much of available production capacity is being used.

[4]Maximum sustainable capacity is the maximum production rate that can be sustained for several months. Market tightness grew over 1983 in Hubbard's control case to 70 percent because of growth in world oil demand. This increase tended to enlarge Hubbard's price effects relative to the other model's.

The U.S. economy

We assumed that the disruption would take place during a period of modest economic growth. Since modelling a supply disruption during a recession would in our judgment unduly minimize the disruption's price and economic consequences, we assumed a moderate economic recovery in 1983. These economic assumptions had already been developed by the Energy Modeling Forum in connection with another study and were being used by both Hubbard and Mork.[5] Gross National Product (GNP) growth in 1983 ranged from 2.6 to 4.1 percent in the Hubbard and Mork models--as opposed to being identical--because economic growth is not an input but is determined by the model.

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[5]The Energy Modeling Forum at Stanford University achieved similar economic growth rates by standardizing economic policy inputs. The Federal Reserve Board is assumed to allow the money supply to grow slightly above the target range in the year preceding the disruption. Monetary policy becomes more restrictive in subsesquent years. Administration proposals on curtailing non-defense spending and increasing the military budget are assumed to be implemented. Federal expenditures, as a percent of GNP, drop from about 23 percent in 1983 to 22 percent in succeeding years. Federal receipts as a percent of GNP drop from 19.7 percent in 1983 to 19.6 percent in succeeding year . No additional Federal revenue-raising policies beyond the tax provisions of the economic recovery and tax act are assumed. These policies do not change in the disruption scenarios.

CHAPTER II

OIL PRICE EFFECTS OF SUPPLY DISRUPTIONS

Oil prices increase in a disruption because production and production capacity are reduced, allowing producers to charge more for their oil. A disruption would raise oil prices regardless of market conditions at its outset. If oil prices happen to be falling before that disruption, they would rise or at least fall less rapidly. Prices could rise steeply even if the market has enough excess capacity to replace most of the lost production, as demonstrated in the 1979 Iranian oil cutoff. Iranian oil production dropped by about 5.7 MMBD between September 1978 and January 1979, the months with their highest and lowest production. Excluding Iran, OPEC had about 4.2 MMBD of excess production capacity in September, 1978. This means that OPEC alone had the capacity to make up all but 1.5 MMBD of Iran's lost production, yet contract oil prices nearly doubled in the year following the disruption.

Past research on disruptions shows that oil prices spiral up in a process often referred to as "price ratcheting." Disruptions tighten the oil market, raising spot market prices (the prices paid for oil exchanged on a day-to-day basis). Expectations of rising prices induce inventory buildup, further tightening the market and raising spot prices. Contract prices, or the prices charged for oil sold under long-term contract, lag behind and this sluggish response forces all of the adjustment to reduced supplies into the spot market, driving spot prices higher than contract prices. Eventually, contract prices increase to reflect higher spot prices. In the long run, the contract price increase causes consumers to change their consumption patterns and lower their oil demand, eventually causing prices to drop. However, prices may not return to their pre-disruption level because production may not be fully restored or may be reduced to maintain higher prices.

SUMMARY OF OIL PRICE RESULTS

Figures 1 and 2 summarize GAO's oil price results. Because of the similarity in models' oil price results, figures show only GAO's results. Any significant differences are noted in the text. Figures 1 and 2 show peak additions to spot and contract prices under different disruption scenarios and market conditions, with and without SPR drawdown. Spot prices generally peak in the beginning and contract prices at the end of the year following the disruption. As expected, spot prices rise substantially above contract prices. The price results figured here and elsewhere in this chapter show that disruption size, market tightness, and oil stocking behavior are important factors determining how high oil prices will rise during supply disruptions.[1] The severity of the price shock accelerates steeply with disruption size. Although slack market conditions minimize price effects, a 3 MMBD disruption could still temporarily raise contract crude oil prices by up to $6 per barrel (see Figure 2). As shown in Figure 2, a 10 MMBD disruption could nearly double contract oil prices. A Persian Gulf disruption, of course, would cause even more severe price shocks, although the increase would be partially moderated by the accompanying recession-induced drop in oil consumption. However, those models may not be appropriate for measuring so severe a disruption because basic oil market relationships may break down.

As shown in Figures 1 and 2, a disruption in a tighter oil market would increase prices in every case. Furthermore, the larger the disruption, the greater the difference increased market tightness makes.

Private stock behavior and SPR drawdown can also make a difference in how high oil prices rise during a disruption. Drawing down private stocks and the SPR could reduce oil price increases.

MODEL CONSENSUS

The three models we used to analyze the price effects of disruptions generally agree on the timing and severity of price shocks. Spot prices peak higher and sooner than contract prices, with spot prices generally peaking after the disruption has ended. The Hubbard and GAO models produce very similar results in the 3 MMBD disruption, differing by only 57 cents at their peak. In the 19 MMBD disruption, the models' prices differ by only $10.00 or 15 percent at their peak.

GAO's and Hubbard's models produce fairly similar results because some of their differences offset each other. Hubbard's model produces slightly higher price increases. All other things being equal, the lack of feedback of lower economic growth and oil consumption and the monthly frequency would tend to give the GAO model larger price increases. However, in Hubbard's model, market tightness grew over 1983 in the control case because of growth in world oil demand. This increase tended to enlarge Hubbard's price effects relative to GAO's.

Because of the similarities in GAO's and Hubbard's oil price results, figures show primarily GAO's. We do not present Mork's

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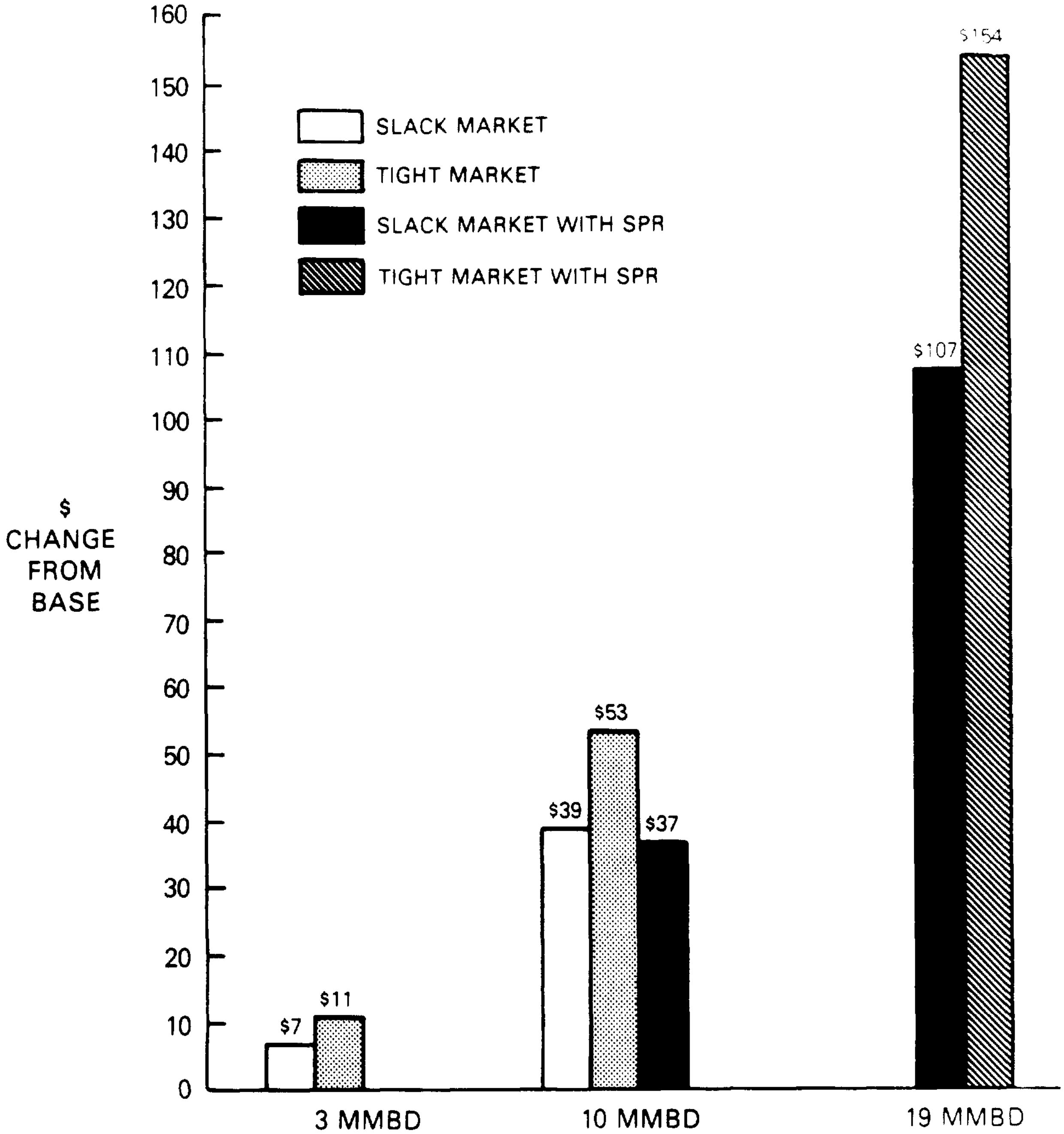
[1]The base price was $30.90.

FIGURE 1

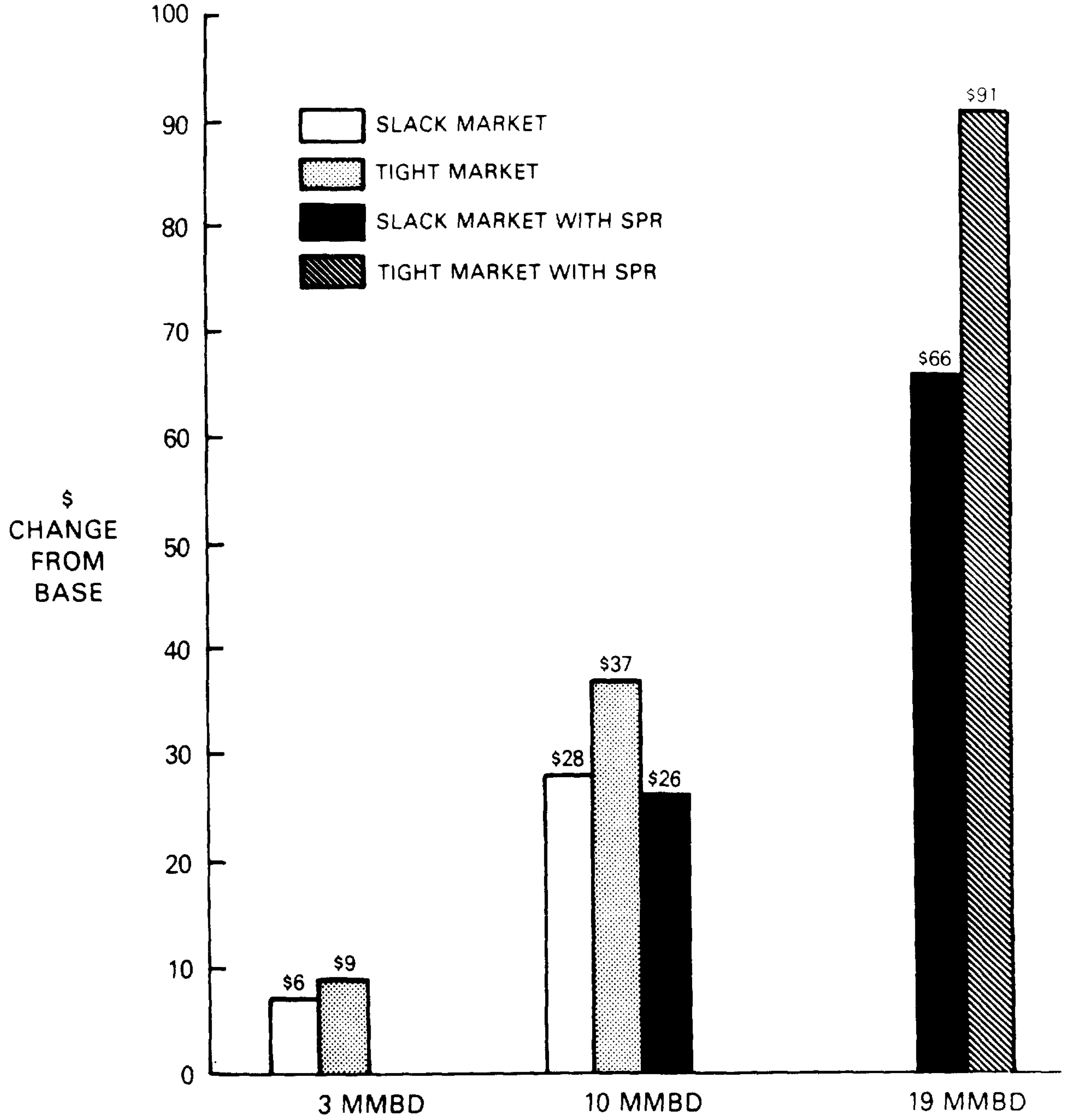
PEAK ADDITIONS TO SPOT PRICES CAUSED BY OIL SUPPLY DISRUPTIONS1/ (GAO MODEL)



1/THESE FIGURES ARE BASED ON QUARTERLY RESULTS. UNLESS OTHERWISE SPECIFIED, SPR DRAWDOWN IS NOT INCLUDED. IN THE CASES WHERE SPR USE IS SPECIFIED, DRAWDOWN IS AT THE MAXIMUM PUMPING RATE.

FIGURE 2

PEAK ADDITIONS TO CONTRACT PRICES CAUSED BY OIL SUPPLY DISRUPTIONS1/ (GAO MODEL)



1/THESE FIGURES ARE BASED ON QUARTERLY RESULTS. UNLESS OTHERWISE SPECIFIED, SPR DRAWDOWN IS NOT INCLUDED. IN THE CASES WHERE SPR USE IS SPECIFIED, DRAWDOWN IS AT THE MAXIMUM PUMPING RATE.

price results here because his model is annual and does not show the timing of price increases as well as the other models. Mork's model is more useful for determining long-term price and economic effects.

The remainder of this chapter discusses in detail oil prices during past disruptions and presents model results.

CRUDE OIL PRICES IN SUPPLY DISRUPTIONS

Spot prices in past disruptions

Spot prices, the prices paid for oil exchanged on a day-to-day basis rather than sold under a long-term contract, rise quickly at the outset of supply disruptions. The amount of crude oil sold on the spot market has varied from practically none under normal circumstances to 25 percent of all sales during the 1979 Iranian oil disruption, as reported by trade journals. Although only a small amount of oil is usually traded on the spot market, spot prices signal market changes. Their sensitivity to supply and demand changes comes from refiners making day-to-day transactions for immediate needs in this market.

Spot prices rose at the outset of both the Arab oil embargo and the 1979 Iranian oil shutdown. Over the first few months of the Arab oil embargo (October to December 1973), the Rotterdam spot price for Arab light oil rose about 500 percent. From November 1978, when oil field strikes began in Iran, to March of 1979, when exports resumed, the spot price of Arab light oil nearly doubled.

Researchers have offered a variety of explanations for this spot price behavior. The primary one is that lower supply exacerbated by stock building forces spot prices up. Danielson, Professor of Economics at the University of Georgia, suggests that spot prices increase because of actual and anticipated refined product shortages and rising product prices. Oil demand remains high or grows because of the initial inflexibility of consumption rates and inventory speculation.[2] Verleger emphasizes the role that stock accumulation, at all levels, plays in driving up spot prices.[3] The combination of expected supply shortages and high demand sends spot prices soaring.

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[2]Danielson, Albert L., "The Role of Speculation in the Oil Price Ratchet Process," Resources and Energy, 1979, p. 256.

[3]Verleger, Philip K., Oil Markets in Turmoil. Ballinger Publishing Company, 1982, Cambridge, Mass., pp. 89-122.

Contract prices in past disruptions

We assumed contract prices to be the official prices that producers charge for oil sold under long-term contract.[4] Various oil industry sources estimate that 90-95 percent of crude oil is normally sold under contract. This percent is reduced during disruptions as oil sales are diverted to the spot market.

The nature of contracts changed dramatically during the 1979 Iranian oil supply disruption, making prices more volatile. In many cases, 6-month and 1-year contracts were shortened to 90 days or less and credit terms were often reduced from 90 to 30 days. Some producers imposed price increases retroactively. Oil market tightness resulting from the disruption enabled producers to make these changes. In contrast, under current slack market conditions, oil buyers have greater leverage and some producers charge below their posted oil prices.

Sharp rises in new contract prices are evident in past disruptions. The official sales price for Arab light, including premiums, rose from about $3.00 per barrel in September of 1973 to about $12.00 in January of 1974. As a result of the 1979 Iranian oil supply cut-off, the official price of Mideast light crude rose from $12.70 in the fourth quarter of 1978 to about $24 in November of 1979, when spot prices peaked. Official prices continued to rise until they peaked at $34 per barrel in the last quarter of 1981.

Two important observations by researchers on contract price behavior during disruptions are that:

--contract prices respond sluggishly to spot market changes and continue to catch up long after the disruption is over, and

--after contract prices peak, they may not return to their pre-disruption level.

Both Verleger and Hubbard state that contract prices follow spot prices upward with a lag. We identified four major causes for contract prices' sluggish response in disruptions:

(1) some contracts may not allow immediate price changes,

(2) OPEC sets prices at quarterly meetings,

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[4]The contract price does not include discounts or premiums, and insurance and transportation costs.

(3) OPEC may not want to raise prices so high that they may have to reduce them later, and

(4) Saudi Arabia may increase production temporarily to restrain prices. One reason for this is that adverse effects on industrial economies could reduce their real returns on foreign assets. In addition, their vast oil reserves give them an incentive to prevent price increases sharp enough to encourage the development of alternative fuels.

Because contract prices are slow to respond to spot price changes they continue to rise long after the disruption ends. This was evident in the Iranian disruption, when contract prices rose more than one-third over the two years after spot market prices peaked.

After contract prices peak, they may drop but not to the pre-disruption level. The long-term quadrupling and doubling of contract prices in the Arab oil embargo and Iranian cutoff, respectively, demonstrate that prices may not drop to their pre-disruption level. One reason for this is that production may not be fully restored as was the case with Iran after the 1979 disruption. Another possible explanation for this phenomenon is that production may be adjusted downward to maintain higher prices.

Timing of models' price increases

All model results show that oil prices first shoot up and then drop, in some cases below the pre-disruption price.[5] As expected, spot prices in all the disruption scenarios peaked higher and sooner than contract prices. Figure 3 charts the paths of spot and contract prices in the 10 MMBD disruption case (with maximum SPR drawdown) and shows spot prices' earlier and higher peak.

Except for the most severe disruption, prices were shown to keep rising after the disruption is over, due to lags in price response to market changes and continued inventory buildup. Spot prices generally peak between the last quarter of the disruption

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[5]The model results show that in some cases prices drop below the original level. However, in past supply disruptions, prices have not returned to their original level in part because lost production was never fully restored. The models do not capture this effect because production is fully restored at the disruption's end. If intentional production cuts were maintained, the models would show a permanent price increase.

year (1983) and the end of the first half of the following year (1984). Following spot prices, contract prices generally peak in the latter half of 1984, the year after the disruption.

A major problem associated with disruptions is the swiftness of the price increase. The economy and consumers have little time to adjust to rapid increases. The size of the disruption determines how swiftly prices will rise, with the larger disruptions accelerating the rise in both spot and contract prices. Prices peak earlier in the larger disruptions. For example, spot prices peak in the fourth quarter of 1983 in the 19 MMBD disruption and in the first half of 1984 in the 3 MMBD disruption.

FACTORS DETERMINING THE SEVERITY OF THE INCREASE

Disruption size

The size of the disruption in terms of production or capacity loss is the most important factor determining how high prices go. As shown in Figures 4 and 5, spot and contract prices increase exponentially with disruption size. Price increases for all figures presented are nominal, meaning that they include increases in inflation. Unless otherwise specified, model results from current slack market conditions are presented.[6] Our 3 MMBD disruption shows modest increases over the base. Current slack market conditions imply that prices should fall due to a surplus of oil relative to demand. However, models show large to severe price shocks more than drying up the current surplus, in the 10 MMBD and 19 MMBD disruptions. The larger the disruption, the sharper the consumption and contract price drop one to two years after the disruption's end.

3 MMBD disruption

Even with slack market conditions, the 3 MMBD disruption generally results in modest price increases since the supply disruption tightens the market. In Hubbard's model, contract prices fell slightly but would have fallen even more if the disruption had not occurred. In GAO's model, the 3 MMBD disruption temporarily raised official crude oil prices by up to about $6/barrel (from a base price of about $31 per barrel) at the peak. As shown in Figure 4, spot prices may rise by more then $7/barrel. According to the GAO model, which examines price effects through 1987, spot prices return to their original level in mid-1986. Contract prices return to "normal" in 1987, almost 4 years after the disruption's end.

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[6]Slack market conditions are defined as mid-summer 1982 market conditions, when OPEC was producing at 65 percent of capacity.

FIGURE 3

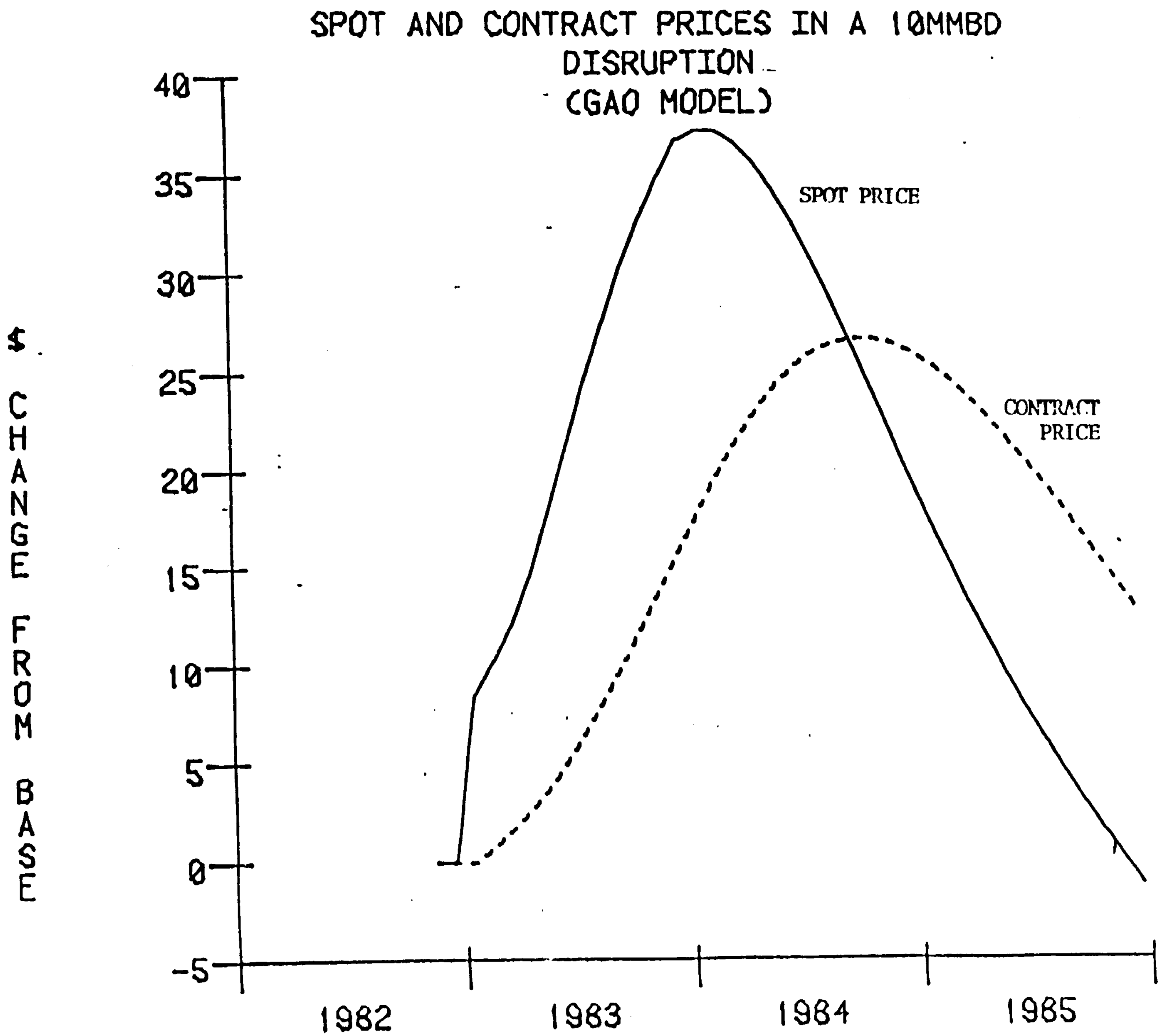
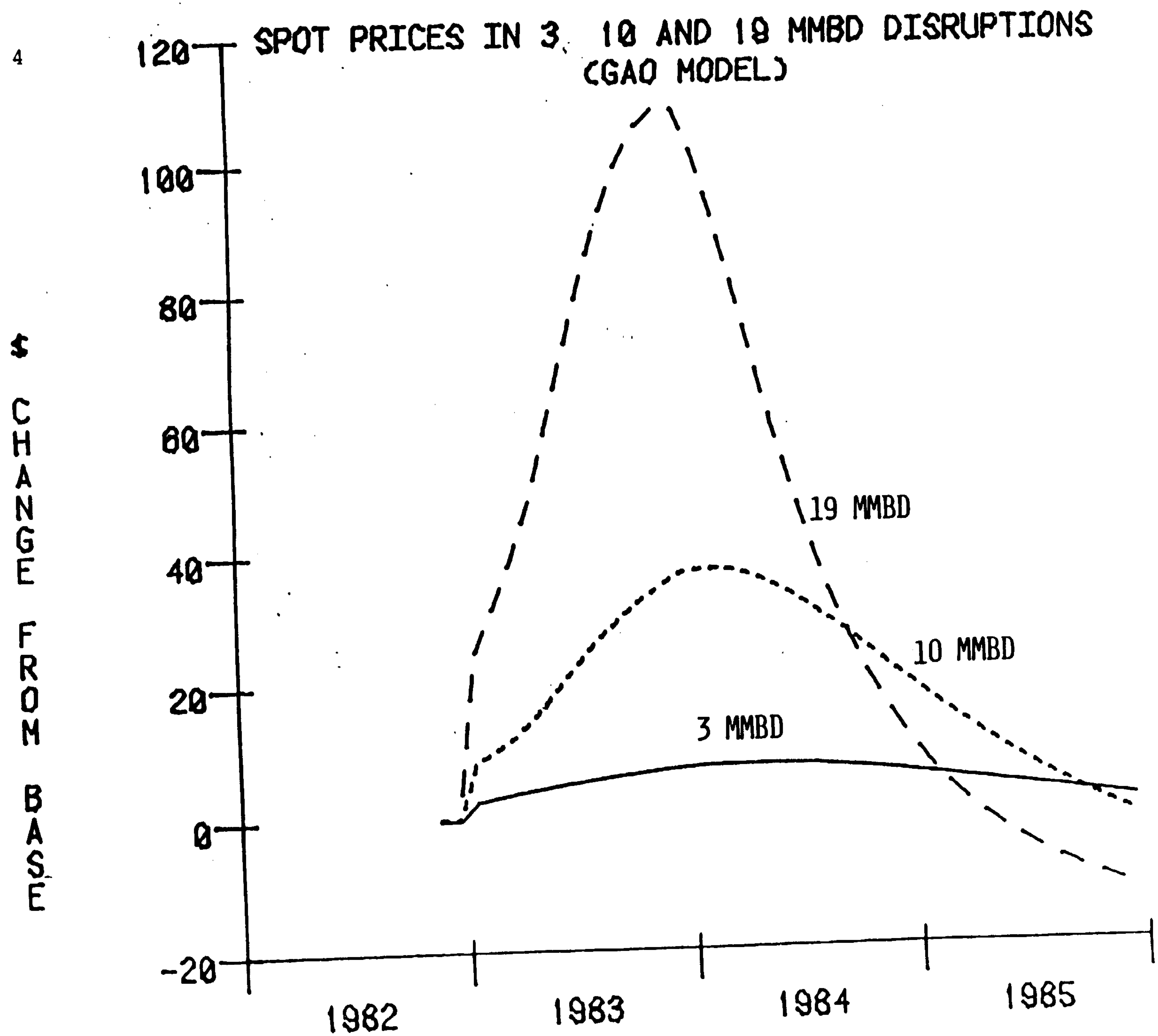
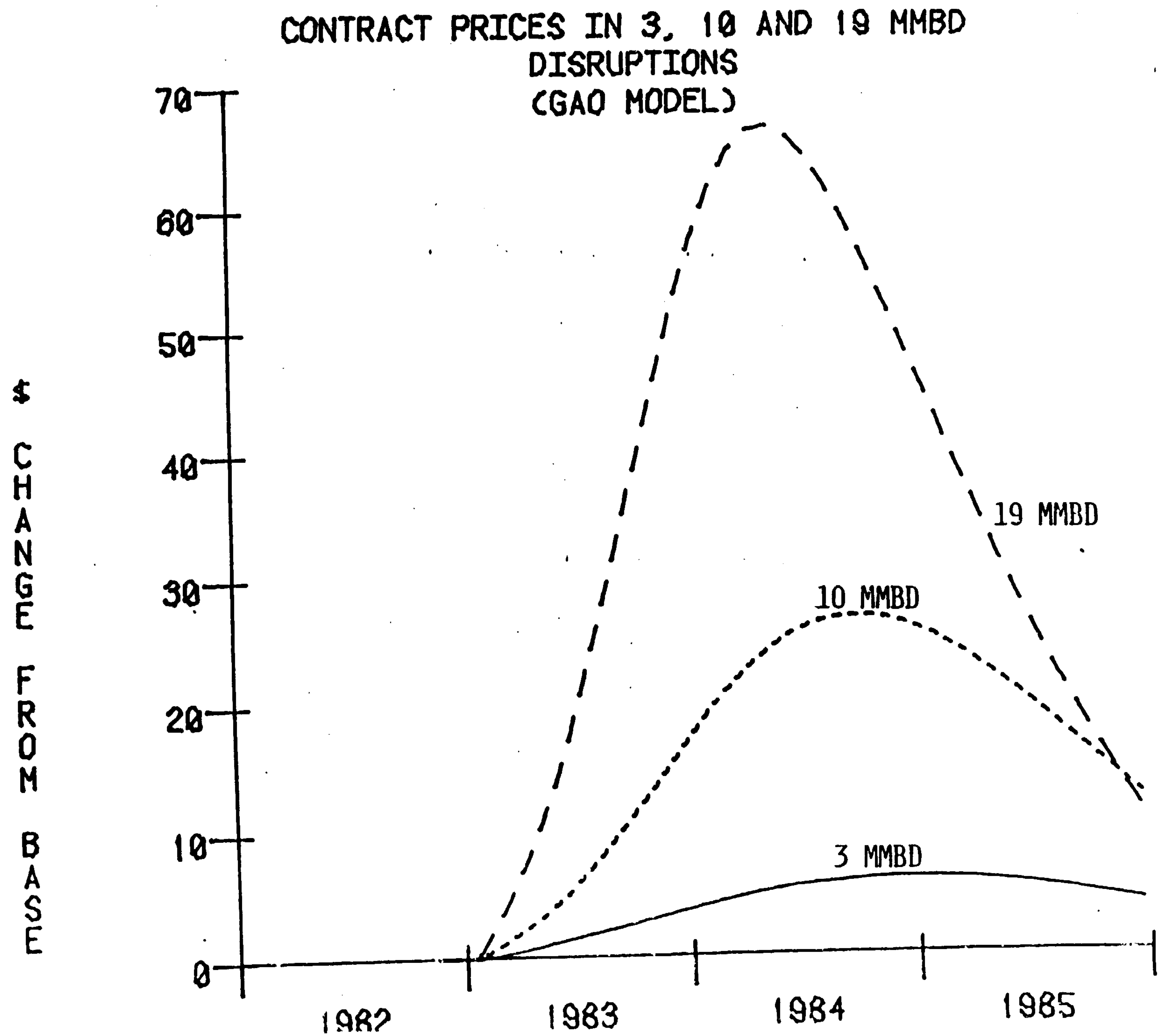

SPOT AND CONTRACT PRICES IN A 10MMBD
DISRUPTION
(GAO MODEL)
$ CHANGE FROM BASE
40
35
30
25
20
15
10
5
0
-5
SPOT PRICE
CONTRACT
PRICE
1982
1983
1984
1985

FIGURE 4



SPOT PRICES IN 3, 10 AND 19 MMBD DISRUPTIONS
(GAO MODEL)
$ CHANGE FROM BASE
120
100
80
60
40
20
0
-20
19 MMBD
10 MMBD
3 MMBD
1982
1983
1984
1985

FIGURE 5


CONTRACT PRICES IN 3, 10 AND 19 MMBD
DISRUPTIONS
(GAO MODEL)
$ CHANGE FROM BASE
70
60
50
40
30
20
10
0
1982
1983
1984
1985
19 MMBD
10 MMBD
3 MMBD

10 MMBD disruption

Despite slack market conditions and assumed maximum SPR drawdown, the 10 MMBD disruption results in large price increases. As shown in Figure 4, spot prices rise by as much as $37 per barrel. This more than doubling of spot prices is accompanied by a doubling of contract prices at their peak, which, as Figure 5 shows, rise by $27 per barrel.

Figure 4 shows that spot prices drop below their starting point at the end of 1985. Although it does not appear on this chart, contract prices would be expected to do the same in early 1987. As a result of reduced consumption accompanying the price shock, the GAO model's spot prices continued to drop until early 1987.

19 MMBD disruption

Model authors do not place much confidence in their models' ability to measure the effects of such a large disruption because basic oil market relationships may break down. (See Chapter IV, p. 38 for an explanation.) However uncertain, the effects of a disruption this large would likely be severe. Despite their unreliability, we show these results to make this point.

Even with market slackness and maximum SPR drawdown, spot prices could rise by about 350 to 470 percent at their peak, depending on the model. In the GAO model, spot prices would temporarily rise by over $100 per barrel. Contract prices could rise by between $66 and $76 per barrel (depending on the model), an increase of over 200 percent. This would bring the official price of crude oil in both models to about $100 per barrel in mid-1984. Figures 4 and 5 show how price effects in the 19 MMBD case are exponentially larger than in the other cases.

Price increases are partially moderated as oil demand falls. The original price shock causes a large oil consumption drop as prices rise and the economy goes into recession. Both Hubbard's and GAO's models produce oil consumption reductions as high as one-third. This large reduction also explains why prices drop quickly after they peak, declining even below their original levels.

Market tightness

The degree of market tightness, defined as the percent of available production capacity in use, plays a major role in determining the size of price increases in a disruption. We therefore modelled both a "slack" and a "tight" market scenario, the former reflecting a plausible greater degree of market tightness. The "slack" market was defined as production at 65 percent of capacity, while the "tight" market was production at the disruption's outset of about 75 percent of capacity.[7] Figure 6 shows GAO's spot prices for both current and tight markets in the 10 MMBD disruption scenario. At its peak, increased market tightness raises spot prices by about $16 per barrel or an additional 50 percent. Figure 6 shows that as spot prices recede, tight market prices drop below slack market prices. This price drop is caused by the tight market cases' higher stock drawdown and demand reduction in 1985.

The price effects of varying degrees of tightness grow with the disruption size. The larger the disruption, the greater the price difference that market tightness makes. This effect can be clearly seen in Figures 1 and 2 (see pp. 11-12), which shows the GAO model's additions to spot and contract prices at the peak in both slack and tight markets. In the 3, 10, and 19 MMBD disruptions, the GAO model's market tightness increases spot prices by up to 13, 53, and 153 percent respectively. The models produce steep spot price growth when both disruption size and market tightness are increased, because spot prices are exponentially related to the production-to-capacity ratios. Raising both disruption size and market tightness increases this ratio, thereby causing a disproportionately large price shock.

Oil inventory behavior

Oil inventory (stock) behavior can greatly influence prices in a disruption. Private stock buildup can intensify the price shock, whereas SPR or private stock drawdown can help moderate the increase. Private stock accumulation in our disruptions ranged from about 300 MBD to 5 MMBD at its peak, depending on the disruption size. While the SPR held 278 million barrels (as of September 1982), the maximum drawdown rate is currently 1.7 MMBD.

Private stocks

Private stocks in past disruptions--Past research and an examination of past disruptions reveal that private oil stock accumulation is a key factor in the upward price spiral accompanying disruptions. Evidence of such inventory accumulation is abundant. For instance, in his recent book, Verleger states that oil companies acquire stocks during shortages, thereby raising

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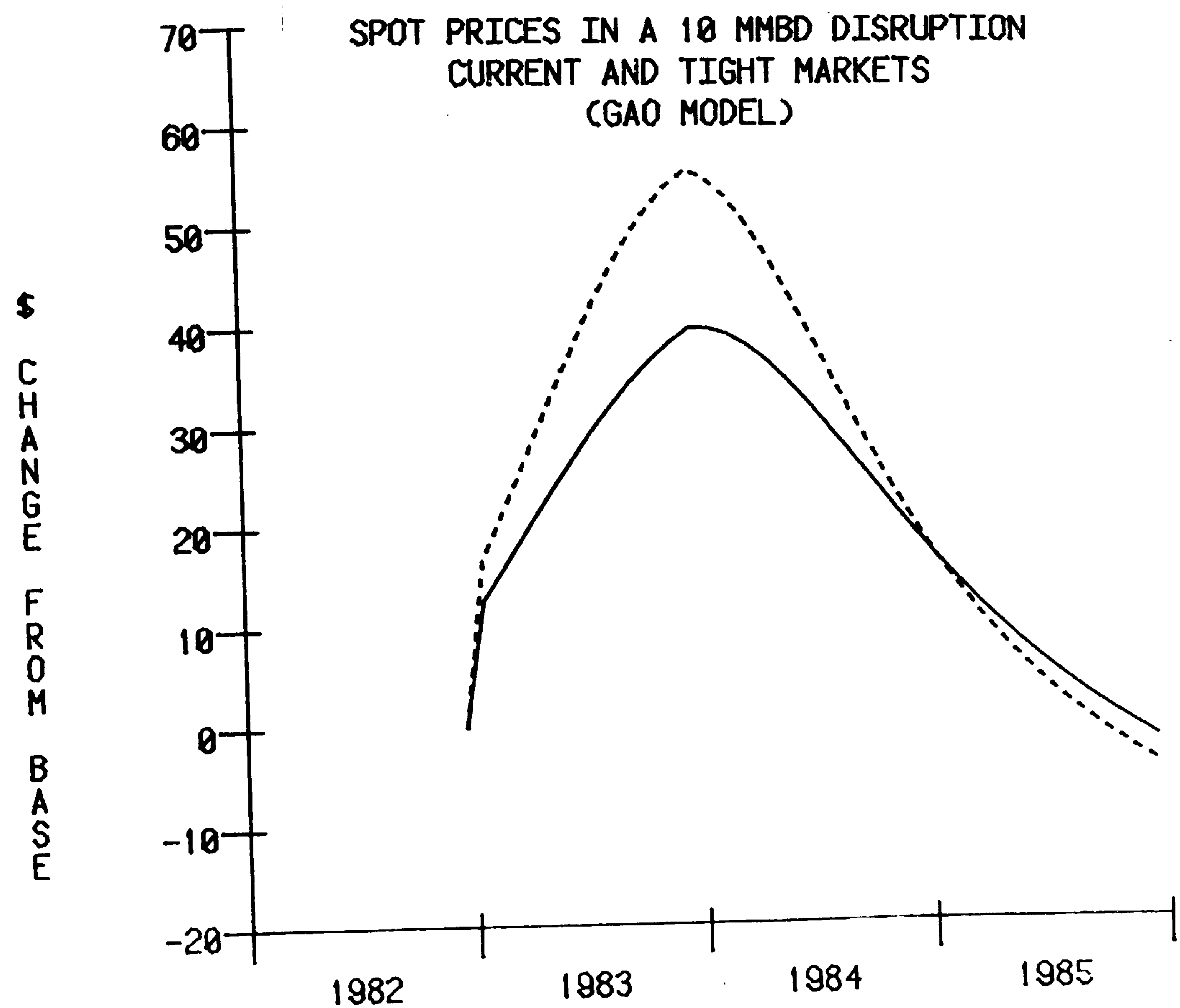
[7]See chapter I, p. 7 for a detailed explanation of our market tightness assumptions.

FIGURE 6


SPOT PRICES IN A 10 MMBD DISRUPTION
CURRENT AND TIGHT MARKETS
(GAO MODEL)
$ CHANGE FROM BASE
70
60
50
40
30
20
10
0
-10
-20
1982
1983
1984
1985

spot prices and increasing the shortage. He estimates that during the Arab oil embargo, refiners accumulated stocks at a rate of over 800 MBD.[8]

Stock buildup also occurred during the Iranian oil cutoff. Although seasonally adjusted International Energy Agency countries' stocks fell about 5 percent in terms of consumption days at the outset of the disruption, they rose about 4 percent during the first quarter of 1979, before exports resumed in March 1979. This first quarter stock rise occurred despite higher oil demand. Danielson claims that "The so-called supply crisis of 1979 was in reality an inventory problem, as indicated by the fact that production exceeded consumption by about 0.8 million barrels per day and inventories increased by 300 million barrels."[9]

Inventory accumulation during a disruption is caused by an expectation of rising prices and uncertainty over whether the disruption may worsen. Verleger determined that oil companies build stocks when spot prices are expected to rise, as indicated by a growing divergence between spot and official oil prices. He stated that individual oil companies are acting in a rational economic manner because buying oil today can be profitable when the price is expected to be higher tomorrow. Hubbard's and Weiner's research indicates that oil companies are apt to stock up when (1) prices are expected to increase by more than the cost of holding stocks, (2) stocks are low relative to sales, and (3) consumption is unexpectedly low.[10]

Oil consumers also build inventories during disruptions, for instance, by topping gasoline tanks and filling storage tanks. Expectations of shortages and rising prices cause consumers and distributors to "panic buy" or stock up on supplies.

Model results--Figure 7 shows the GAO model's expected inventory accumulation for the 3, 10, and 19 MMBD disruption cases. The volume of stocks accumulated accelerates steeply with the disruption size. Stock buildup for the 3, 10, and 19 MMBD

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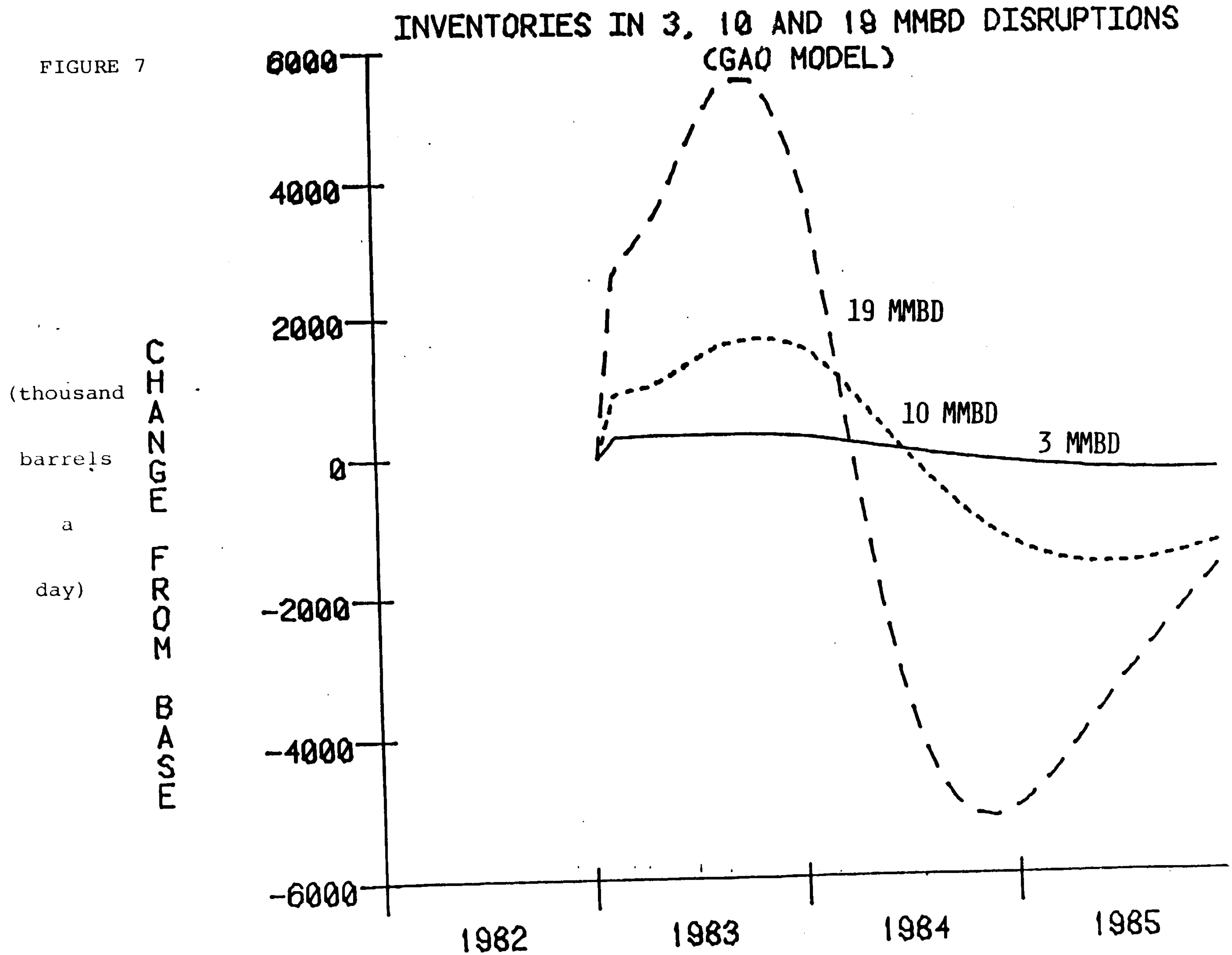
[8]Verleger, Philip K., Oil Markets in Turmoil, Ballinger Publishing Company, Cambridge, Mass., 1982, p. 93.

[9]Danielson, Albert L. and Selby, Edward, B., "World Oil Price Increases: Sources and Solutions." The Energy Journal, October 1980, p. 60.

[10]Hubbard, R. Glenn and Weiner, Robert, The "Sub-Trigger" Crisis: An Economic Analysis of Flexible Stock Policies Harvard University, Cambridge, Mass., 1982, p. 14.

FIGURE 7


INVENTORIES IN 3, 10 AND 19 MMBD DISRUPTIONS
(GAO MODEL)
(thousand barrels a day)
CHANGE FROM BASE
6000
4000
2000
0
-2000
-4000
-6000
1982
1983
1984
1985
19 MMBD
10 MMBD
3 MMBD

cases peaked in 1983 at 0.3 MMBD, 1.6 MMBD and 5.3 MMBD respectively. Figure 7 also shows the stock drawdown and subsequent replenishment that occurs after the disruption ends. As also shown in Figure 7, the larger the buildup, the larger the eventual stock release.

During our study, Mork tested the effect of stock buildup on oil prices during disruptions. This test was possible because, unlike the other models, Mork's uses stocks estimates determined outside the model. Mork's model was run with and without Hubbard's stock changes. However, since Mork's model is annual, and stock changes are smoothed over the year, price peaks are likely to be understated. In the 3 MMBD case, Mork's results showed that a small stock buildup (averaging about 78 MBD over 1983) made only a 30 cent per barrel difference. The price difference in 1983 was substantial in the larger disruptions, nearing $8 per barrel in the 10 MMBD disruption.

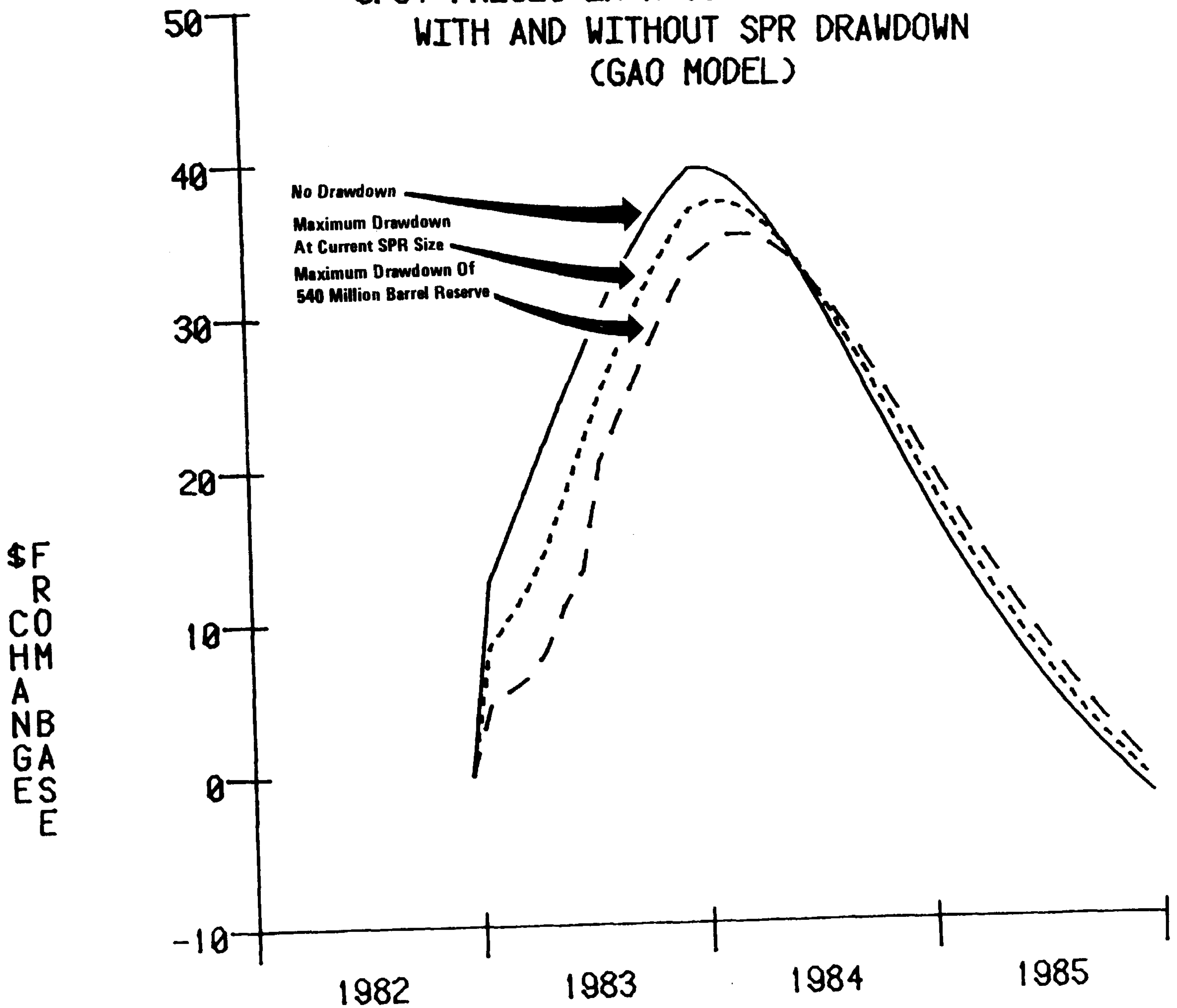
SPR drawdown

The SPR, the U.S. government's oil inventory, has the potential to reduce the price increase in a disruption. We examined the price effects of maximum versus no drawdown in a 10 MMBD disruption and found that, over 1983, drawdown made a $5 or 8 percent difference in the GAO model's spot price results and a slightly lower 6 percent difference in the prices predicted by Hubbard's model. Maximum SPR drawdown lowered spot prices by only about $2 per barrel at the spot price peak. This lower peak price difference occurs because prices peak during 1984, while SPR drawdown occurred in the first three quarters of 1983. Figure 8 shows that SPR drawdown lowers both the price increase and the price falloff associated with supply disruptions.

Models may underestimate the price effects of SPR drawdown because they do not take into account that SPR oil could have a disproportionately large influence on spot prices. According to the Department of Energy's Strategic Petroleum Reserve Drawdown Plan, most SPR oil drawn down during disruptions will be sold by auction. Because the oil will be auctioned during the disruption, as opposed to sold in advance under long-term contract, it is by definition being sold on the spot market. The 1.7 MMBD drawdown rate is comparable to the amount of oil usually sold on the spot market so spot price effects may be substantial. However, the SPR's current size and maximum drawdown capabilities limit the leverage it can have over prices in large disruptions. Maximum drawdown for the first 3 months of a disruption is 1.7 MMBD and the amount tapers off quickly thereafter. At 1.7 MMBD, the SPR represents only about 3 percent of current world oil production. The drawdown amount may also be small relative to disruption size.

FIGURE 8

SPOT PRICES IN A 10 MMBD DISRUPTION WITH AND WITHOUT SPR DRAWDOWN (GAO MODEL)



Despite limited drawdown capability, the SPR can affect prices somewhat. Furthermore, as the SPR grows and develops a larger drawdown capability, it will allow greater flexibility in drawdown and can be a more useful counter to price increases. This can also be observed in Figure 8, where the price effects of drawdown when the SPR reaches a level of 540 million barrels are shown. The Department of Energy plans on completing Phase II, where this fill level will be achieved, by the end of fiscal year 1986. Maximum drawdown capability of a Reserve of this size is more than twice as large as the current rate, ranging from averages of 3.5 MMBD in the fist 3 months to 1.9 MMBD in the sixth and last month of drawdown. Averaged over 1983, maximum drawdown at these rates lowered the spot price increase by 17 percent.

CONSUMER OIL PRICES

Consumer oil prices in past disruptions

Consumer prices respond sluggishly to supply disruptions because they follow contract rather than spot prices. In addition, short-term demand is not very responsive to price changes. A larger demand reduction would lower the disruption-induced price increase.

In his recently published book, Verleger concludes that "oil companies tend to raise consumer prices too slowly during disruptions," because they follow OPEC (e.g., contract) rather than the spot market in setting prices, and because of actual or anticipated government restrictions.[11] This observation is supported by examining the behavior of spot, contract, and heating oil price increases resulting from the 1979 Iranian oil disruption. Between October 1978, at the outset of the disruption, and October 1979, heating oil and contract oil prices increased at an average rate of about 4 percent per month, while spot prices rose at a rate of 9 percent per month.

In addition to the delay in demand response, short-term demand is not very responsive (inelastic) to changes in price. In the short-run, oil consumer ability to substitute other fuels and alter energy use patterns is limited. This lack of short-run demand response to a disruption makes both spot and contract prices rise more than they would have if there had been a greater demand reduction.

In the long-run, the rise in consumer oil prices changes consumption patterns and spot prices stabilize or drop. Following spot prices with a lag, consumer prices drop. Large price

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[11]Verleger, Philip K., Oil Markets in Turmoil, Ballinger Publishing Company, Cambridge, Mass., 1982, p. xxvi.

shocks can cause precipitous demand reductions one to two years after the disruption's end. This process was evident after the 1979 Iranian oil cutoff. In the two years following the cutoff, yearly average International Energy Agency countries' petroleum consumption fell by about 13 percent. This drop primarily results from reduced economic growth, fuel efficiency improvements, conservation measures, and fuel switching, which were brought about by the sharp rise in oil prices. For example, gasoline prices peaked in March 1981, two years after the disruption's end, and fell by 9 percent through the first quarter of 1982.

Model results

Our model results show that consumer oil prices follow contract oil prices with a two month lag, and generally peak between the second and fourth quarters of 1984. Table 1 shows gasoline price increases in the four disruption cases. Heating oil price increases are generally the same as those for gasoline. Residual fuel price increases are somewhat lower dollar amounts.

Table 1
Additions to Gasoline Prices
Caused by Oil Supply Disruptions a/
(GAO Model)

	1983	1984	1985	Quarter Peak
	- - - - (dollars per gallon) - - - -			
3 MMBD	$ .11	.23	.22	.25
Slack market 10 MMBD	.39	.93	.64	.97
Tight market 10 MMBD	.52	1.22	.74	1.28
19 MMBD b/	.92	2.00	.84	2.20

a/Results are for current market conditions and do not include SPR drawdown unless otherwise noted. The assumed base gasoline price is $1.29 per gallon.

b/Includes SPR drawdown at maximum rate.

As shown in Table 1, gasoline prices could rise by as much as 25 cents per gallon, or 19 percent in a 3 MMBD disruption. In a 10 MMBD disruption, gasoline prices may temporarily rise by $.97 to $1.28 or as much as 75 to 100 percent, depending on the extent of market tightness at the disruption's outset. Table also shows that, in a 19 MMBD disruption, gasoline prices may rise by $2.20 per gallon at their peak. This amount represents a temporary increase of about 170 percent.

Disruptions will also raise the price of residual fuel oil, which is mostly used by industrial boilers and electric utilities. At their peak, price increases range from 16 cents per gallon in the 3 MMBD disruption to $1.42 per gallon in the 19 MMBD disruption.

CHAPTER III

ECONOMIC EFFECTS OF OIL SUPPLY DISRUPTIONS

Oil price shocks accompanying supply disruptions have hurt the U.S. economy and have been a major cause of inflation and recession in the 1970s. Our research shows that the severity of the economic impacts of a disruption, in terms of increased inflation and unemployment and reduced economic growth, depends on the size of the price shock accompanying the disruption. As we expected, the economic effects of a 3 MMBD disruption would be modest, while a Persian Gulf disruption would severely damage the U.S. economy. The adverse economic effects of disruptions are temporary with one exception. They result in a permanent one-time GNP loss, which is mostly due to lost investment.

The literature identifies two ways in which oil price shocks weaken the Nation's economy: direct (or wealth transfer) costs and indirect (or adjustment) costs. The economy bears direct costs when raising the price of imported oil causes a transfer of income from consuming to producing nations. The indirect costs are caused by the rise in the price of oil relative to other production inputs. Oil is an input into the production of other goods and services as well as final goods. Disruptions raise oil costs, reducing profit-maximizing output of oil-using firms and thereby lowering GNP. As GNP shrinks, the demand for labor and non-energy inputs declines. To the extent that real wages and non-energy prices do not fall, demand for labor and materials falls, further increasing unemployment.

The economic results generated by the Mork, Hubbard, and GAO[1] models differ in severity and timing, especially the results of the Mork model. Due to greater concentration of price effects in the disruption year, Mork's model generally produces more severe economic effects in that year and less severe effects thereafter.

The remainder of this chapter focuses on how the price shocks caused by supply disruptions affect inflation, economic growth, and unemployment. Because the models' economic results are not as similar as their oil price results, either ranges of model results or the maximum effects are presented here, depending on which is more appropriate. Oil price shocks can also cause substantial income redistribution, from the United States to foreign producers, and from domestic oil consumers, labor, and owners of capital to oil producers. While these effects are not presented here, they can be broadly estimated by multiplying the oil price increase by oil imports before and after the disruption.

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[1]To obtain economic effects for GAO's oil model, results were used in Data Resources Inc.'s Macroeconomic model.

INFLATION

Supply disruptions can increase inflation by increasing the price of energy and energy-using goods and services. In the short-term, these price increases are probably not offset by a decline in wage rates or the price of non-energy using goods and services.

Table 2, presenting inflation rates in the last decade, reveals a large increase in the inflation rates in 1974 and 1979, the years following world oil supply disruptions. Although other factors may be involved, researchers have cited the oil disruptions as a principal cause of increased inflation in these periods. A study by Data Resources Inc., concluded that the oil price increases from the Arab oil embargo added about 1.8 percentage points to the U.S. inflation rate in 1974 and 1975.[2] The University of Michigan's model has similar results, with the inflation rate increasing by 1.8 percent in 1974, as a result of the embargo.[3] Mork and Hall estimated that the 1979 energy price shock added 1.8 percentage points to the inflation rate in 1979 and 1.3 percent in 1980.[4]

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[2]Data Resources, Inc., "1980 Oil Embargo Study," U.S. Long-term Review, Fall 1977, p. 2.

[3]Mork, Knut and Hall, Robert E., "Energy Prices, Inflation, and Recession, 1974-75," The Energy Journal, July 1980, p. 51.

[4]Mork, Knut and Hall, Robert, "Macroeconomic Analysis of Energy Price Shocks and Offsetting Policies: An Integrated Approach." Edit. by Mork, Knut. Energy Prices, Inflation, and Economic Activity. Ballinger Publishing Company, Cambridge, Mass., 1981, p. 51.

Table 2

Inflation, Economic Growth, and Unemployment in the United States

Year	Inflation (CPI)	Real GNP growth	Unemployment rate
1970	5.9	- .2	4.9
1971	4.3	3.4	5.9
1972	3.3	5.7	5.6
1973	6.2	5.8	4.9
1974	11.0	- 0.6	5.6
1975	9.1	- 1.1	8.5
1976	5.8	5.4	7.7
1977	6.5	5.5	7.1
1978	7.7	4.8	6.1
1979	11.3	3.2	5.8
1980	13.5	- 0.2	7.1
1981	10.4	- 1.9	7.6

Source: Economic Report of the President, Feb. 1982, Table B-55, p. 295, Table B-5, p. 239, Table B-33, p. 271.

Table 3 shows the annual increases in the inflation rate caused by the three disruptions under slack market conditions estimated by the models. In the 3 MMBD disruption, the inflation rate is estimated to grow by one-half of one percent or less in any year. The 10 MMBD disruption causes annual peak increases ranging from 1.9 to 2.6 percent, depending on the model. The Persian Gulf disruption case has severe inflationary effects, with the three model's annual increases extending from 3 to 11.4 percent at their peak.

Mork's results for 1983 exceed those of the other two models because the price shock is concentrated in that year. Inflation increases for the other models peak on an annual basis in 1984. However, the quarter with the highest peak generally is in the first half of 1985. Hubbard's Persian Gulf disruption case results in a surprisingly small addition of three percent to the inflation rate in 1984, partly because the recession caused by the large price shock constrains inflation.

Table 3

Additions to the Inflation Rate
Caused by Oil Supply Disruptions a/

	1983	1984	1985
	----(Percent change in the GNP Implicit Price Deflator)---		
3 MMBD			
Mork	0.3	0	0
Hubbard	0.1	0.4	0.2
GAO	0	0.5	0.3
10 MMBD			
Mork	2.5	-0.1	-0.1
Hubbard	0.5	1.9	0.7
GAO	0.2	2.6	1.9
19 MMBD b/			
Mork	11.4	-3.2	-1.3
Hubbard	1.0	3.0	1.0
GAO	0.3	6.4	2.4

a/Rate of change in the GNP price deflator, except for Mork's 1983 change, where we used the deflator for personal consumption expenditures. Results shown are for current market conditions.

b/Includes maximum SPR drawdown.

ECONOMIC GROWTH

Oil supply disruptions and their accompanying price shocks reduce the GNP growth rate during the two years following the disruption's outset. Although the growth rate eventually catches up and temporarily exceeds the base rate, a permanent loss in GNP remains.

Much of economic literature considers oil supply disruptions to have greatly contributed to the recessions in 1975 and 1980. Table 2 shows that real GNP growth dropped dramatically in the years following the 1973-74 Arab oil embargo and 1979 Iranian oil disruption. Data Resources Inc. concluded that the 1973-74 oil price shock reduced real GNP by 3 percent in 1974.[5] According to Mork's model, the embargo caused GNP to drop by 2 percent in

[5]Data Resources, Inc., "1980 Oil Embargo Study," U.S. Long-term Review, Fall 1977, p. 2.

1974 and 5 percent in 1975.[6] The University of Michigan's model attributed a 1.5 percent GNP drop in 1974 and a 4 percent drop in 1975 to the embargo.[7] The Congressional Budget Office believes that the Iranian oil cutoff and Federal Reserve Board reactions caused GNP growth to fall from an annual rate of 1.2 percent in the first quarter of 1980 to minus 9.6 in the second.[8]

The model results show, as expected, that small disruptions have modest effects on economic growth and that larger disruptions could have severe effects. Table 4 indicates that the 3 MMBD disruption would lower GNP growth by no more than 0.4 percent at its peak. This would mean that if GNP would have grown at an annual rate of 3 percent without the disruption, it would grow at a rate of 2.6 percent with the disruption. The 10 MMBD disruption could temporarily reduce real GNP growth by as much as 0.5 to 3.2 percent, depending on the model, which translates into a loss of up to $98.6 billion in 1982 dollars.

As we expected, the annual and sub-annual models diverge widely on the economic growth effects of a 19 MMBD disruption. The sub-annual models focus on the short-term effects of disruptions which we would expect to be larger than the long-term effects. Table 4 shows that the annual peak loss ranges from 1.5 to 13.3 percent, depending on the model. Despite different results, the 19 MMBD disruption has severe impacts in all cases. The peak average annual GNP loss in terms of 1982 dollars ranges from about $71 billion to $415 billion, depending on the model. Furthermore, the economic growth reductions in certain quarters are much larger than the annual averages indicate. Although Hubbard has a comparatively small 1.5 percent average loss for 1983, the loss during the peak quarter at an annual rate is 3.2 percent.

The timing of economic losses is evident in the sub-annual models. Economic losses generally peak during the last quarter of the disruption year. However, in the GAO model's 19 MMBD case, losses peak in the third quarter. Mork's model shows large GNP growth in the year following the disruption because investments that were postponed throughout the disruption year are made at this time.

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[6] Mork, Knut and Hall, Robert E., "Energy Prices, Inflation, and Recession, 1974-1975," The Energy Journal, July 1980, p. 51.

[7] Ibid., p. 51.

[8] U.S. Congressional Budget Office, Managing Oil Disruptions: Issues and Policy Options, U.S. GPO, Washington, D.C., 1981, p.3.

Although the economic growth rate "catches up" with the non-disruption growth rate by the end of 1985, a loss in GNP remains. For example, in Mork's 10 MMBD disruption case, a GNP loss of 1.5 percent exists even in the year 2014. This permanent, one-time GNP loss is primarily caused by reduced investment,

Table 4

Changes in the Real GNP Growth Rate Caused by Oil Supply Disruptions a/

	1983	1984	1985
	--- (p e r	c e n t)	----
3 MMBD			
Mork	- 0.4	+ 0.1	+ 0.1
Hubbard	- 0.2	- 0.2	+ 0.1
GAO	- 0.1	- 0.1	+ 0.3
10 MMBD			
Mork	- 3.2	+ 1.9	+ 0.5
Hubbard	- 0.5	- 0.5	+ 0.5
GAO	- 1.1	- 1.1	+ 0.7
19 MMBD b/			
Mork	-13.3	+10.8	+ 0.9
Hubbard	- 1.5	- 0.7	+ 0.1
GAO	- 2.7	- 2.5	+ 2.3

a/Reductions in GNP growth have negative signs.

b/Includes maximum SPR drawdown.

with non-energy investments being reduced by 21 percent in the disruption year. Pindyck and Rotemberg point out that price shocks reduce investment because they increase inflation and interest rates and they increase uncertainty about the profitability of private investment.[9]

UNEMPLOYMENT

Price shocks caused by oil supply disruptions increase unemployment, although the increase is delayed and severe only in the larger disruptions. Price shocks reduce consumer demand for

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[9]Pindyck, Robert S. and Rotemberg, Julio J., Energy Shocks and the Macroeconomy, Massachusetts Institute of Technology, Cambridge, Mass., 1982, p. 12.

products[10] and thus output, thereby lowering the demand for labor. In the face of this lower demand for labor, maintenance of full employment would require a real wage decline. However, since wages fall slowly, if at all, wage rigidity results in increased unemployment.

Table 2 shows that unemployment increased sharply for the two years following the 1973-74 Arab oil embargo and the 1979 Iranian oil supply cutoff. Unemployment increased by a total of 3.6 percent from 1973 to 1975, and by 1.8 percent from 1979 to 1981, although these increases are not caused exclusively by higher oil prices. Data Resources Inc., concluded that by 1975, the Arab oil embargo had increased the unemployment rate by 1.7 percentage points.[11] Mork and Hall determined that the 1979 price shock increased the unemployment rate by 0.4 percent and 1.2 percent in 1980.[12]

The model results showed that average annual increases in unemployment due to oil price shocks are likely to exceed one percent only in larger disruptions. Table 5 displays the results obtained from the different models. The 3 MMBD disruption, in all models, will increase unemployment by 0.2 percent or less. In the 10 MMBD disruption, additional unemployment peaks at less than 1 percent, except for Mork's 1983 increase. The 19 MMBD disruption is likely to result in increases of greater than 1 percent, and Mork's model suggests an increase of nearly 6 percent.

Unemployment effects follow the economic growth effects and, as shown in Mork's model, last for about two years. The timing of unemployment is more evident in the sub-annual models. For example, in the 10 MMBD disruption, unemployment usually starts rising in the middle of 1983 (the disruption year), and peaks in either the end of 1984 or the first half of 1985. In general, these models show that the larger the disruption, the sooner the impact on unemployment. The delay in unemployment effects occurs because unemployment increases in response to the initial decline in output. In Mork's model, unemployment decreases in 1985 because labor is replacing the largely reduced capital stock.

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[10]In the short-run, consumer demand for products other than oil should not increase sufficiently to offset the decrease in demand for oil products. Thus, overall consumer demand should decrease.

[11]Data Resoures Inc., "1980 Oil Embargo Study," U.S. Long-term Review, Fall 1977, p. 2.

[12]Mork, Knut and Hall, Robert, "Macroeconomic Analysis of Energy Price Shocks and Offsetting Policies: An Integrated Approach." Edit. by Mork, Knut. Energy Prices, Inflation, and Economic Activity. Ballinger Publishing Company, Cambridge, Mass., 1981) p. 51.

Comparing these unemployment effects to those in the current recession puts their severity in perspective. From its beginning to the current trough,[13] unemployment has grown by 2.6 percent. As shown in Table 5, the Persian Gulf disruption is the only case where unemployment effects exceed those in the current recession.

Table 5

Additions to Unemployment Rates
Caused by Oil Supply Disruptions

	1983	1984	1985
	(percent)		
3 MMBD			
Mork	0.2	0.1	0
Hubbard	0	0.1	0.1
GAO	0	0	0.1
10 MMBD			
Mork	1.4	0.2	-0.1
Hubbard	0.2	0.4	0.2
GAO	0.2	0.5	0.7
19 MMBD a/			
Mork	5.7	-0.3	-0.5
Hubbard	0.6	0.9	0.9
GAO	0.4	1.4	1.6

a/Includes maximum SPR drawdown.

In addition, small increases in the unemployment rate translate into a substantial loss of jobs. A one percentage point increase in the unemployment rate, represents a loss of over one million jobs. In the 3 MMBD disruption, for example, Mork's 1983 unemployment increase of 0.2 percent means 224,000 fewer jobs. In the 10 MMBD disruption, unemployment increases, at their peak, represent losses ranging from about 450,000 to 1.6 million jobs, depending on the model. All models show that peak losses in the Persian Gulf disruption would exceed one million, while Mork's 1983 unemployment increase of 5.7 percent reflects the loss of 6.4 million jobs.

[13]As of the third quarter of 1982.

CHAPTER IV

CONCLUSIONS, POLICY IMPLICATIONS, AND KEY AREAS WHERE ADDITIONAL RESEARCH IS NEEDED

CONCLUSIONS

Oil Price effects

--Despite current slack market conditions and assuming SPR drawdown at the maximum pumping rate, oil price increases in large supply disruptions could be severe.

--Except for the most severe disruptions, oil prices keep rising after the disruption is over due to lags in the price response to market changes and continued inventory buildup. Spot prices generally peak between the end of the disruption year and the first half of the following year. Following spot prices, contract prices generally peak in the latter half of the year after the disruption.

--Disruption size, market tightness, and oil stockpiling behavior are important factors determining the severity of oil price increases in disruptions.

Disruption size

--The price increase grows exponentially with the size of the disruption. Prices also peak earlier in the larger disruptions. Under slack market conditions, 3 MMBD, 10 MMBD, and 19 MMBD disruptions would raise contract crude oil prices by about $6, $27, and $66 per barrel, respectively, at their peaks.

--In large disruptions, price increases are moderated by a recession-induced oil consumption drop.

Market tightness

--Disruptions in tighter oil markets would result in greater price increases, and the larger the disruption, the greater the price difference that increased market tightness makes.

Oil stock behavior

--Private oil stock buildup, caused by expectations of rising oil prices and uncertainty over whether the disruption may worsen, adds to the shortage, and thus further increases oil prices.

--SPR drawdown can reduce the size of the price increase somewhat but its current size and maximum drawdown capability of 1.7 MMBD limits its leverage on world oil prices. When the Reserve reaches 540 million barrels, the drawdown rate will double, as will the Reserve's impacts on oil prices.

Consumer oil prices

--Consumer oil prices respond sluggishly to disruptions because they follow contract rather than spot prices.

--Under slack market conditions, gasoline prices in 3, 10, and 19 MMBD disruptions could temporarily rise by as much as $ .25, $ .97, an $2.20 per gallon, respectively, at their peaks.

Macroeconomic effects

--Oil price increases hurt the U.S. economy by causing a transfer of income from consuming to producing nations and by raising the price of oil relative to other production inputs.

Inflation

--Inflation, caused by increases in energy costs and the costs of energy-using goods and services, increases by one-half a percentage point or less in the 3 MMBD disruption. Larger disruptions can cause severe inflation, with the Persian Gulf disruption increasing inflation by about 3 to 11 percent (depending on the model) at the peak.

Economic Growth

--Oil price shocks reduce the GNP growth rate during the two years following the disruption's outset. Although the growth rate eventually catches up, a permanent loss in GNP remains, primarily due to lost investment.

--The models show that small disruptions have modest effects on economic growth with the 3 MMBD disruption reducing the economic growth rate by no more than 0.4 percentage points at its peak. The 10 MMBD disruption could temporarily reduce real GNP growth by up to 3 percentage points, while the 19 MMBD disruption could reduce GNP growth by up to about 13 percent.

Unemployment

--Oil price shocks increase unemployment by reducing consumer demand for products and output, thereby lowering the demand for labor. Unemployment increases are delayed and greater than one percent only in the larger disruptions. In the Persian Gulf disruption, peak increases in the unemployment rate range from about 1 to 6 percent, depending on the model.

--Even small percentage increases in the unemployment rate represent a substantial loss of jobs. I[illegible] the 3 MMBD disruption, for example, a 1983 unemploy[illegible] increase of 0.2 percent means 224,000 fewer j[illegible] while a 19 MMBD disruption's 5.7 percent incr[illegible] reflects the loss of 6.4 million jobs.

POLICY IMPLICATIONS

We found that disruption size, market tightness and oil stocking behaviors are three important factors determining the size of the oil price shock in a disruption. While little can be done about the disruption size, our findings indicate that maintaining a slack oil market and adequate private stocks before a disruption, and drawing down private stocks and the SPR during a disruption will help to moderate the price increase.

Maintaining a slack oil market

Our research shows that the degree of market tightnes[illegible] plays a major role in determining the size of the price increase [illegible]n a disruption. For example, in GAO's 10 MMBD disruption, ti[illegible]tening the market increased spot prices by an additional 50 perc[illegible]t.

The Government could help maintain market slackness by encouraging oil production and exploration in non-OPEC countries; helping to resolve conflicts between oil-producing nations such as Iran and Iraq; developing and/or encouraging the use of alternative fuels; and by promoting energy conservation.

Maintaining high oil stocks

Our examination of past disruptions showed that private oil-stocks are built up during disruptions, increasing the size of the shortage and oil prices. Oil stockpiling may be partially motivated by oil companies' fears of not being able to meet their contractual obligations. Holding emergency stocks would reduce company's concerns about inadequate supplies, thereby reducing their motivation to stock up during a disruption.

Maintaining high stocks could significantly reduce the price increase in a disruption by reducing stock buildup. We were unable to model the price effects of varying initial stock levels because the models we used do not accept stock levels as an input. However, isolating its effects from other factors, Verleger's research showed that the stock level at the start of a disruption makes a large difference in the spot price increase. With initial stocks 2.5 percent above "normal," spot values are $15 per barrel lower--nearly 30 percent. Conversely, with initial stocks 2.5 percent below "normal," spot prices are 50 percent higher.

There are a variety of ways the Government could encourage industry to hold oil stocks for emergency use, with varying levels of cost to private industry and the Government. The Government could require oil companies to set aside emergency stocks directly or by creating a separate government corporation. The Government could also provide a variety of financial incentives to companies for holding stocks. We are currently assessing the costs and benefits of government options for encouraging private oil stockpiling and expect to report on this soon.

Encouraging private stock drawdown during disruptions

Maintaining high emergency oil stocks would reduce stock buildup during disruptions; encouraging stock drawdown during disruptions could go further to reduce the price increases. Encouraging private stock drawdown in disruptions could also be accomplished through tax and financial incentives. Since oil stockpiling is partly motivated by an expectation of rising prices, Verleger proposed that a declining disruption tariff be instituted which would discourage stocking up by causing prices to decline.[1]

While some research has been done in this area, we feel that more is needed because knowledge of stock behavior during disruptions is insufficient and research focuses mostly on incentives to maintain stocks before disruptions rather than draw them down during disruptions.

SPR drawdown

As with private stock drawdown, SPR drawdown was found to reduce price increases in disruptions. In a 10 MMBD disruption, maximum drawdown decreased spot prices by 6-8 percent over the

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[1]Verleger, Philip K., Oil Markets in Turmoil, Ballinger Publishing Company, Cambridge, Mass., 1982, p. xxviii.

disruption year. These price effects of SPR drawdown could be understated. In calculating price increases, the models implicitly assume that SPR oil is sold in the same manner as other oil with spot market sales comprising about 5 percent. In fact, SPR oil would be auctioned during the disruption and might have a disproportionately large influence in reducing spot price increases. Thus, the models may understate the SPR's price mitigation potential. However, the price mitigation potential of the SPR is limited by its current size and maximum drawdown rate. At the SPR's current size, maximum drawdown for the first 3 months is 1.7 MMBD and the amount tapers off quickly thereafter to 0 in the fourth quarter of the disruption year. However, as the SPR grows, it will develop a larger drawdown capability and will be more useful in mitigating price increases.

KEY AREAS WHERE ADDITIONAL RESEARCH IS NEEDED

In requesting this report, Chairman Sharp asked us to identify any key questions concerning the oil price and economic effects of shortages that have not been adequately assessed. The two sub-annual models we used substantially agree on the timing and severity of price increases. It may be that our overall understanding of oil market behavior has progressed to the point that the underlying common view overwhelms surface differences. We have identified several areas where additional research is needed:

--the effects of large disruptions such as a loss of the entire Persian Gulf,

--the effects of and ways to reduce private stock buildup during disruptions, and

--the effects of different government policies to minimize the economic costs of disruptions.

Oil price and economic effects of large disruptions

More research is needed on the price and economic effects of large oil supply disruptions. Model authors were not confident about the validity of Persian Gulf disruption results and they did not agree on the magnitude of effects. Lack of knowledge in this area is a serious concern because the oil price and economic effects may be severe. Mork's model, for example, showed that a Persian Gulf disruption could temporarily raise the inflation rate by up to 11.4 percentage points, and the unemployment rate by up to about 6 percent.

Model authors do not place much confidence in their models' abilities to measure the effects of so large a disruption. In a disruption this severe, the usual oil market relationships may break down, so models constructed on data reflecting these relationships may no longer be suitable. For example, in large disruptions, limited storage capacity constrains stock buildup, making our models' projected stock buildup unrealistic. Besides physical limitations in the distribution system, shortages could also cause other market relationships to break down. For example, oil purchase contracts could be shortened dramatically, as they were in the 1979 disruption, altering the historic relationship between spot and contract prices. In this case, the models would no longer be suitable for measuring the disruption's price effects. Traditional market relationships may also break down because it is unlikely that governments of industrialized nations would take no countervailing actions in such a severe disruption.

In addition to questions about the models' appropriateness for studying the effects of severe disruptions, model results for the 19 MMBD disruption lack agreement on the magnitude of oil price and economic effects. For example, in the disruption year, inflation is estimated to increase by a range of 0.3 to 11.4 percent (see p. 33). Much of this difference is due to Mork's concentration of the price growth in 1983, versus the other model's prices peaking in the following year. However, even when compared at their peaks, the range in additional inflation is still large (3 to 11.4 percent).

<u>Reducing Private stock buildup during disruptions</u>

Research on past disruptions shows that some of the oil price increase and associated economic costs resulted from oil companies building rather than drawing down oil stocks. Research on the price effects of private stock buildup during disruptions and ways to reduce buildup might help minimize the economic costs of future disruptions. Additional research is needed because knowledge of stock behavior during disruptions is limited and existing research focuses on maintaing emergency stocks rather than encouraging drawdown during a disruption.

The models showed that private stocks are accumulated during disruptions adding to the size of the shortage and prices (see Chapter II, pp. 21 and 23). Additional research on the price effects of inventory behavior are needed. Current knowledge is insufficient to support firm conclusions about how to influence inventories because models showed significantly different stock behaviors and results we did obtain were probably understated. While both the Hubbard and GAO models show substantial stock buildup during disruptions, they produce different patterns of stock behavior. Hubbard's stock behavior is more complex than

GAO's because his stock equation contains two other factors besides expected price increases (see Chapter II. p. 21). In Hubbard's model, stocks can both rise and fall in disruptions, and the initial drawdown more closely resembles past disruptions than does GAO's pattern.

Stock-related price results we obtained may also be understated. Mork's model is the only one where we could readily measure price effects with and without stock changes. However, his model is annual so that stock changes are smoothed over the year, and his model does not include an inventory accumulation spot price spiral like the others. Thus, the price effects of stock buildup are probably understated.

Additional research on ways to discourage stock buildup and encourage drawdown during disruptions would also be useful. While there is disagreement about stock behaviors and their effect on prices in a disruption, researchers agree that stock buildup raises prices substantially. In Oil Markets in Turmoil, Verleger concluded that "the behavior of spot values during a disruption becomes much less volatile when the inventory acquisition practices are stopped or reversed."[2]

Charles River Associates has done research on measuring the size of private oil inventories and on government incentives for encouraging a buildup of private stocks above usual levels for use during emergencies. Their September 1981 study concluded that while price controls provide a disincentive to private stockpiling, capital gains treatment of stockpile profits and investment tax credits are the most promising government incentives for it.[3] However, their studies do not explicitly address incentives to draw them down during disruptions. Besides some work by Verleger and the Harvard Energy Security Program, we are not aware of any research on incentives to discourage buildup during a disruption.

Assessment of government policies to reduce economic costs of disruptions

Determining the consensus, if any, on which government policies are most effective in minimizing the economic costs of oil supply disruptions, would improve the U.S. government's response to future disruptions. Some research indicates that

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[2]Verleger, Philip K., Oil Markets in Turmoil, Ballinger Publishing Company, Cambridge, Mass., 1982, p. 146.

[3]Charles River Associates, Inc. Public Policy and Private Petroleum Stockpiling CRA, Boston, Mass., CRA, 1981 pp. 1-1 to 1-4.

past government policies may have increased the economic costs of disruptions. For example, one of the secondary effects of the Federal Reserve Board's contraction of the money supply after the 1979 Iranian oil disruption was increased interest rates, which further reduced economic growth. Hubbard and Fry's research shows that oil price controls reduce GNP growth more than relying on unregulated markets.[4] This phenomenon occurs because the artificially low price resulting from price controls stimulates U.S. oil demand and increases imports, thereby putting an upward pressure on market prices. The greater eventual price increase under price controls results in a higher reduction in GNP growth.

While research on government policies to reduce the economic costs of disruptions is abundant, much of it conflicts or addresses different aspects of the problem. Verleger, Mork, Hubbard, ICF, Inc., Rowan and Weyant, Pindyck and Rotemberg, and Resources for the Future are among the authors and institutions that have studied these concerns. The Energy Modeling Forum at Standford University is currently studying the economic effects of a 50 percent oil price shock and various government responses across 14 participating models. Results of this study are expected by June 1983.

Because researchers examine different types of policies, comparison between them is difficult. Government policies studied can be divided into those which are instituted before and after the disruption. Policies instituted before the disruption that prevent economic losses include encouraging private stock buildup in excess of normal levels; predisruption tariffs to lower oil imports; and incentives for technologies which allow easy substitution away from oil use in a disruption. Response policies during a disruption can be categorized as those that mitigate price increases, stabilize the economy, and redistribute income. Price mitigation policies can include price controls, private and public stock drawdown, and incentives to reduce oil demand. Various monetary and fiscal policies have been offered for relieving the economic costs of disruptions. Monetary expansion, disruption tariffs, payroll tax cuts, revenue recycling, and tax incentives for investment are the usual policies discussed in this area. Income redistribution, in terms of preventing the wealth transfer from consuming to producing nations, can be accomplished with a disruption tariff. Revenue recycling and energy emergency assistance programs have been discussed as ways to reduce income transfers from consumers to producers and the government during disruptions.

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[4]Hubbard, R. Glenn and Fry, Robert C., The Macroeconmic Impacts of Oil Supply Disruptions, Harvard University, Cambridge, Mass., 1982, p. 43.

Researchers disagree on the appropriateness of these various government responses to disruptions. One major reason for disagreement is conflicting policy objectives. Objectives such as minimizing inflation and unemployment effects may require conflicting policies. In this example, monetary expansion might be pursued to reduce unemployment, while contraction would be pursued to lower inflation. Response policies often affect more than one goal and must be judged by their effects on a range of objectives. Disagreements arise because of differences in the importance of objectives. Disruption tariffs, for example, encourage stock drawdown, lower oil consumption, and reduce the wealth transfer from consuming to producing nations. The appropriateness of a disruption tariff depends on the importance placed on these objectives and how well it meets them compared to other policies.

THE GAO MODEL

The GAO model closely follows the relationships and uses some of the estimates of Philip Verleger's model outlined in his recent book, Oil Markets in Turmoil. However, we reestimated all but two of Verleger's equations, using somewhat different variables, seasonal adjustments, and extended time periods. These reestimations resulted in substantially different coefficients in many cases. In GAO's version of the model, disruptions produce lower price increases, because our model generates smaller inventory accumulation and larger initial oil demand reductions than Verleger's model.

As in Verleger's model, spot price changes are the driving force in the GAO model. Spot price changes in this monthly model are a function of the ratio of expected-to-actual production. If expected and actual production are equal, spot prices will not change. A disruption is modelled by lowering actual production, raising the expected-to-actual production ratio and thus spot prices.

Inventory accumulation during disruptions causes an upward spiral in spot prices. Stocking up is the result of expected spot price increases, signified by the spread between last period's spot and contract prices. This accumulation raises expected production, again raising the expected-to-actual production ratio, and thus spot prices.

Contract prices are a function of a combination of last period's spot and contract prices. Consumer oil prices and consumption are functions of contract rather than spot prices. Like contract prices, consumer prices respond sluggishly to the disruption. This sluggish response delays the adjustment of consumer oil demand to reduced supplies. Combined with inventory accumulation, excess consumption exerts an upward pressure on spot prices.

As prices rise, the lagged reduction in oil demand lowers expected production, the expected-to-actual production ratio, and eventually spot prices. The GAO Model is summarized below.

Variables

OPAL = Contact price for Arab light oil
SPAL = Spot price for Arab light oil
SPREAD = Difference between spot and contract prices
CONPRICE = Consumer oil product price
INV = Inventory demand
FWPR = Free-world oil production
QE = Expected producton
QHAT = Oil consumption

Equations

(1) Spot Price
    SPAL = (SPAL\1) x (QE/FWPR)**2

(2) Contract Price
    OPAL + .904xOPAL\1 + .096xSPAL\1

(3) Spread
    SPREAD = SPAL - OPAL

(4) Inventory Demand
    INV = 113.225 + 3.17925xSPREAD\1 + 0.953258xINV\1

(5) Consumer Product Price
    CONPRICE = $6 + OPAL

(6) Oil Consumption
    QHAT = 8972.44 - 41.1628xCONPRICE + 0.823993xFWPR\1

(7) Expected Production
    QE = QHAT + (INV-INV\1)

ESTIMATION OF CONSUMER OIL PRICES

The models produced spot and contract prices for crude oil, which we converted into consumer oil prices, or prices for gasoline, home heating oil, and residual fuel. Product prices were estimated on the basis of statistical relationships betwen product and crude oil prices. These relationships were estimamted separately for monthly and quarterly results over a recent time period. Consumer prices were ultimately converted from dollars per barrel to cents per gallon units. The equations for converting prices are listed below.

Variables

PCONTRACT = Contract price for crude oil
PSPOT = Spot price for crude oil
PCOF = U.S. refiner's acquisition cost for imported crude oil
PCOCP = U.S. refiner's acquisition cost for composite of domestic and foreign oil
MOGAS = Average retail gasoline price for all types
DIST = Average retail No. 2 Heating oil price
RESID = Average retail No. 6 residual oil price

Equations

(1) U.S. Refiner's Acquisition Cost for Imported Oil (dollars per barrel)

$$PCOF = .614357 + .184278xPSPOT = .89825xPCONTRACT$$

(2) U.S. Refiner's Acquisition Cost for Composite of Domestic and Foreign Oil (dollars per barrel)

$$PCOCP = PCOF-(.034xPCOF)$$

(3) Gasoline Price (cents per gallon)

$$MOGAS = \frac{13.2644 + 1.27384xPCOCP}{42} x 100$$

(4) Home Heating Oil Price (cents per gallon)

$$DIST = \frac{3.32439 + 1.28428xPCOCP}{42} x 100$$

(5) Residual Oil Price

$$RESID = \frac{3.33034=.819528xPCOCP}{42} x 100$$

APPENDIX III

ROOM H2-331, HOUSE ANNEX NO. 2;
PHONE 202 225-0320

U.S. HOUSE OF REPRESENTATIVES

SUBCOMMITTEE ON FOSSIL AND SYNTHETIC FUELS

COMMITTEE ON ENERGY AND COMMERCE

WASHINGTON, D.C. 20515

May 21, 1982

The Honorable Charles A. Bowsher
Comptroller General of the
United States
441 G Street, NW
Washington, DC 20548

Dear Mr. Bowsher:

As Chairman of the House Subcommittee on Fossil and Synthetic Fuels, I am deeply concerned that disruptions of imported oil supplies threaten our Nation's economy and security. The United States and its allies continue to depend on OPEC for much of their oil, with most of this oil coming from the Middle East and North Africa. Continued reliance on supplies from this politically volatile area leaves our Nation and the Western allies vulnerable to supply disruptions.

Both the 1973-74 Arab oil embargo and the 1979 Iranian oil cutoff demonstrated that even relatively moderate shortages can result in disproportionately large oil price increases which can be devastating to the economy. While U.S. oil losses during the 1979 disruption comprised a very small percentage of total consumption, crude oil prices nearly doubled between 1978 and 1980. This doubling of prices cut economic growth and added to inflation and unemployment.

The Administration's commitment to relying entirely on the market to allocate and set the price of oil during severe supply disruptions was recently reinforced by its rejection of emergency allocation authority. I find this policy alarming because of the great uncertainty surrounding the extent to which U.S. oil prices would rise during such instances in the absence of any countervailing government response.

Before the Nation places its security and economic health entirely at the mercy of a laissez-faire approach to petroleum supply disruptions, the Congress should be aware of the consequences of such a policy. In this regard, the GAO can make a

The Honorable Charles A. Bowsher
May 21, 1982 2

valuable contribution by assessing objectively what is known about the behavior of world oil market price increases during supply disruptions. Your previous three reports on contingency planning written by GAO's Energy Policy and National Security group have been very helpful in Congressional debate on disruptions policy, and I feel that additional work in this area could provide needed assistance to the Congress as it continues consideration of U.S. energy emergency preparedness.

Specifically, I would like GAO to do the following:

-- Identify and assess the adequacy of the research to date on oil price effects of supply disruptions in the absence of U.S. government intervention;

-- Determine the consensus, if any, on the effect shortages have on prices both during and after a disruption;

-- Determine the consensus, if any, on the effects of oil price shocks on the major components of the U.S. economy.

If you find that current research does not adequately address how high prices may rise during an oil shortage or the effects that given increases have on the various components of the economy, please advise us on what key questions remain unanswered and how we might proceed to answer them. Your views on the extent and duration of price increases or on how to study them would be greatly appreciated. Please have your staff contact Committee staff to decide on a work plan.

Sincerely,

Philip R. Sharp
Chairman

PRS:dg