United States General Accounting Office

GAO

Report to Congressional Requesters

March 1993

ENERGY SECURITY AND POLICY

Analysis of the Pricing of Crude Oil and Petroleum Products

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United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-249628

March 19, 1993

Congressional Requesters

This report responds to your request that we analyze the pricing of crude oil and three petroleum products—gasoline, home heating oil, and jet fuel—under normal market conditions and during market shocks. The report then describes the federal government's authorities for responding to a disruption in the supply of oil and the use of those authorities during the Persian Gulf Crisis. The report also discusses the concerns of independent gasoline distributors and dealers that major refiners placed them at a competitive disadvantage during the Persian Gulf Crisis (see app. III). Finally, the report includes the views of several government agencies on the availability of data, collected by the Department of Energy's Energy Information Administration and others, for monitoring the oil market and enforcing antitrust laws (see app. IV).

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 10 days from the date of this letter. At that time, we will send copies to appropriate congressional committees, the Secretary of Energy, the Attorney General, the Chairman of the Federal Trade Commission, the Chairman of the Commodities Futures Trading Commission, and other interested parties. We will also make copies available to others upon request.

Please call me at (202) 512-3841 if you have any questions about this report. Major contributors to this report are listed in appendix V.

Victor S. Rezendes
Director, Energy and Science Issues

List of Requesters

The Honorable Ernest F. Hollings
Chairman, Committee on Commerce,
Science, and Transportation
United States Senate

The Honorable Richard H. Bryan
Chairman
The Honorable Slade Gorton
Ranking Minority Member
Subcommittee on Consumer
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Carl Levin
Chairman
The Honorable William S. Cohen
Ranking Minority Member
The Honorable Joseph I. Lieberman
Member
Subcommittee on Oversight
of Government Management
Committee on Governmental Affairs
United States Senate

Executive Summary

Purpose

During the first week after Iraq invaded Kuwait on August 2, 1990, crude oil prices in the United States rose by about 36 percent—from about $22 a barrel to about $30 a barrel—and there were increases in the prices of gasoline, home heating oil, and jet fuel, ranging from 28 percent to about 30 percent. At the time, world inventories of crude oil were at their highest levels since the late 1970s. The immediacy of the domestic price increases—even though oil supplies were abundant—raised questions about how prices for crude oil and petroleum products are set, particularly during market shocks. Oil market shocks can have significant effects on the economy. The lost economic output from a shock that increases the price of crude oil by $5 a barrel has been estimated to range from about 0.1 percent to 2 percent of the United States' gross national product.

A number of congressional requesters asked GAO to, among other things, (1) explain the pricing of crude oil and three products refined from it—gasoline, home heating oil, and jet fuel—under normal market conditions and during market shocks and (2) describe the federal government's authorities to respond to disruptions in the supply of oil and the government's use of these authorities during the Persian Gulf Crisis.

Background

Before the 1970s, the major oil companies controlled the global network for supplying, pricing, and marketing crude oil. Key changes, however, have dramatically altered the structure of the world oil market over the past few decades. These changes include the nationalization of oil fields by oil-producing countries, the emergence of the independent oil companies, and the growth of trading on the futures and spot markets. Moreover, U.S. oil prices, controlled by the government since 1971, were deregulated by late 1981.

There are now three basic types of global trading markets for crude oil and petroleum products—the futures, spot, and contract markets. Some participants in the futures market, in an effort to protect themselves against potential losses resulting from rapid price changes, buy or sell crude oil and petroleum products for future delivery at prices set at the time of the transaction, while other participants seek profits by bearing the risk of price changes. In the spot market, oil companies can acquire additional or dispose of excess supplies, typically at a price that changes daily, or even hourly. In the contract market, participants sign contracts that normally stipulate the delivery of a fixed supply at flexible prices.

Results in Brief

Since their decontrol by late 1981, domestic prices for oil have been linked to world oil prices. The world price of crude oil is not necessarily related to its production cost nor to its acquisition cost. Rather, several other factors appear more important in determining the price of crude oil. First, because of the Organization of Petroleum Exporting Countries' (OPEC) large low-cost crude oil reserves and excess production capacity, members' decisions affecting the world's supply influence crude oil prices. Second, crude oil is a scarce and valuable resource. Third, in the short term, there is a lack of substitutes for oil. Finally, seasonal demand—for heating oil, in particular—affects crude oil prices. Reflecting all of these influences on supply or demand, crude oil prices are revealed in the global trading markets—the futures, spot, and contract markets.

Wholesale and retail prices of refined petroleum products—gasoline, home heating oil, and jet fuel—are largely determined by the price of crude oil. Besides the price of crude oil, the most influential factors affecting wholesale prices are seasonal demand and the type of supply arrangement between the buyer and the seller of the products. Retail prices are influenced by the prices of crude oil and wholesale petroleum products, but are also affected by seasonal demand, the relative stability of demand for petroleum products, and the extent of local competition.

During a market shock, the same factors influence the prices of crude oil and petroleum products, producing sometimes rapid price changes at all levels. Also, because prices are market-based, the value of crude oil and petroleum products held in inventory during the market shock adjusts quickly to reflect their current and future value. There is evidence that retail gasoline prices may not fall as quickly and/or as completely as they rise in relation to decreases and increases in crude oil prices during market shocks. Econometric models, by GAO and others, and the opinions of industry experts differ on whether this price behavior occurs and, if so, whether it occurs mostly between crude oil and wholesale prices or between wholesale and retail prices, and what the reasons are for it.

The Energy Policy and Conservation Act of 1975 is a key federal law addressing oil supply disruptions. This act provides the authority to develop and use the Strategic Petroleum Reserve and to participate in the International Energy Agency. The reserve was created to reduce the impact of severe interruptions of petroleum supplies. The International Energy Agency is an organization established in 1974 to coordinate the actions of its 23 member countries during energy emergencies. Current U.S. policy relies on the free market during an oil supply disruption to allocate the supply to meet the demand at the current market price. If necessary, an early and large release of oil from the reserve can be authorized. The use of the reserve during the Persian Gulf Crisis has revived the debate on the appropriate trigger for a release from the reserve during a market shock, as well as the timing and magnitude of such a release.

GAO's Analysis

Crude Oil Pricing Under Normal Market Conditions

Most of the world's crude oil is located in OPEC countries, and OPEC has nearly all of the world's estimated excess production capacity. Although OPEC no longer sets prices for crude oil, members' decisions about the supply of oil can still have a significant impact on world oil prices. In setting voluntary production quotas for member countries, OPEC seeks to effect a target price for oil. The price of crude oil also reflects its value as a scarce resource. Since crude oil can only be replaced at a higher cost once current reserves are depleted, the price of crude oil compensates the owner for its scarcity. Crude oil producers are also aware that in the short term, there are few substitutes for petroleum products, and crude oil prices reflect this lack of substitutes. Finally, the demand and prices for crude oil may increase in the winter because of the high demand for heating oil then.

World prices for crude oil are revealed in the three oil trading markets—the futures, spot, and contract markets. The futures market, in which participants' expectations about the potential supply and demand are reflected, often serves as the reference point for transactions in the other two markets. Spot and near-term futures prices for crude oil generally closely track each other. Under normal market conditions, prices in the spot market for crude oil are generally lower than contract prices because contract prices normally contain some premium for the security of the supply.

Petroleum Product Pricing Under Normal Market Conditions

In general, the wholesale prices of gasoline, home heating oil, and jet fuel are largely based on crude oil prices. Over the short term, these wholesale prices also depend, though to a lesser extent, on supply relationships between refiners and wholesalers and/or retailers. Also, under normal market conditions, the spot price of a petroleum product, which is generally close to the near-term futures price, is somewhat lower than the contract price because the quantity not sold through the contract market is often sold on the spot market at a discount. Seasonal demand also influences wholesale prices over the short term.

Normally, retail prices for petroleum products do not necessarily react to the almost daily, small fluctuations that are common in crude oil prices and wholesale prices. Instead, retail prices, in the short term, may be more responsive to the extent of local competition within a given area. For example, gasoline prices can be higher in rural areas where there are fewer gasoline stations. At the retail level, seasonal demand again has an influence on prices, as does the relative stability of demand in general, which exists because there are no economically viable substitutes for petroleum products.

Pricing of Crude Oil and Petroleum Products During Oil Market Shocks

Prices for crude oil and petroleum products in inventories during a market shock, including gasoline held by local service stations, will rapidly adjust to reflect the oil's and products' current market value, even if that oil or those products were produced or acquired at a lower or higher cost. Oil prices change quickly to reflect actual or potential changes in the scarcity and value of crude oil and petroleum products. Crude oil prices respond faster to oil market shocks today than they did before the 1980s, when most oil was purchased in the contract market. Currently, information about events that can cause an actual or potential change in the supply of and demand for oil is quickly translated into price changes on the international futures exchanges. Transactions in the other pricing markets will also immediately reflect the price changes in the futures market that were induced by the market shock.

During market shocks, differences in the demand for petroleum products can lead to differences in how wholesale prices increase and decrease. For example, during the Persian Gulf Crisis, wholesale prices for jet fuel increased more than did prices for gasoline and home heating oil because of the increased demand for jet fuel to support allied military operations.

In the case of gasoline, many consumers believe that retail prices rise quickly when crude oil prices rise during a market shock but are slow to reflect price decreases. Many oil company officials GAO spoke with agreed that, in comparison to crude oil prices, retail gasoline prices do fall more slowly than they rise during market shocks. GAO's model of price adjustment in the gasoline market shows some evidence that this happens, but only under certain circumstances. For example, GAO's model found that for every 10-cent-a-gallon increase in the spot price of crude oil during a market shock, the spot price of wholesale gasoline increases by 10.2 cents within the first week, while a 10-cent decrease in the spot price of crude oil leads to a decrease in the spot price of wholesale gasoline of only 8.0 cents. The results of GAO's model suggest that this price behavior may be largely attributable to the level of crude oil inventories and to the excess production capacity available at refineries during market shocks. However, GAO's model also found that retail gasoline prices rise and fall with the same speed and magnitude as wholesale gasoline prices do during market shocks.

Other models have mostly found evidence that retail gasoline prices adjust more slowly to falling crude oil prices and/or wholesale gasoline prices. Industry officials and experts and these other modelers point to several factors that may help explain why retailers may be slow to pass along decreases in their costs. For example, if price decreases at the crude oil and wholesale levels are perceived to be temporary, sellers may be disinclined to lower retail prices; consumers may become accustomed to the higher retail price; and consumers may not force prices down by aggressively shopping for the lowest retail price.

Federal Authorities to Respond to Oil Supply Disruptions

The Energy Policy and Conservation Act of 1975 provides a key means for the federal government to respond to oil supply disruptions. The Strategic Petroleum Reserve, established by this act, is the cornerstone of the federal government's strategy for responding to severe market shocks. The United States also coordinates its responses during market shocks with the other members of the International Energy Agency. Although current U.S. policy supports the "early" use of the reserve during an energy emergency, the policy provides little specific guidance on how long market forces should be allowed to operate before the reserve is used or on what conditions should dictate drawing down the reserve. A 1992 law amending the Energy Policy and Conservation Act of 1975, however, gives the President more explicit authority to release oil from the reserve if doing so would assist in relieving severe economic problems directly related to a significant increase in the price of crude oil and petroleum products.

During the Persian Gulf Crisis, the first major release of oil from the reserve was authorized, in cooperation with the International Energy Agency, on January 16, 1991—over 5 months after Iraq invaded Kuwait. Though the spot price of crude oil dropped from $32 to about $21 a barrel between January 16 and 17, 1991, DOE acknowledges that this decline in the price of crude oil cannot be solely attributed to the drawdown of the reserve because the drawdown coincided with the early success of the allied air force against Iraq and expectations that the Gulf Crisis would soon end.

Recommendations

GAO is not making recommendations in this report.

Agency and Other Comments

As requested, GAO did not obtain written agency comments on a draft of this report. GAO did, however, discuss the factual content of the report with officials in DOE, the Department of Justice, and the Federal Trade Commission and provided a draft of the report to oil market experts in government, industry, and academia. These officials and experts generally agreed with the report's accuracy. Several officials and experts also stated that the report was an informative and balanced presentation of oil market pricing. Where appropriate, GAO made revisions on the basis of these discussions and comments.

Contents

Figures

Abbreviations

API	American Petroleum Institute
bd	barrels a day
CFTC	Commodities Futures Trading Commission
DOE	Department of Energy
DTW	dealer-tankwagon
EIA	Energy Information Administration
EPCA	Energy Policy and Conservation Act
FBO	fixed-base operator
FERC	Federal Energy Regulatory Commission
FRS	Financial Reporting System
FTC	Federal Trade Commission
GAO	General Accounting Office
GNP	gross national product
iid	independently and identically distributed
IEA	International Energy Agency
IEP	International Energy Program
mmb	million barrels
mmbd	million barrels a day
NPR	Naval Petroleum Reserves
NYMEX	New York Mercantile Exchange
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
PDL	polynomial distributed lag
PMAA	Petroleum Marketing Association of America
RAC	refiner acquisition costs
SPR	Strategic Petroleum Reserve
WTI	West Texas Intermediate

Introduction

After Iraq invaded Kuwait on August 2, 1990, the United Nations imposed an embargo on oil exports from these two countries. As a result, 4.3 million barrels a day (mmbd) of crude oil, amounting to about 9 percent of the daily oil production to the market economies, was lost.[1] At the time, world inventories of crude oil were at their highest levels since the late 1970s.

Nevertheless, domestic oil prices immediately rose sharply. During the first week after the invasion, crude oil prices increased from about $22 a barrel to about $30 a barrel. At the same time, prices for petroleum products—gasoline, home heating oil, and jet fuel—rose by from 28 to about 30 percent. The immediacy of the domestic price increases during the Persian Gulf Crisis—increases that did not seem to acknowledge the abundance of the world's oil supplies—raised questions about the pricing of petroleum products, particularly during market shocks.[2]

United States Increasingly Dependent on Imported Oil

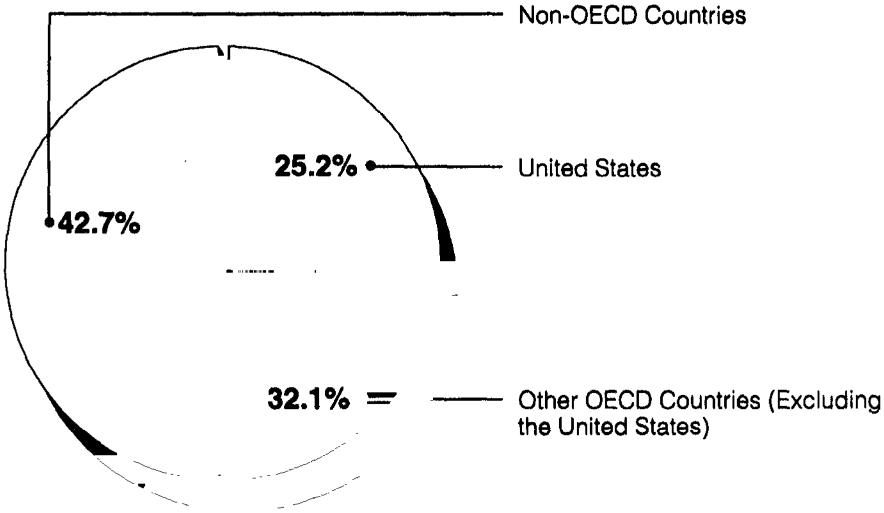
The United States is the single largest consumer of the world's oil. In 1991, the United States consumed about 17 mmbd, accounting for over one-fourth of the world's daily oil consumption. In 1991, the United States and the other industrialized countries that are members of the Organization for Economic Cooperation and Development (OECD) consumed about 38 mmbd, or 57 percent of the world's total oil consumption of about 66 mmbd.[3] Though OECD countries accounted for 57 percent of the world's consumption in 1991, this figure has declined—from 71 percent in 1970. From 1970 to 1991, non-OECD countries have increased their share of the world's consumption, from 29 percent to 43 percent. Figure 1.1 shows the shares of the world's oil consumption in 1991.

[1]According to the Department of Energy's (DOE) Energy Information Administration (EIA), countries with market economies include all countries other than those with centrally planned economies, including economies formerly so or evolving.

[2]For the purposes of this report, we consider the Persian Gulf Crisis to have begun with Iraq's invasion of Kuwait on August 2, 1990, and to have ended after the early months of 1991 with the success of allied military actions and the release of International Energy Agency (IEA) members' emergency oil stocks, including those from the U.S. Strategic Petroleum Reserve (SPR).

[3]In 1991, the 24 OECD countries included Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States and its territories.

Figure 1.1: Shares of the World's Oil Consumption, 1991



Source: Based on data from EIA.

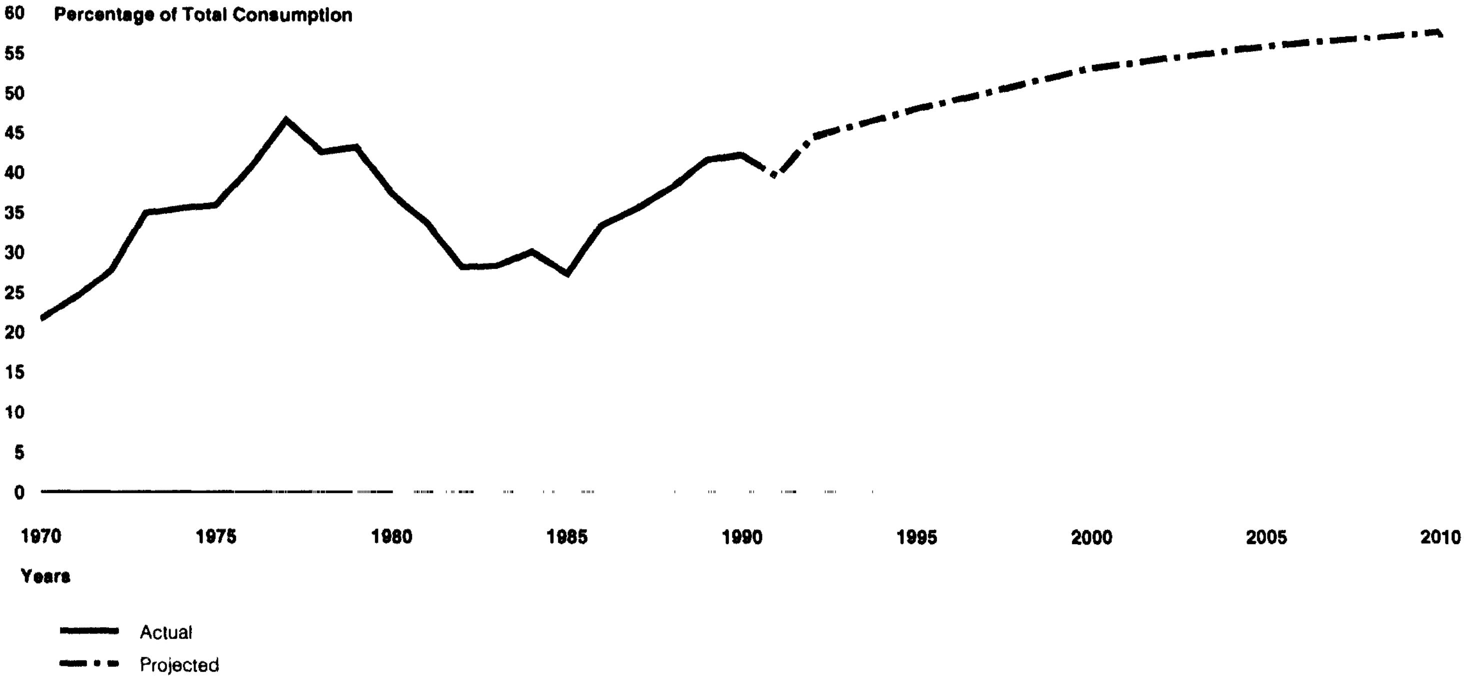
The United States' high level of oil consumption, coupled with declining domestic oil production, has resulted in a growing dependence on imported oil.[4] In 1977, the United States' dependence on imported oil peaked, with net imports accounting for about 47 percent of domestic consumption.[5] Higher oil prices in the early 1980s led to a drop in both domestic oil consumption and imports. From 1985 to 1990, however, the United States' oil consumption and net imports gradually rose as U.S. and world oil prices fell. In 1991, imports accounted for about 40 percent of the domestic petroleum consumption. Net petroleum imports are projected by

[4]According to the 1991-92 National Energy Strategy, oil imports alone are not an adequate gauge of the United States' vulnerability to oil market shocks. Other important measures of vulnerability include (1) the dependence of the United States' economy on oil, as measured by oil consumption per gross domestic product; (2) the capacity for switching to alternative fuels; (3) the world's reserve oil stocks; and (4) the world's excess production capacity.

[5]EIA calculates net petroleum imports, which include both crude oil and petroleum products, by subtracting the total petroleum exports from the total petroleum imports. Net imports as a percentage of consumption are derived by dividing net petroleum imports by the total amount of "petroleum products supplied" (consumption).

EIA to continue to rise, reaching about 58 percent of domestic consumption by 2010.[6] (See fig. 1.2.)

Figure 1.2: United States' Net Petroleum Imports as a Percentage of Total Consumption, 1970-2010



Source: Based on data from EIA.

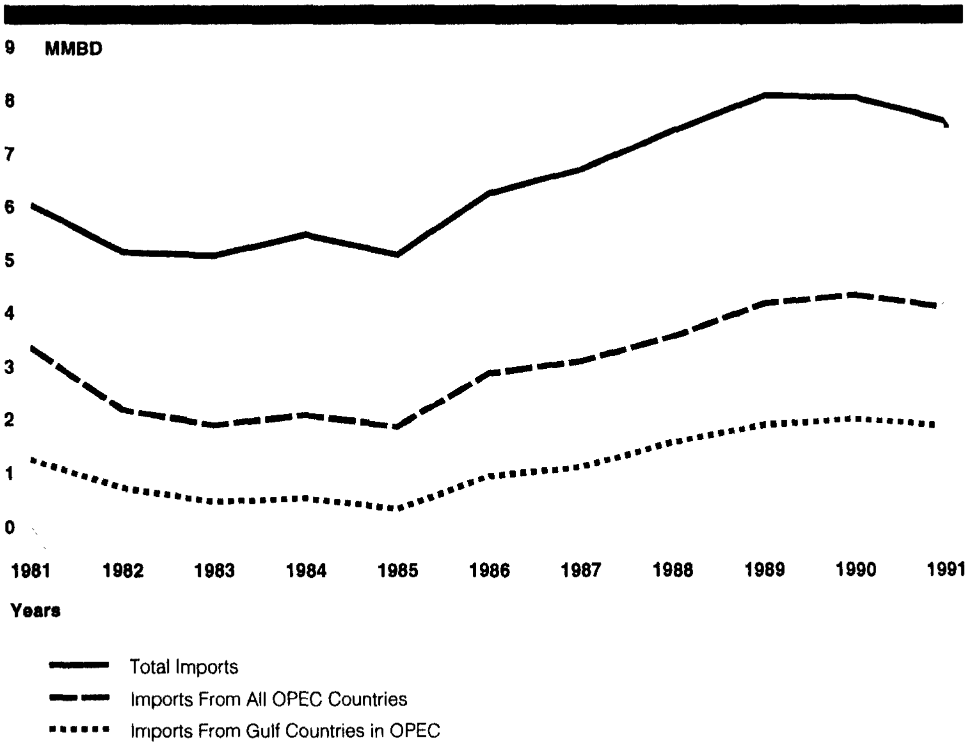
As the United States' dependency on oil imports has increased since 1985, so have imports from the Persian Gulf countries that are members of the Organization of Petroleum Exporting Countries (OPEC).[7] Total imports from OPEC countries have more than doubled in recent years, increasing from about 1.8 mmbd in 1985 to about 4 mmbd in 1991. Within OPEC, the primary

[6]This projection, published in January 1992, is based on EIA's "reference case" assumption that world crude oil prices will be $20.80 a barrel in 1995, $26.40 a barrel in 2000, $30.50 a barrel in 2005, and $33.40 a barrel in 2010, in 1990 dollars.

[7]OPEC was created in 1960. In 1991, the 13 OPEC members were Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela. The Persian Gulf countries in OPEC are Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates. As of January 1, 1993, Ecuador was no longer a member of OPEC.

suppliers to the United States in 1991 were Saudi Arabia, Venezuela, and Nigeria. From 1985 to 1991, the imports from the Persian Gulf countries in OPEC, particularly from Saudi Arabia and Iraq, have increased more dramatically than have the imports from other sources.[8] (See fig. 1.3.) According to DOE, it is expected that the United States and the world will increasingly rely on Persian Gulf oil supplies in the future.

Figure 1.3: United States' Petroleum Imports, by Source, 1981-91



Source: Based on data from EIA.

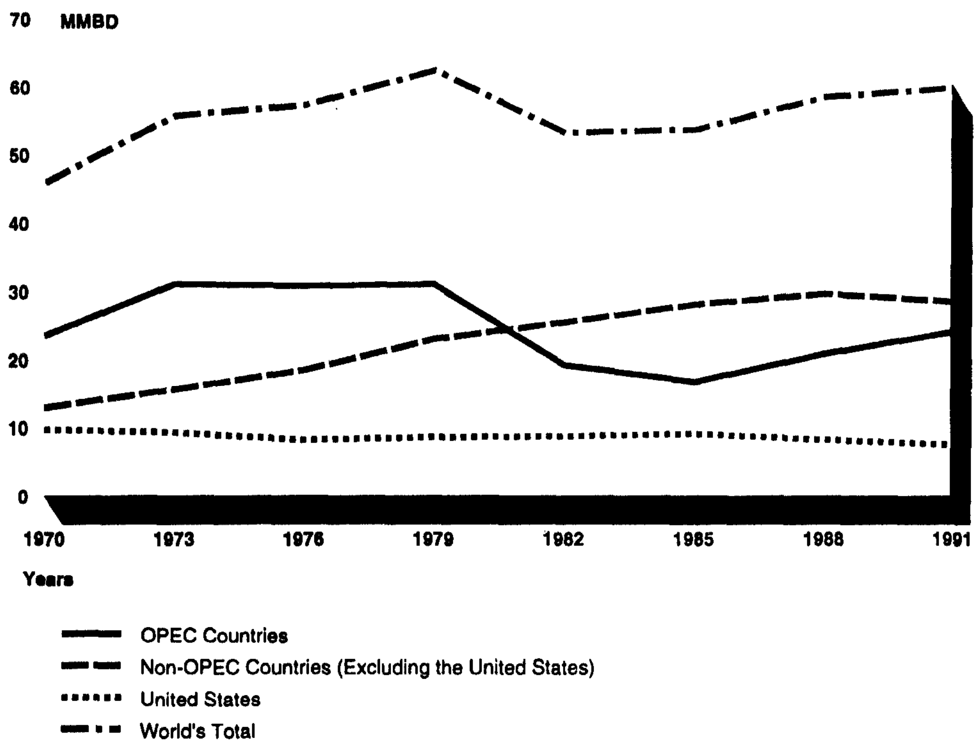
OPEC's Production Has Increased Since 1985, Reversing Previous Trend

In 1991, OPEC's production accounted for 24 mmbd, or 40 percent of the world's production of about 60 mmbd. Over the last decade, non-OPEC producers of crude oil—such as Mexico and the United Kingdom—have emerged as significant players in the world oil market. High prices for oil during the late 1970s and early 1980s encouraged exploration and production from these higher-cost non-OPEC sources. From 1980 to 1991, non-OPEC countries' production of crude oil, excluding the United States',

[8]Since the 1990 embargo imposed by the United Nations on Iraq's oil exports, the United States has not imported oil from Iraq.

increased from 23.7 mmbd to 28 mmbd. From 1980 to 1985, OPEC's production fell from 26.9 mmbd to a low of 16.6 mmbd—a decline of 38 percent. Since 1985, however, OPEC has increased its production of crude oil. Increased production by OPEC has led to lower world oil prices and an increase in the world's oil consumption. On the basis of its reference case price projections, EIA expects that OPEC's production will continue to rise, reaching 30.9 mmbd by the year 2000, or half of the oil production in the market economies. Figure 1.4 shows changes in the world's oil production.

Figure 1.4: World's Oil Production, 1970-91



Source: Based on data from EIA.

The Structure of the World Oil Market Has Changed

Before the 1970s, the seven major oil companies effectively controlled the global network for supplying, pricing, and marketing crude oil.[9] However, key changes occurred in the 1970s and 1980s that altered the structure of the world oil market:

- The major oil companies lost their dominance of the oil market as oil-producing nations nationalized their oil fields. Independent oil companies and oil traders and brokers also increasingly competed with the major companies for crude oil supplies.
- The growth in trading on the spot market and the use of oil futures[10] has meant that developments in the oil market are reflected rapidly in oil price changes.
- The U.S. government lifted its controls on domestic oil prices and thus integrated the domestic oil market with the world market.

World Oil Market Now Contains Many Players

The major oil companies' control of the world oil market declined drastically over the past few decades as the national oil companies of producing nations assumed control in supplying and pricing their own oil. Also, the entrance of new players, such as independent oil companies and oil traders and brokers, led to increased competition with the major companies for the world's supply of crude oil. Consequently, today's market consists of many players involved in a variety of operations.

In general, the oil industry is composed of both "upstream" and "downstream" operations. Upstream operations include exploring for oil, developing oil fields, and producing the oil. Downstream operations include refining and marketing petroleum products at both the wholesale and retail levels. Organizationally, oil companies can be vertically integrated, participating in both upstream and downstream operations. Independent companies, however, specialize in certain sectors of the oil industry, such as production, refining, and/or marketing.

The types of companies generally participating in the oil market and the sectors of the market in which they are usually involved are shown in table 1.1.

[9]These seven companies, also known as the "seven sisters" were Exxon, Mobil, Gulf, Socal, Texaco, Royal Dutch/Shell, and British Petroleum. Chevron, formerly Socal, acquired Gulf.

[10]Futures contracts are agreements to buy or sell a commodity, such as crude oil or a petroleum product, for delivery on a specified date in the future, at a price determined at the initiation of the contract. These standardized contracts are traded in the United States on the New York Mercantile Exchange (NYMEX).

Table 1.1: Types of Companies Participating in the World Oil Market

Type of company[a]	Exploration and development	Production	Refining	Wholesale marketing	Retail marketing
Integrated oil company	X	X	X	X	X
Independent producer	X	X			
Independent refiner			X	X	X
Trader and broker[b]			X	X	
Independent distributor/dealer				X	X

[a]There are also other types of companies particular to the gasoline, home heating oil, and jet fuel markets.

[b]For a brokering fee, traders and brokers also bring buyers and sellers together in oil futures contracts and transactions on the spot market.

Several World Oil Trading Markets Have Evolved

There are now three basic types of global oil trading markets—the contract, spot, and futures markets.[11] Before the 1970s, most of the world's oil was supplied through long-term, fixed-price supply contracts, and, to a lesser extent, the spot market. The contract market generally guaranteed a steady supply of oil at stable prices. The spot market provided an outlet for oil companies to acquire additional oil or dispose of excess oil.

The spot market became increasingly important after the second oil crisis in 1979-80, resulting from the revolution in Iran, when oil prices became more volatile and the spot market was more responsive than the contract market to changes in overall market conditions. The volatility of prices after the second oil crisis also provided an impetus for the development of a viable oil futures market as a way for participants in the oil market to guard against potential losses resulting from rapid price changes. Moreover, in response to the market shocks of the last few decades, prices in today's supply contracts are no longer fixed, but are flexible, designed to adjust to changes in market conditions, as reflected in spot and futures prices.

U.S. Oil Market Linked to World Oil Market

On April 5, 1979, the President announced that the government would gradually decontrol domestic crude oil prices. The decontrol had been authorized in 1975 so that domestic oil prices would eventually reach

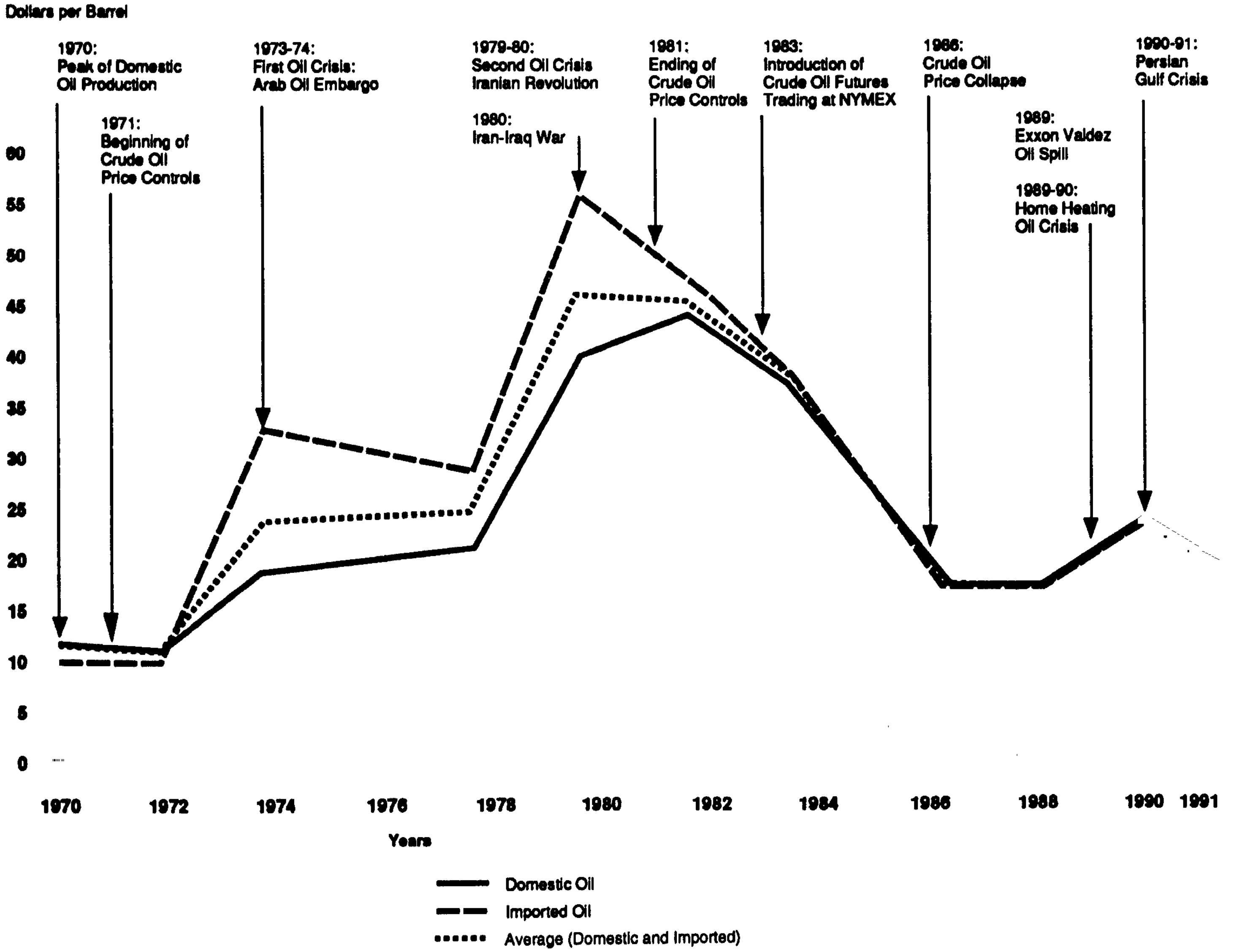
[11]How prices are set in these markets will be discussed in detail in chapter 2.

world oil prices.[12] In 1981, domestic crude oil prices were completely decontrolled. The decontrol of domestic oil prices has effectively linked the U.S. oil market to the world oil market. Previously, domestic oil prices did not move freely in response to international events or world prices. Rather, during the 1970s, domestic prices, controlled by the government, were artificially low in comparison to world prices.

As shown in figure 1.5, after the decontrol of domestic oil prices and the introduction of crude oil futures trading, the average price U.S. refiners paid for domestic crude oil approximated the price of imported crude oil.

[12]Price controls were placed on domestically produced crude oil and petroleum products in 1971. In 1975, the Energy Policy and Conservation Act (EPCA) authorized the decontrol of domestically produced crude oil and petroleum products beginning June 1, 1979, and ending September 30, 1981. The President was authorized to determine whether and how price controls would be applied during this period of decontrol.

Figure 1.5: Major Events Affecting U.S. Crude Oil Prices, 1970-91



Notes: EIA defines crude oil prices as "refiner acquisition costs" (RAC), an approximation of the average crude oil prices paid by domestic refiners for domestic and imported crude oil. The RAC is derived by dividing the sum of reporting refiners' total costs and fees by the total volume of all refiners' purchases. The composite cost is the weighted average of domestic and imported crude oil costs.

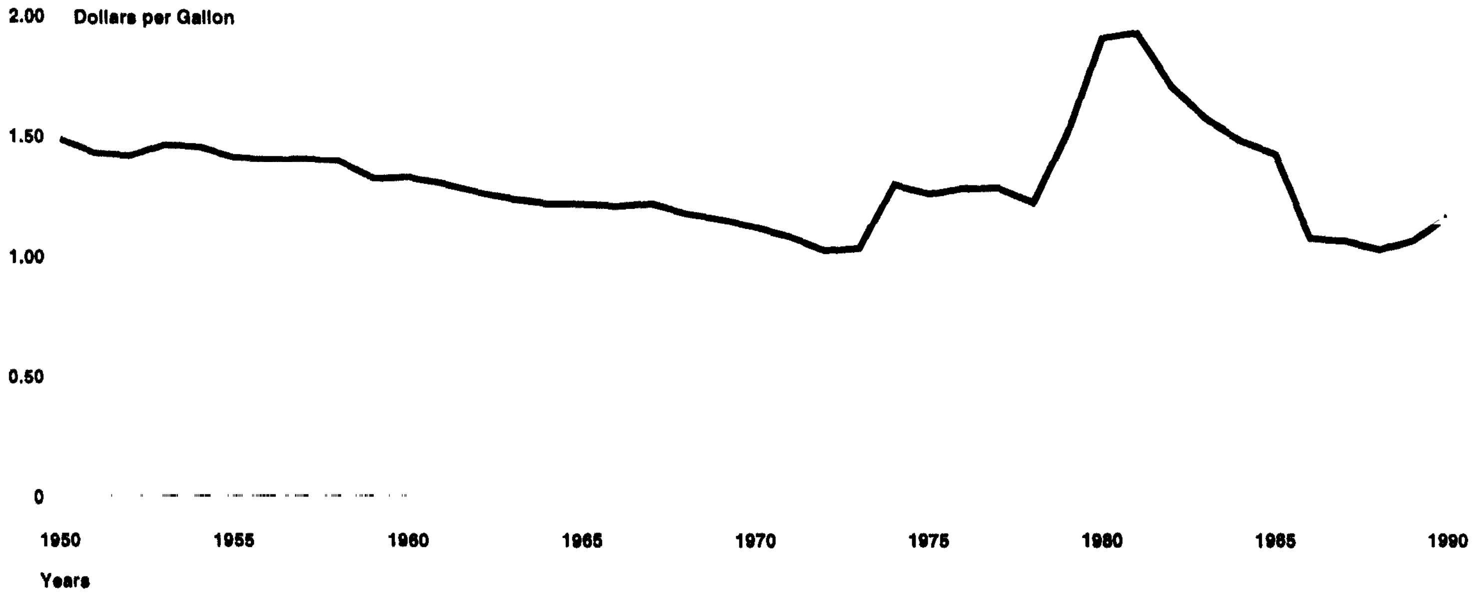
Prices are converted into 1991 dollars.

Source: Based on data from EIA.

Gasoline Prices, Adjusted for Inflation, Were Lower in 1990 Than in 1950

Although the United States' reliance on imported oil has increased, and the structure of the world oil market has changed, the price of gasoline, adjusted for inflation, was lower in 1990—at about $1.16 a gallon—than it was in 1950—at about $1.48 a gallon, as seen in figure 1.6.

Figure 1.6: Retail Gasoline Prices, Adjusted for Inflation, 1950-90



Notes: Prices are converted into constant 1990 dollars. To convert nominal prices into real prices, the gross national product (GNP) "deflator" was used. The GNP deflator is not available for 1991.

Prices of leaded regular gasoline are used for 1950-75. Prices of unleaded gasoline are used for 1976-90. Prices include taxes.

Source: Based on data from EIA.

Objectives, Scope, and Methodology

A number of congressional requesters asked us to analyze the pricing of oil. Specifically, we were asked to

- explain the pricing of crude oil, gasoline, home heating oil, and jet fuel, under normal market conditions and during market shocks (chs. 2, 3, 4, and app. II) and

- describe the federal government's authorities for responding to disruptions in the supply of oil and the government's use of those authorities during the Persian Gulf Crisis (ch. 5).

As secondary objectives, we were asked to

- review the concerns of independent gasoline distributors and independent service station dealers that major refiners placed them at a competitive disadvantage during the Persian Gulf Crisis (app. III) and
- obtain the views of the Commodities Futures Trading Commission (CFTC), Department of Justice, and Federal Trade Commission (FTC), on the availability of data from EIA and other sources for monitoring oil markets and enforcing antitrust laws (app. IV).

To explain the pricing of crude oil and petroleum products, we reviewed numerous economic papers on the oil market. We also reviewed and evaluated pertinent reports and studies, by the federal government, state governments, and private industry, on pricing, particularly during market shocks. We interviewed and gathered information from a cross section of high-level oil company officials responsible for pricing. These officials represented integrated oil companies, independent producers, and independent refiners. (App. I contains a complete list of the companies, agencies, and organizations we contacted during our review.)

In addition, we interviewed top officials at NYMEX as well as oil futures traders and officials from the CFTC, which is responsible for regulating NYMEX. We contacted a petroleum industry specialist at the Internal Revenue Service to gather information on the accounting practices of the oil industry. We met with officials of the California Energy Commission to discuss their ongoing work on oil pricing. We also met with other experts on the oil market—including energy economists—for their perspectives on pricing and with representatives of publications widely used by the oil industry for price information.

To gather information on the pricing of gasoline, home heating oil, and jet fuel, we also spoke with officials in the Petroleum Marketing Division of EIA and the Massachusetts State Energy Office. We interviewed representatives of industry trade associations and independent gasoline and heating oil distributors, independent terminal operators, and a jet fuel distributor. For our analysis of the jet fuel market, we also met with officials in the Department of Transportation's Office of Aviation

Information Management, and we interviewed personnel involved with the purchasing of jet fuel at two major airlines.

We adopted a three-phased approach to determine whether gasoline prices fall as quickly and to the same extent as they rise during market shocks. First, we interviewed an extensive number of oil industry representatives involved in all sectors of the industry, and experts on the oil market. Second, we reviewed econometric models on gasoline pricing. Third, we developed our own econometric model that examined the speed and magnitude with which retail gasoline prices adjust to changes in the price of crude oil on average and, more specifically, during market shocks. Our model examined changes between prices for crude oil and wholesale prices for gasoline and between wholesale and retail prices for gasoline. Appendix II contains details on our model's methodology and our statistical analysis.

To describe the federal authorities for responding to disruptions in the supply of oil, we focused on the principal authorities that governed DOE's actions during the Persian Gulf Crisis. We met with officials and obtained documents from DOE's Offices of the Deputy Assistant Secretary for Energy Emergencies, the Deputy Assistant Secretary for Strategic Petroleum Reserve, the Associate Deputy Under Secretary for Policy Analysis, and General Counsel. We also relied on work done for prior GAO reports on the federal authorities for responding to oil supply disruptions.

To review the concerns of independent gasoline distributors and service station dealers that may have been placed at a competitive disadvantage during the Persian Gulf Crisis, we interviewed representatives of industry trade associations and evaluated selected studies and testimony of these associations. We also interviewed selected gasoline distributors and service station dealers in Michigan. In addition, we interviewed the Director of DOE's Office of Competition to gather data on the retail gasoline market. Finally, we contacted officials in the Department of Justice's Antitrust Division and the FTC's Bureau of Competition to discuss their investigations—done under the agencies' concurrent authority for enforcing antitrust laws—into allegations of anticompetitive pricing in the oil market.

To obtain the views of the CFTC, the Department of Justice, and the FTC on the availability of data from EIA and other sources for monitoring oil markets and enforcing antitrust laws, we met with officials in these agencies and consulted officials in EIA's Office of the Administrator.

Most of the statistical data used in this report came from EIA, the federal agency responsible for collecting and documenting energy statistics. If EIA did not collect the data we needed, we used published data from a variety of other sources, including the American Petroleum Institute (API), NYMEX, Oil and Gas Journal, The Oil Daily, and the United States Geological Survey. However, we did not obtain certain pricing data, such as oil companies' confidential pricing data, that would have enhanced our analysis.

We discussed our methodology and econometric analysis with and obtained comments on a draft of this report from our consultant, Dr. J. Daniel Khazzoom, Professor of Quantitative Studies, San Jose State University.

As requested, we did not obtain written agency comments on a draft of this report. We did, however, discuss the factual content of the report with officials in DOE, the Department of Justice, and the FTC and provided a draft of the report to oil market experts in government, industry, and academia. These officials and experts generally agreed with the report's accuracy. Several officials and experts also stated that the report was an informative and balanced presentation of oil market pricing. However, a DOE reviewer and one other expressed concern that our analysis of OPEC's role in the pricing of crude oil may suggest that OPEC still sets its price. We disagree with this comment. In chapter 2, we clearly state that OPEC no longer sets the price of crude oil but can influence it through the decisions member countries make about the supply. Where appropriate, we made revisions on the basis of these discussions and comments.

Our review was conducted between February 1991 and December 1992 in accordance with generally accepted government auditing standards.

Crude Oil Pricing Under Normal Market Conditions

The world price of crude oil is not necessarily related to the cost of extracting the oil nor to the price paid for the oil at a previous time. Rather, the world price of crude oil—which U.S. crude oil buyers and sellers face—is largely determined by a number of factors that influence the supply of and demand for crude oil.[1] First, OPEC influences crude oil prices through decisions affecting the supply of oil. OPEC supplies a significant portion of the world's oil, and most of the world's oil reserves and excess production capacity are in OPEC countries. Typically, OPEC determines a "target price" for its crude oil and seeks to achieve that price by adopting a production quota, which is allocated among the organization's members. Most likely, OPEC establishes a target price at a level low enough to preclude the long-term viability of alternative fuels in the oil-importing countries. The target price may not be reached if some member nations overproduce or if the world's demand for oil falls short of the expected level.

Second, the price of crude oil is influenced by its "opportunity cost." The opportunity cost of any good can be measured by the value of forgone alternative uses for the good—or the value of the best alternative use for that good. For crude oil, the opportunity cost of consumption also includes the value of the best future alternative use because crude oil left in the ground can be sold at some future date when the price may be higher. In addition, because crude oil is a depletable, nonrenewable resource, its price may include a premium to account for that fact. As known reserves of oil are tapped, they are depleted and can only be replaced through costly oil exploration or by other higher-cost sources of energy.

Third, the price of crude oil is also influenced by the fact that petroleum products have no substitutes in the short term. Crude oil prices, therefore, may change substantially in the short term without a significant change in consumption. Finally, changes in demand due to seasonal factors, such as the generally high demand for oil during the winter, tend to drive crude oil prices higher during this season.

These factors influencing supply and demand interact to determine crude oil prices, which are revealed in the global trading markets: the futures, spot, and contract markets. Though the prices may differ slightly from market to market and from transaction to transaction within a single market, prices in these markets do follow similar upward and downward

[1]Our analysis in chs. 2 and 3 pertains to the pricing of crude oil and petroleum products over the short term and under normal market conditions, unless otherwise stated. Normal market conditions are defined as a period when there is no market shock.

trends. Prices in the futures and spot markets serve as daily indicators of overall conditions in the marketplace, including buyers' and sellers' perceptions about the future supply and demand. As a result, futures and spot prices are used as references for transactions in the contract market.

The Price of Crude Oil Is Not Based on Its Historical Cost

The price of crude oil is generally not determined by its production cost or its acquisition cost—its historical cost. The current price, like the price of any other asset, reflects its current value. Thus, sellers of crude oil—in the United States or any other country with a free market economy—will price their oil at the prevailing market price, even if that oil may have been previously produced or purchased at a lower or higher cost.

It is sometimes argued that the current price of crude oil is, or ought to be, based on its production cost or on its acquisition cost for its current owner. If this were so, there would be a variety of current prices, each reflecting a different production cost or past purchase price. Thus, an increase in the acquisition cost of crude oil would not be reflected in the price of crude oil until the newer, higher-priced oil was purchased, possibly refined, and subsequently reached its point of sale. The same would be true of a price decrease. With few exceptions—such as in regulated industries—however, market-determined prices do not generally follow this pattern. For example, house prices rise and fall depending upon current market conditions—the current price usually is unrelated to the previous purchase price or to the initial investment in building the house. The same is true of crude oil.

OPEC's Policies Affecting the Supply of Crude Oil Influence Its Price

The supply policies of the members of OPEC—Saudi Arabia, in particular—have a significant influence on world prices of crude oil. OPEC influences world oil prices because its members collectively supply about half of the world's oil and possess the world's largest and lowest-cost crude oil reserves and most of the world's excess production capacity, which can be brought to bear in the world market relatively quickly.[2] While member countries no longer set "official" prices for their crude oil, OPEC adopts a pricing strategy that seeks to achieve a target price through production quotas for individual members and the organization as a whole.

[2]Production capacity refers to the maximum amount of oil that can be produced from existing developed reserves. Excess production capacity is derived by subtracting actual production at a given time from production capacity. EIA defines excess production capacity as the maximum sustainable capacity that can be brought on-line within 3 months and sustained for 1 year.

OPEC Continues to Supply Much of the World's Crude Oil

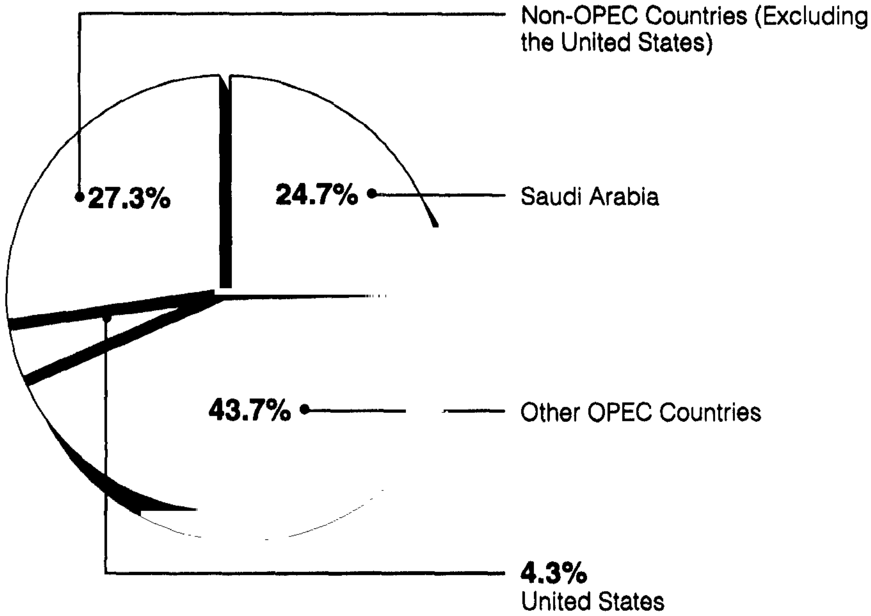
During the 1970s, OPEC provided over 60 percent of the oil supplied to the market economies. But the increase in oil prices and the perception that OPEC was not a secure source of oil helped to boost exploration and development in many non-OPEC oil-producing countries. The increase in the supply from non-OPEC producers, coupled with increased energy conservation and the substitution of other fuels for some traditional uses of oil in many oil-importing countries, has diminished OPEC's share of the oil market in the market economies, from a peak of about 64 percent in 1976 to below 40 percent in 1985. Since 1985, however, OPEC's supply has been increasing, and by 1991, its members collectively supplied about 48 percent of the market economies' oil.

Most of the World's Crude Oil Reserves Are Located in OPEC Countries

OPEC holds the world's largest and lowest-cost reserves of crude oil, with about two-thirds of the world's estimated conventional reserves, about 720 billion barrels (see fig. 2.1).[3] Persian Gulf countries in OPEC hold the largest reserves, with Saudi Arabia alone accounting for about one-fourth of world's reserves. In contrast, the United States holds an estimated 4 percent of the reserves.

[3]The U.S. Geological Survey's estimates of conventional crude oil reserves include proven, possible, and probable reserves. Proven reserves are those reserves recoverable and ready for production with present technology and at present prices. Possible and probable reserves represent the potential growth in proven reserves over time at present prices as oil fields continue to be developed. Possible reserves are those reserves developed when additional engineering technology is applied to improve recovery, and probable reserves are those additional reserves confirmed by new drilling. Present prices are assumed to range from $15 to about $25 a barrel.

Figure 2.1: Shares of the World's Conventional Crude Oil Reserves, 1990



Note: Estimates of reserves are as of January 1, 1990.

Source: Based on data from the U.S. Geological Survey.

Most of the World's Excess Production Capacity Is Also Located in OPEC Countries

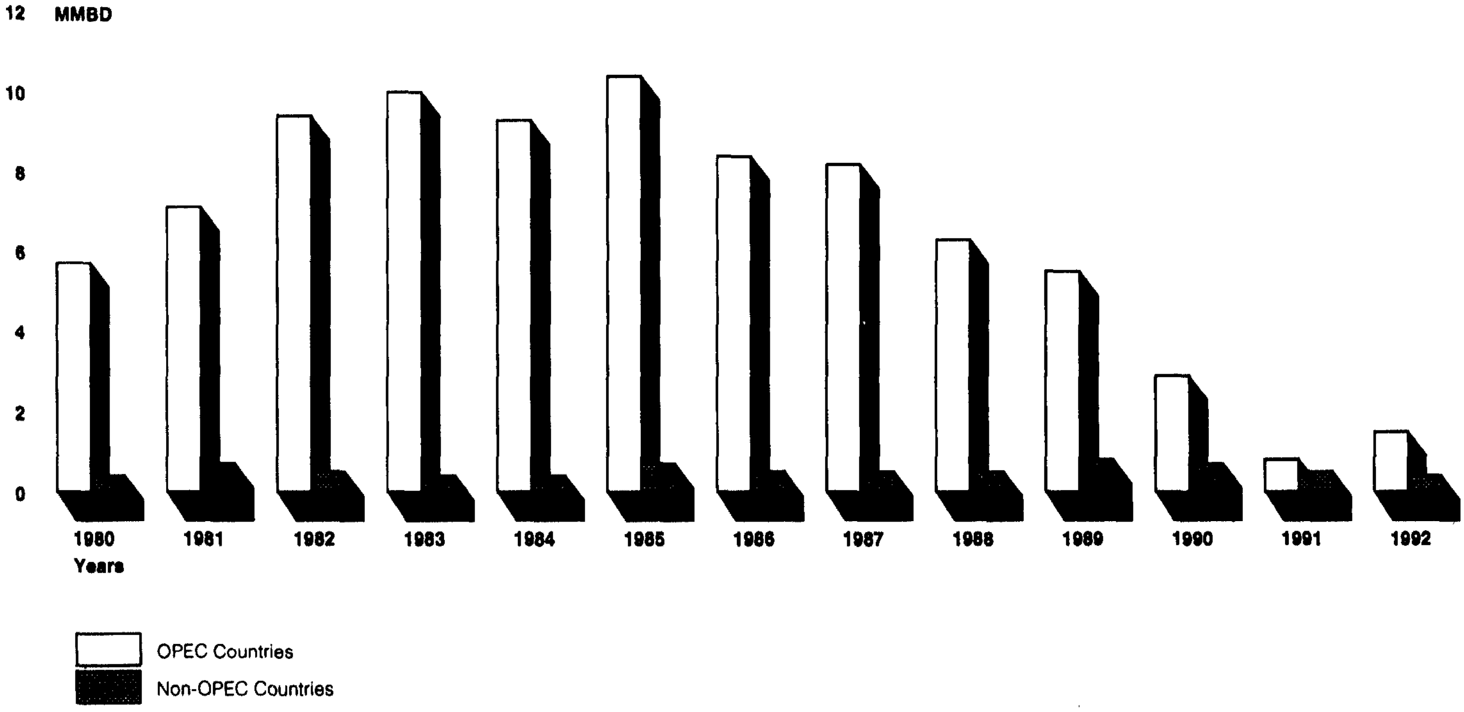
OPEC—in particular, Saudi Arabia—has nearly all of the world's estimated excess production capacity. That is, OPEC countries are the most able to increase oil production relatively quickly.[4] However, OPEC's excess production capacity decreased drastically, from about 10 mmbd in 1985 to about 3 mmbd in 1990, as seen in figure 2.2. According to an EIA official, lower oil prices after 1985 reduced OPEC's revenues, so OPEC invested less in the oil exploration and development that could have added to its production capacity. At the same time, OPEC produced more oil, which resulted in lower oil prices and increased consumption. OPEC's increased production without a simultaneous increase in production capacity, led to a decline in the organization's excess production capacity.

Between 1990 and 1991, OPEC's share of the world's excess production capacity fell by more than half, as excess capacity—primarily Saudi

[4]Non-OPEC oil producers cannot increase their supply substantially in the short term in response to an increase in crude oil prices. For example, one study estimated that the short-term price elasticity of the supply by non-OPEC producers is only about 0.05, which is inelastic. See Ali M. Reza, "The Price of Oil and Conflict in OPEC," The Energy Journal, Vol. 5, No. 2 (1984).

Arabia's—was used to cover the shortfall in production resulting from the embargo on Iraq's and Kuwait's oil exports.

Figure 2.2: World's Estimated Excess Production Capacity, 1980-92



Note: Data for 1992 were forecast.

Source: Based on data from EIA.

OPEC Is the World's Marginal Supplier

Oil-consuming nations are encouraged to produce oil from domestic sources until their incremental costs to produce another barrel reach the world price and then import the remainder of their crude oil supplies at that price. In economic terms, the world price becomes the buyer's marginal cost—the cost of purchasing an additional barrel of crude oil on the world market—and OPEC becomes the world's marginal supplier—the supplier that can provide the additional oil at the current world price.

OPEC Establishes a Target Price for Crude Oil

Although OPEC by itself no longer sets prices for crude oil, the individual and/or collective actions of the organization's member countries still can have a significant impact on world oil prices. During the 1980s, OPEC nations abandoned their strategy of setting "official" prices for their crude oil. OPEC now establishes a "target" price during its biannual meetings.[5] To achieve this price, OPEC sets an aggregate production level, or quota, based on the organization's determination of the demand for its oil. OPEC then allocates voluntary production quotas among its members primarily on the basis of the size of each member's oil reserves, as well as other negotiated factors.

Whether or not the target price is achieved depends on the discipline exercised by member countries in producing oil, as well as on the actual demand for oil and non-OPEC countries' production levels. If by adjusting its production, OPEC successfully keeps the world's oil supply relatively tight with respect to demand, the average world price will likely be close to the target price. On the other hand, if all or some members of OPEC fail to stick to their quotas and overproduce instead, the average world price may be substantially below the target price.

Because of its large and low-cost oil reserves and excess production capacity, OPEC may be able to set its target price low enough to preclude the viability of alternative fuels in the marketplace in the long term. Saudi Arabia, in particular, can make use of its excess production capacity to increase the world's supply of oil and thus lower oil prices.

The Price of Crude Oil Is Also Influenced by Its Opportunity Cost

The price of crude oil is also determined in part by its opportunity cost. The opportunity cost of any good can be measured by the value of forgone alternative uses for the good—that is, the value of the best alternative use for that good. If there were a new alternative use for crude oil, for example, that would tolerate higher prices, then prices would likely rise to a new level. The opportunity cost of crude oil, as with any other good, is a measure of its scarcity as a valuable resource. Thus, the price of crude oil is determined, in part, by its scarcity, for which the owner is compensated.

For crude oil, the opportunity cost of consumption is not merely the value of the best current alternative use, but also includes the value of the best future alternative use because crude oil left in the ground can be sold at some future date when the price may be higher. A related point is the fact

[5] OPEC's target price is based on the weighted average of the prices of a group, or "basket," of several different types of member nations' crude oil. During OPEC's September 1992 meeting, the organization's target price was said to be about $21 a barrel for OPEC's basket of crude oil.

that crude oil is a depletable, nonrenewable resource; it cannot be replaced once it is used. The current price of oil, then, may include a premium for potential losses to sellers if future users value the resource more highly than today's users and for the fact that once current reserves of oil are depleted, they can only be replaced through oil exploration—a costly and uncertain process—or by other higher-cost sources of energy. The opportunity cost of consuming current reserves, then, includes not only the cost of producing those reserves, but also the cost of replacing them.

There is debate among economists concerning how much of the price of crude oil is attributable to its status as a depletable resource. Some economists believe, as discussed above, that there is a premium attached to the price of crude oil because it is depletable. According to this view, the price of crude oil would rise in tandem with the rising costs of finding and extracting oil and/or would rise to equal the cost of a substitute as oil neared its depletion. Other economists argue, however, that it is uncertain when oil will be depleted or how much oil there is in the ground. These economists point out that discoveries of abundant and low-cost oil have been made many years after it was commonly believed that the world's crude oil "reserve" in the ground was nearing depletion. Such discoveries could continue to be made indefinitely, as long as investments in the search for oil yield an acceptable rate of return. Those who argue this latter view, therefore, believe that the price of oil has little or no premium attributable to its depletion. Instead, they believe that crude oil prices are more fundamentally determined by the market power of OPEC.

A Lack of Substitutes for Oil Over the Short Term Can Influence Its Price

The difficulty of substituting other sources of energy for petroleum products over the short term influences the demand for and price of crude oil. Because petroleum products—gasoline, in particular—have virtually no substitutes over the short term, oil consumption does not depend very much on the price of oil. Changes in the price of oil lead only to minimal changes in its consumption in the short term. For example, economists have estimated that a 10-percent increase in the price of oil can be expected to cause only a 2-percent reduction in its consumption in the short term.[6]

Because oil consumption is relatively unaffected by changes in the price of oil, suppliers that possess market power are able to influence the price of crude oil to the benefit of all oil suppliers, even those that are too small to

[6]This estimate is based on a price elasticity of demand for crude oil of about −0.2, which is inelastic.

possess market power themselves. As discussed earlier, members of OPEC—Saudi Arabia, in particular—are able to influence oil prices through their supply policies. To the extent that OPEC can maintain its prices above the competitive level, all oil producers benefit from the higher price.

Seasonal Demand Also Affects the Price of Crude Oil

The world price of crude oil is also influenced by seasonal demand. For example, the demand for crude oil typically increases during the winter because of a generally high demand for heating oil. Thus, during OPEC's yearly fall meeting, the organization generally adjusts its target price upward or increases its production quota to reflect the normal increase in the demand for its oil. On the other hand, during OPEC's spring meeting, the organization may settle for a lower target price or try to reduce its production quota in an attempt to maintain the demand for its oil during the spring and summer.

Crude Oil Prices Are Revealed in Global Trading Markets

Although market prices for crude oil generally move in the same direction in the futures, spot, and contract markets, on any given day the price of a particular grade of crude oil may differ slightly in the three markets.[7] The futures market plays a critical role in providing a leading reference price for buyers and sellers' negotiations about prices in the spot and contract markets. Prices for crude oil in all three markets may differ because within a particular market, the price adjusts to reflect market-specific interests.

When buying or selling crude oil, oil companies monitor the transactions in the various markets very closely to keep abreast of supply and demand conditions and the market prices. Most oil company officials we spoke with subscribe to several relevant information services and have direct access electronically to prices in the futures market. These officials also closely monitor inventory levels and incorporate this information in their prices.

Futures Market Acts as a Mechanism to Discover Prices

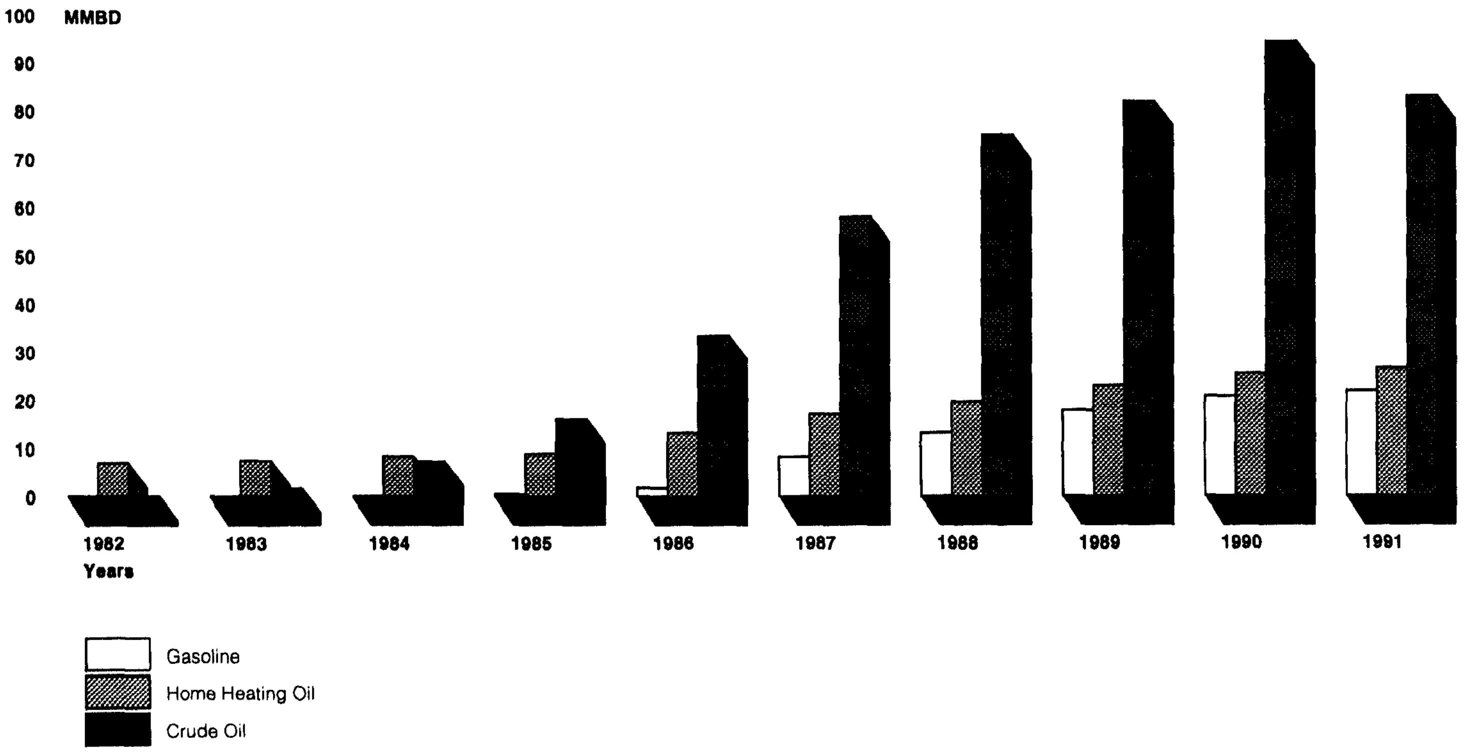
NYMEX, which began oil futures trading in 1978,[8] is the dominant market for such trading. Oil futures exchanges have also developed on London's International Petroleum Exchange and on the Singapore International

[7]A fourth market, the forward market, also exists for the trading of crude oil and products. A forward contract is an agreement between a buyer and seller to deliver a certain quantity of a particular type of crude oil at a specified future date. Unlike trading in the futures market, however, trading in the forward market is not transacted on a regulated exchange with a standardized contract.

[8]NYMEX began the trading of heating oil in 1978, followed by gasoline in 1981 and crude oil in 1983. At NYMEX, the crude oil futures contract covers 1,000 barrels of crude oil. This contract specifies the delivery of a particular type of crude oil—West Texas Intermediate (WTI)—at Cushing, Oklahoma.

Monetary Exchange. The average volume of crude oil traded daily in futures contracts on NYMEX increased from about 1.7 mmbd in 1983 to about 83 mmbd in 1991. Since the futures market is largely used as a means to hedge against future price changes or speculate on such changes rather than to buy and sell oil, less than 1 percent of these oil futures contracts result in the actual delivery of crude oil or petroleum products. Figure 2.3 shows the average daily volume of crude oil and of some petroleum products traded on the exchange in futures contracts.

Figure 2.3: Daily Volume of Crude Oil and Selected Petroleum Products Traded In Futures Contracts on NYMEX, 1982-91



Note: The volume of gasoline traded in futures contracts in 1985 is too small to appear clearly in the figure.

Source: Based on data from NYMEX.

Futures prices act as a barometer of the actual supply and demand and the expectations about market conditions in the future. The two primary economic functions of the oil futures market, or any futures market, are to (1) transfer risk and (2) "discover" prices. The first function occurs as producers and consumers pursue a financial strategy that transfers the risk inherent in volatile prices to those parties most willing to bear it. The second function occurs as the free flow of information in a futures market provides an efficient means for buyers and sellers to determine the market prices.

Participants in the futures market are generally categorized as either hedgers or speculators. Hedgers, who generally hold an inventory, use the futures market to protect themselves against financial loss resulting from volatile prices. Speculators own no inventory but participate in the futures market to realize profits from the changes in price. Speculators perform a key role in any futures market by bearing risk and providing the market with financial liquidity. According to NYMEX officials, speculators account for less than 10 percent of all participants in the oil futures exchange. However, in classifying participants as either hedgers or speculators, these officials may be underestimating the amount of speculation on the oil futures exchange because hedgers can also engage in speculation.

Transactions in the spot and contract markets use the futures market as a reference to set prices. The process of determining the price in the futures market is relatively efficient for a number of reasons. Compared to other markets for crude oil, the futures market includes a large number of geographically dispersed sellers and buyers. They make offers and bids—either directly or through their representatives on the trading floor—for particular standard types of crude oil to be delivered at standard locations. Thus, buyers and sellers effect the market prices for the trading period. These prices become immediately available to interested parties outside the futures market through electronic means and are systematically reported by the financial and trade press to the general public.

The futures market is also efficient because participants utilize a substantial amount of information to form their opinions about supply and demand and, ultimately, the price of oil. As part of their monitoring of the futures market, most participants subscribe to specialized news services, such as Reuters, that speedily report any news about events that may affect the supply of or demand for oil throughout the world. Such information is quickly reflected in the prices of crude oil at the futures market because buyers and sellers base their decisions on their perceptions of the impact that news events will have on the supply of and demand for oil. News about, for example, potential hostilities in a major oil-producing country or region, such as Saudi Arabia or the Persian Gulf, may be interpreted by market participants as a threat to future supplies from that region. Even if current supplies are sufficient to meet demand in the short term, prices in the futures market could be driven primarily by expectations and therefore could shoot beyond what the current supply and demand would warrant. However, prices change frequently, as market participants revise or reevaluate their expectations on the basis of new information.

Spot Market Provides Incremental Supply at Prices That Reflect Current Market Conditions

The share of U.S. supplies of crude oil acquired on the spot market is not known with certainty. Worldwide, before 1979, crude oil delivered on the spot market constituted an estimated 1 percent to 3 percent of all crude oil traded, but by 1989 that figure had increased to an estimated 33 percent. In general, the quantity of crude oil involved in a typical domestic transaction on the spot market is smaller than the quantity in an international transaction.[9] There are four major types of crude oil, known as "marker crudes," whose prices serve as indicators of world prices on the spot market. These include the U.S. WTI, the U.S. Alaskan North Slope, the U.K. North Sea Brent, and Dubai's Fateh.

Like the futures market, the spot market serves as an indicator of overall market conditions. The spot market, also known as the "cash and carry" or "prompt" market, provides the incremental supply not covered by contractual arrangements. The spot market provides a readily available channel to dispose of and buy oil, in response to the prevailing demand and supply, at more flexible prices than those specified in contracts. Unlike the futures market, however, the spot market is an informal network of buyers and sellers who carry out parcel-by-parcel sales and purchases of crude oil. On the spot market, traders or brokers usually bring together buyers and sellers for a brokering fee.

The negotiated price of crude oil on the spot market—or spot price—is typically guided by references to the prices quoted on NYMEX or the other exchanges for near-month futures contracts.[10] However, the ultimate price

[9]A typical domestic transaction involves about 250,000 barrels of crude oil delivered via a pipeline. A typical international transaction, however, involves a larger cargo of about 500,000 barrels.

[10]"Near-month futures contracts" are those closest to maturity, or those specifying the earliest upcoming date for delivery.

agreed upon between the buyer and the seller in the spot market does not necessarily have to correspond with the futures price that is quoted on the day of the transaction for future delivery.[11] The spot price for a particular type of crude oil may vary daily or even hourly because the price is for the delivery of a specific parcel or cargo of crude oil at a given location and time. An agreed-upon spot price can apply on the date of the transaction or the date of the delivery.

For domestic purchases, the spot price of WTI crude oil, for example, can be quoted for prompt delivery to the East Coast—within 10 to 20 days—which includes the time it takes to transport the crude oil from the Gulf Coast. If the buyer and seller "lock in" this price on the day the deal is negotiated, using the futures market as a guide, they are committed to it up to the delivery, regardless of what changes in price may occur in the interim or at the time of the delivery. Alternatively, the spot price may be left open to be determined by the prices prevailing on the spot and/or futures markets on the delivery day. The decision to lock in the price or leave it open is usually based on the volatility of prices.

The pricing of imported oil on the spot market follows the same principles as domestic pricing. Usually, the foreign oil being traded is already at sea. The national oil companies of some of the major oil-exporting countries of OPEC often maintain cargos of crude oil at sea, called "floating inventories." These floating inventories are the primary objects of international trading on the spot market and are readily shipped on demand to destinations specified by buyers. While the cargo remains at sea, bids are usually handled by traders and brokers. The spot price can be locked in on the day of the transaction, reflecting the price quoted on NYMEX or the other exchanges for near-month futures contracts, or left open to be determined by the prevailing prices at the time the oil arrives at the refiner's dock—maybe 45 days later.[12]

Contract Market Ensures Supply at Flexible Prices

Much of the world's crude oil today is supplied under contract. A supply contract commits the buyer and seller to trade a specific quantity of oil for the duration of the contract, normally at flexible prices tied to spot and futures prices. Supply contracts, also known as "term contracts," usually are for up to 1 year, but are "evergreen" in that they renew automatically

[11] The spot price tends to converge with the near-month futures price so that they are virtually the same price. On a day-to-day basis, however, spot and quoted futures prices are not necessarily the same.

[12] The forward market has not only the features of the futures market, as explained in a earlier footnote, but also a feature of the spot market: Prices for transactions in the forward market can be agreed upon in advance of or on the delivery of the oil.

unless either side chooses to end them. Thus, in effect, these contracts can be long-term arrangements.[13] Contractual prices are flexible enough to allow for periodic adjustments that take price changes in the spot and futures markets into account. Although all prices for similar types of crude oil tend to move in the same direction in the various markets, the mechanisms for pricing domestic and imported crude oil under the contract system differ.

Prices for Domestic Oil in the Contract Market Less Volatile Than in Other Markets

In the domestic contract market, refiners "post" the prices they are willing to pay to the oil companies with which they have supply contracts. These prices vary by oil field and by the type and quality of the crude oil. Each buyer must post a price that is close to other posted prices in the market because oil companies are not obligated to supply oil if the prices offered are not competitive. As a result, posted prices closely reflect changes in spot and futures prices, but posted prices fluctuate less because they are not widely disseminated and transactions may not occur daily.

For a domestic refiner that buys crude oil directly from a producer on the open market, posted prices represent acquisition costs. In the case of integrated oil companies, crude oil produced from their domestic wells is generally transferred directly from the production sector to the refining sector of the company. The opportunity cost of such a transfer of crude oil within an integrated oil company is the market price of the oil. In fact, several integrated oil company officials told us that the refining sectors of their company bid for and purchase the company's domestic crude oil at competitive posted prices.

Imported Oil in the Contract Market May Be Priced on Loading or Delivery

Oil-exporting countries price their crude oil sold under contract by using complex pricing formulas that are pegged to world prices on the spot market. The price paid by U.S. oil companies for imported oil is not always equal to the spot price of that oil on the day the oil arrives in U.S. ports. The actual price paid by the importer depends on, among other things, whether the oil is priced on the day of loading at the exporting country or the day of arrival at a U.S. port. In either case, the price is normally tied to the spot price of a marker crude oil—Alaskan North Slope crude oil for most of the oil imported at the Gulf Coast from the Mideast and WTI or West Texas Sour crude oil for oil imported at the East Coast from the Mideast.

[13]There is no consensus on how long supply contracts actually last. Several oil company officials gave us a wide range of estimates: from 1 month to 5 years.

Under the formulas, the price calculated is the average spot price of the marker crude oil for the 5 or 10 days around either the loading date (point-of-loading formula) or the delivery date (point-of-delivery formula).[14] Because spot prices can change between the time a cargo of crude oil is loaded overseas and the time it arrives in a U.S. port, contracts incorporating the point-of-loading formula generally include some adjustment factor that allows the exporting country to raise or lower the price by a certain dollar amount, depending on the movement in spot prices.[15] A few U.S. importers buy crude oil that is not priced by these pricing formulas; these importers pay the prevailing spot price on the day the oil is delivered to them.

Although oil-exporting countries generally have nationalized their oil fields, even today some portion of imported oil is owned by domestic oil companies investing overseas through production-sharing, or "equity," arrangements. Under these arrangements, oil companies invest in the exploration for and development of overseas oil fields and in the production of oil from those fields. In exchange, the oil companies receive a share of the oil. We believe that, on average, crude oil obtained in these arrangements costs the oil company less than the market prices for that oil. Several oil company officials we spoke with, however, told us that the crude oil produced through equity arrangements is valued at prevailing market prices.

[14]Our analysis of pricing formulas is based on periodic profiles of them prepared by Petroleum Intelligence Weekly—a leading industry trade journal.

[15]The amount of premium or discount granted by the exporter varies among customers. The reasons for different premiums or discounts are proprietary information and are generally kept confidential by oil companies and the exporting governments.

Petroleum Product Pricing Under Normal Market Conditions

Wholesale and retail prices of petroleum products—such as gasoline, home heating oil, and jet fuel—are largely determined by the price of crude oil. For those purchasing crude oil for subsequent refining, acquisition costs are a major factor in determining the prices they set for their products. For integrated oil companies, which both produce and refine oil, acquisition costs may be less influential in the prices they set. What is influential, though, is the market price of crude oil, which is determined by the factors discussed in chapter 2, including OPEC's supply policies and the opportunity cost of the consumption of crude oil. Besides the price of crude oil, the most influential factors affecting the prices of petroleum products are the type of supply arrangement between the buyer and supplier, seasonal demand, the lack of substitutes for petroleum products over the short term, and the extent of local market competition.

Marketing Structures Differ for Gasoline, Home Heating Oil, and Jet Fuel

Although gasoline, home heating oil, and jet fuel are jointly produced during the refining process, the marketing structures for them are significantly different. The marketing structure for gasoline is the most complex—with numerous types of suppliers and associated prices—whereas the marketing structure for jet fuel is the least complicated.

Domestically, the marketing of petroleum products involves integrated oil companies and independent refiners of crude oil, product distributors,[1] and dealers. In 1991, about 202 refineries were operating in the United States. In 1990, gasoline constituted nearly one-half of their output. Distillate fuel oil—which consists of both home heating oil and diesel fuel—made up about 21 percent of the output, and jet fuel, 10 percent.[2] In 1991, there were about 10,000 distributors and dealers—of gasoline, heating oil, and other petroleum products—who were members of the Petroleum Marketers Association of America (PMAA).[3] There were an estimated 200,000 retail gasoline outlets in the United States in 1991.

Marketing Structure for Gasoline

The gasoline market consists of various supply arrangements that ultimately influence gasoline prices throughout the supply chain. As figure

[1]Distributors are also known as "jobbers" and "marketers."

[2]The remainder consisted of other petroleum products, such as residual fuel oil.

[3]PMAA's membership does not include home heating oil and gasoline terminal operators, who are wholesale suppliers. Some of PMAA's gasoline distributors may also operate retail gasoline stations. According to PMAA, its members sell approximately 45 percent of the gasoline, 75 percent of the home heating oil, and 60 percent of the diesel fuel sold in the United States annually.

3.1 shows, gasoline flows from the refinery to the consumer through a direct distribution system and an indirect distribution system. The direct system typically involves the sale and/or supply of "branded" gasoline (which is marketed under the refiner's trademark) by a refiner to its company-operated stations or other retail outlets operated by lessee dealers.[4] Refiners can also sell "unbranded" gasoline directly to open dealers.[5] In the indirect distribution system, however, refiners sell branded or unbranded gasoline to independent middlemen—distributors[6] —who sell to consumers through their own retail operations or resell the gasoline to other retailers.[7]

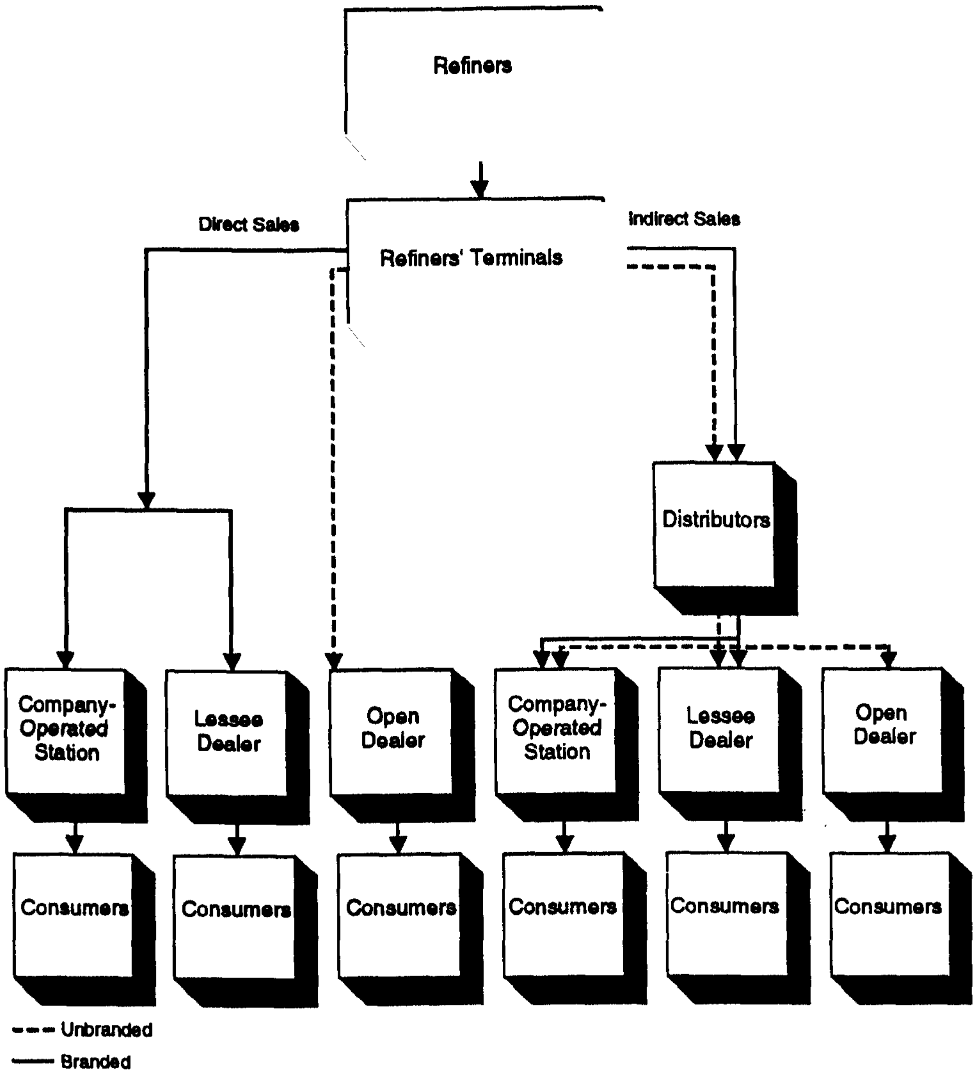
[4]Lessee dealers lease the service station and basic equipment from the refiner or distributor, but operate their own retail Open dealers own their own outlets or lease a retail gasoline stations.

[5]station from a third party, someone other than the supplier. Open dealers are independent businesspersons who generally operate one or two retail outlets.

[6]Distributors would include chain marketers, who are independent marketers primarily involved in retailing branded or unbranded gasoline through a chain of private outlets, such as convenience stores.

[7]Like refiners' stations, the stations owned and operated by distributors can be referred to as "company-operated stations," and stations leased by distributors to independent businesspersons can be referred to as "lessee dealers."

Figure 3.1: The Marketing Structure for Gasoline



Marketing Structure for Home Heating Oil

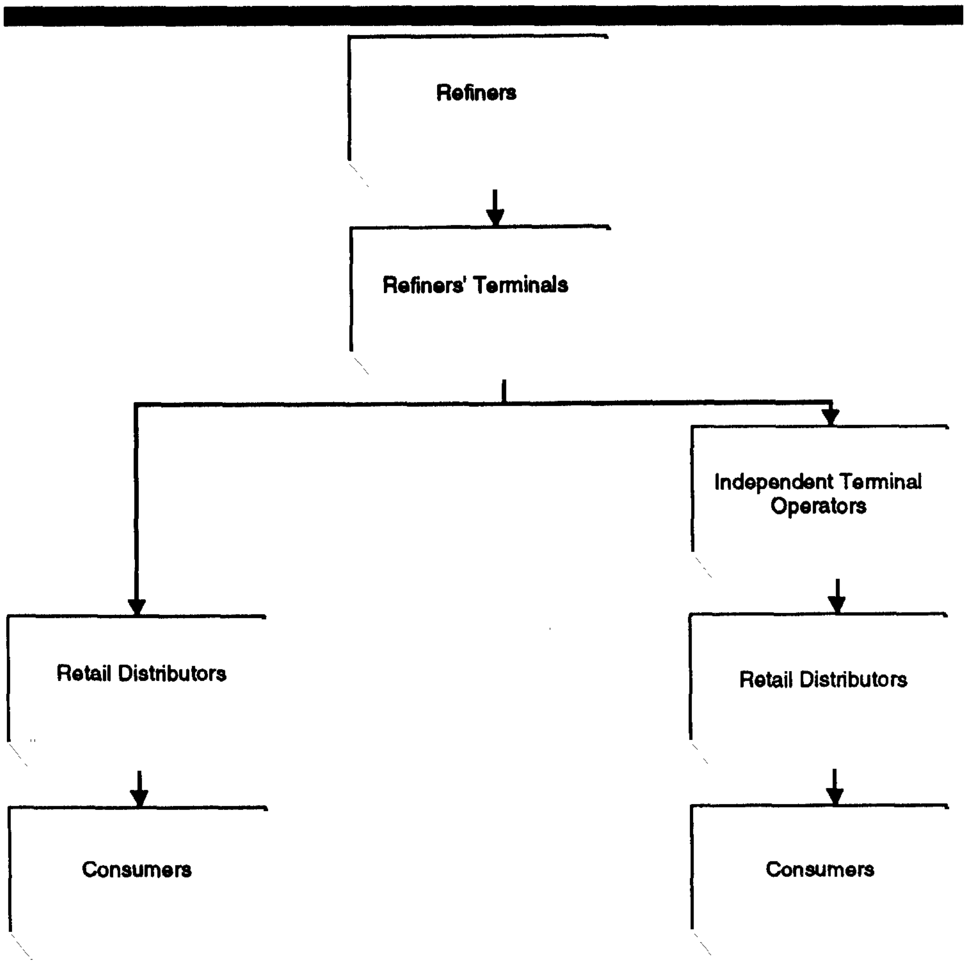
As shown in figure 3.2, the marketing structure for home heating oil consists of refiners, independent terminal operators,[8] retail distributors, and consumers. Heating oil is transported from the domestic or overseas refinery to storage in terminals owned by the refiners and is sold by the refinery at its terminals to retail distributors or to independent terminal operators. Imports of heating oil are significant to the northeastern states,

[8]Independent terminal operators are large wholesale distributors of heating oil and of unbranded gasoline and other petroleum products.

primarily the New England states, which are not connected to any major pipeline and which do not have any refineries.

Most refiners and independent terminal operators sell their heating oil through smaller retail distributors rather than directly to the residential customer. Retail home heating oil distributors then sell the product to their residential customers.

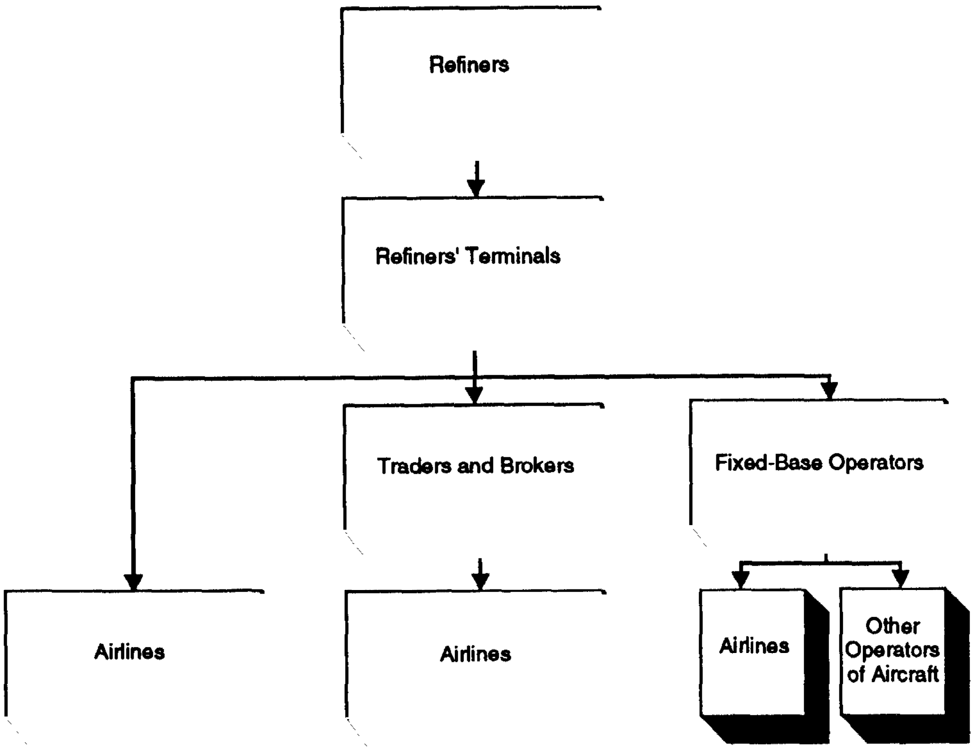
Figure 3.2: The Marketing Structure for Home Heating Oil



Marketing Structure for Jet Fuel

Jet fuel is primarily sold as a wholesale product because the main consumers of the fuel—commercial airlines and the military—purchase most of their supplies in bulk. As shown in figure 3.3, the primary suppliers of jet fuel are refiners, but traders and brokers and fixed-based operators (FBO)—which are based at airports—also serve, to a limited extent, as middlemen between refiners and airlines and/or other operators of aircraft, including private and charter airplanes.[9]

Figure 3.3: The Marketing Structure for Jet Fuel



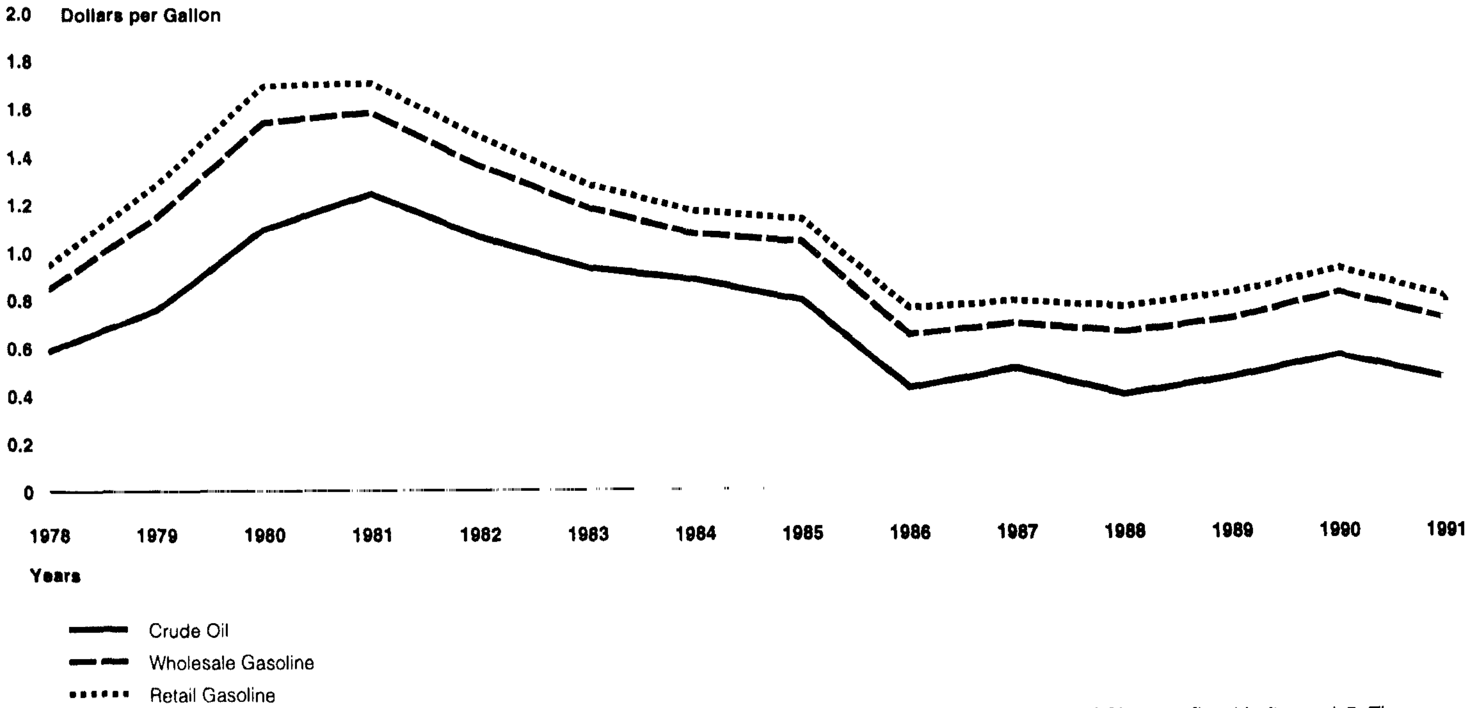
Note: Other aircraft operators can include private and chartered airplanes.

Petroleum Product Prices Are Generally Influenced by Crude Oil Prices's

The prices of petroleum products—gasoline, home heating oil, and jet fuel—are fundamentally determined by the price of crude oil. Competition in the markets for petroleum products and the threat that OPEC could raise crude oil prices if petroleum products are priced disproportionately higher than crude oil tend to keep the prices of crude oil and petroleum products in line with one another, particularly under normal market conditions. As shown in figures 3.4, 3.5, and 3.6, over the long term, wholesale and retail prices of gasoline, home heating oil, and jet fuel mirror changes in crude oil prices.

[9]A small percentage of jet fuel is sold at the retail level, mostly by FBOs to operators of small airlines and private and charter airplanes, usually at small airports. Commercial airlines purchase very little jet fuel from FBOs.

Figure 3.4: Crude Oil and Wholesale and Retail Gasoline Prices, 1978-91

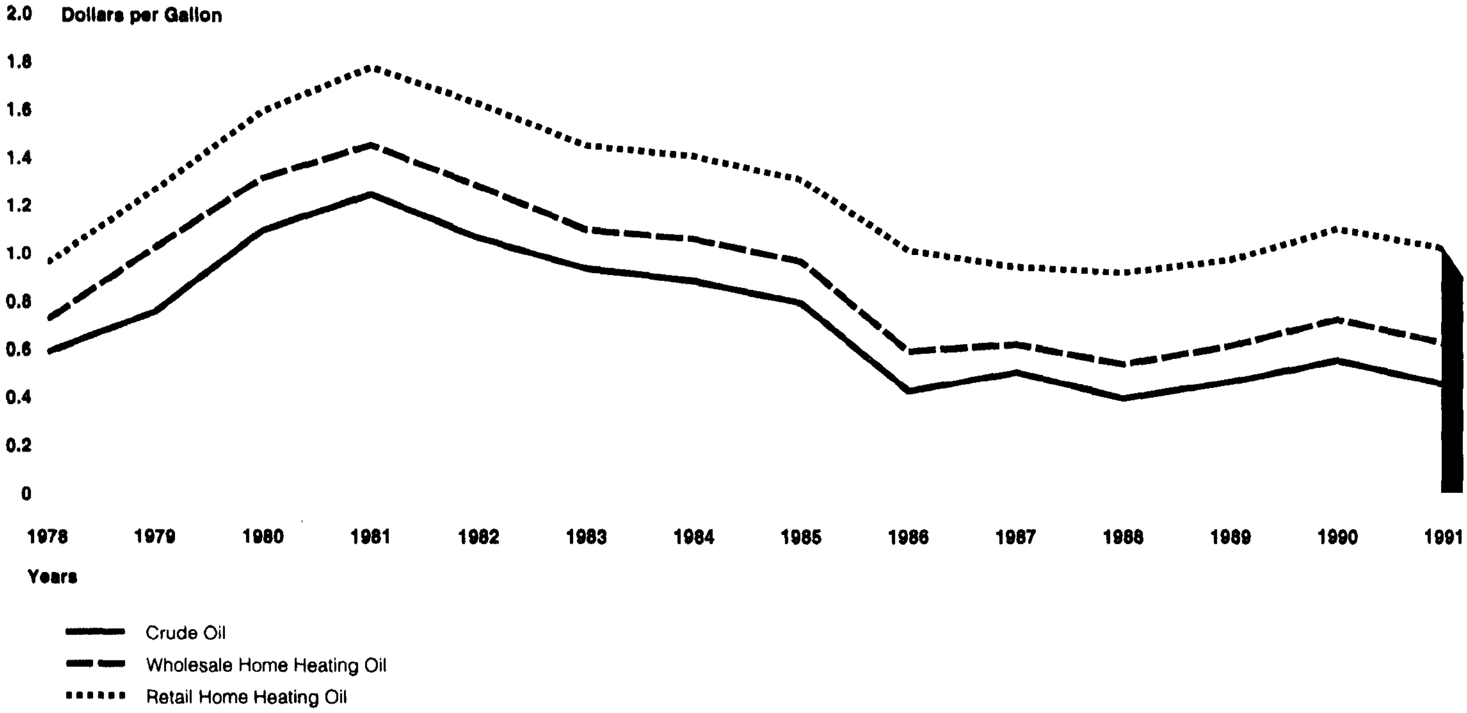


Notes: The prices for crude oil are refiner acquisition costs (RAC), as defined in figure 1.5. The prices for wholesale gasoline are "sales prices to resellers," which EIA defines as the prices charged to purchasers other than the ultimate consumers. The prices for retail gasoline are "sales prices to end users," which EIA defines as the prices charged to the ultimate consumers, including bulk customers such as agricultural firms, industry and utilities, as well as residential and commercial customers.

Prices are converted into 1991 dollars. All prices exclude all taxes.

Source: Based on data from EIA.

Figure 3.5: Crude Oil and Wholesale and Retail Home Heating Oil Prices, 1978-91

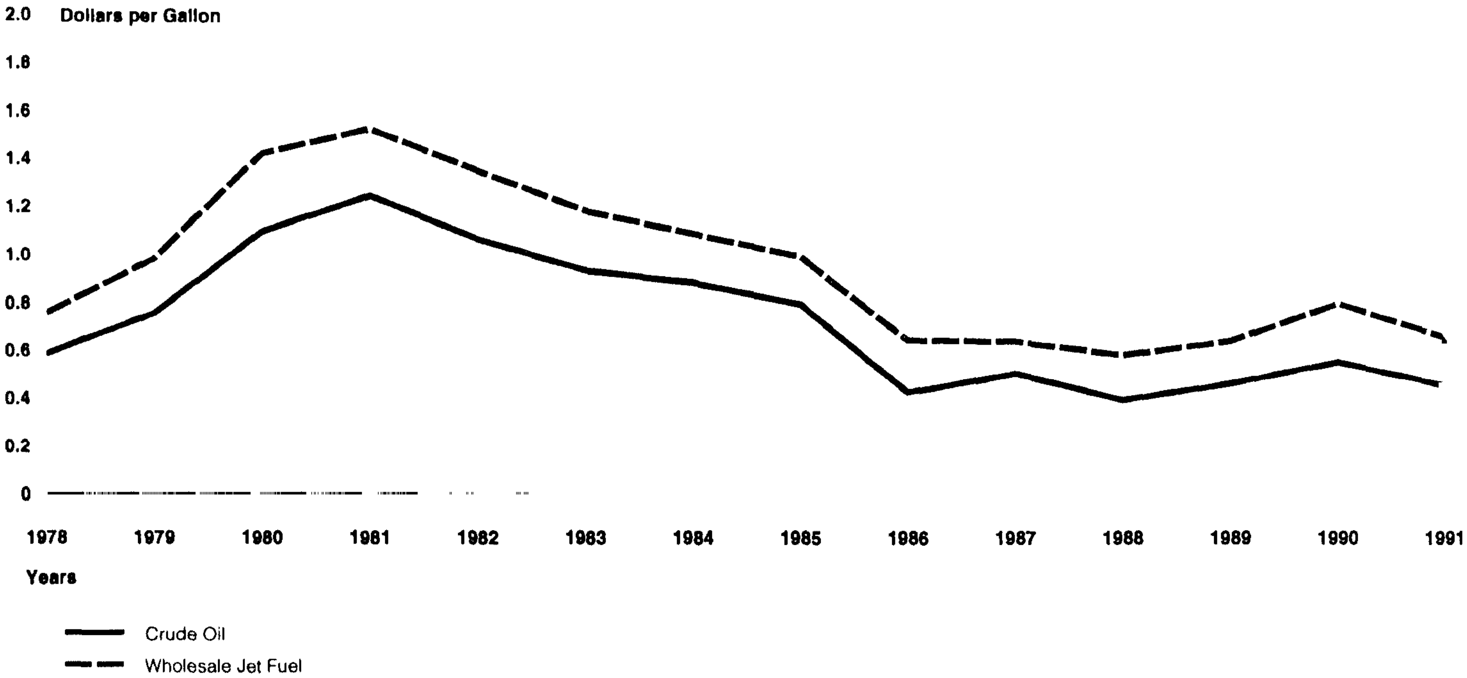


Notes: The prices for crude oil are RAC. The prices for wholesale home heating oil are "sales prices to resellers." The prices for retail home heating oil are "prices to residential customers."

Prices are converted into 1991 dollars. All prices exclude all taxes.

Source: Based on data from EIA.

Figure 3.6: Crude Oil and Wholesale Jet Fuel Prices, 1978-91



Notes: The prices for crude oil are RAC. The prices used to approximate wholesale jet fuel prices are "sales prices to end users." We did not consider "sales prices to resellers" in calculating the wholesale prices of jet fuel since most sales are made to end users such as airlines, which buy in bulk.

Prices are converted into 1991 dollars. All prices exclude all taxes.

Source: Based on data from EIA.

Wholesale Prices Also Affected by Seasonal Demand and by Supply Arrangements

Although crude oil prices largely influence wholesale prices, increased demand for gasoline and home heating oil during the summer and winter, respectively, generally lead to higher wholesale gasoline and home heating oil prices during these seasons. The type of supply arrangement between the buyer and seller also affects the short-term variations in wholesale prices.

Petroleum products can be bought and sold at the wholesale level in the futures, spot, and contract markets. Daily movements in wholesale prices for these products on the futures market serve as the basis for negotiations about prices in the other two markets. Spot prices are generally lower and more volatile than contract prices. On the spot market, the buyer is free to shop around for the lowest prices. Conversely, under a contract, which is based on a prearranged pricing formula, the buyer pays a premium for the security of having a guaranteed supply.

Seasonal Demand Drives Wholesale Prices for Three Petroleum Products

Although the three fuels are regularly produced, the overall supply, particularly of gasoline and home heating oil, often reflects seasonal demand. During the spring and summer, U.S. refineries increase their production of gasoline and reduce their production of heating oil. Beginning in the early fall and continuing through the winter, refiners readjust to increase the amount of heating oil they produce. Wholesale prices for gasoline and home heating oil reflect the seasonal demand: During periods of higher anticipated demand, prices increase as distributors build up their inventories.

In general, the domestic gasoline market is said to be in "contango" during the spring and summer months as prices rise steadily from one month to the next for contracts of different maturity in the futures market. During these seasons, the heating oil market is said to be in "backwardation." That is, prices on the futures market are falling. The reverse relationships occur during the winter months.[10]

The demand for jet fuel generally rises during the summer months and occasionally during November and December because of increased air travel. In general, jet fuel prices can also be higher during these times. However, jet fuel prices do not exhibit the same strong seasonal patterns as the prices for the other two fuels do.

Wholesale Gasoline Prices Reflect Supply Arrangements

The wholesale prices that gasoline distributors and dealers pay depend on the type of supply arrangement. In general, different types of dealers may pay one or more of several distinct wholesale prices, which are spot prices and three contractual prices, namely, the unbranded rack, branded rack, and dealer-tankwagon (DTW) prices, as discussed in detail below. Table 3.1 shows the types of wholesale prices distributors and different types of dealers pay.

[10]"Contango" and "backwardation" are general terms used in the futures market.

Table 3.1: Types of Wholesale Prices Paid for Gasoline

Purchaser of gasoline	Spot	Unbranded rack	Branded rack	DTW	Transfer price[a]
Distributor	X	X	X		
Company-operated outlet					X
Lessee dealer				X	
Open dealer		X		X	

Note: This table is meant to convey the types of wholesale prices paid by distributors and the various types of dealers. The exact wholesale prices paid by dealers receiving their supply directly from refiners and dealers receiving their supply indirectly through distributors could differ.

[a]Transfer prices are not considered to be actual prices paid by a company-operated outlet.

Under normal market conditions, the spot price is the lowest wholesale price,[11] followed by the unbranded rack price, branded rack price, and DTW price—the highest wholesale price. This ordering of prices is determined by the nature of the supply arrangements between the suppliers and purchasers.

Spot Prices

The spot market generally offers the lowest price under normal market conditions because there is no binding contract between the seller and the buyer. Participants in the wholesale market typically use the spot market when faced with surpluses or shortages that may arise from their contractual transactions.[12] Although the spot market accounts for only a small portion of domestic gasoline sales, spot prices, as well as futures prices, strongly influence the contract—rack and DTW—prices. Spot and futures prices provide the daily competitive signals that serve as a basis for setting the contract prices.

Despite the apparent advantage the spot market offers in having the lowest prices during normal market conditions, industry officials pointed out that some gasoline distributors and dealers prefer the security that contractual arrangements offer over the risk that the supply available on the spot market may be inadequate, especially during a market shock. Therefore, these distributors and dealers are willing to pay a premium above spot prices for this security. Purchasers who rely more on the spot market are also aware of the potential risk of having to pay higher than average prices during a market shock.

[11]Spot prices for gasoline, as with other petroleum products, generally closely track near-month futures prices for these products, under normal market conditions.

[12]Lessee dealers do not generally purchase from the spot market, as they purchase all of their supply from the refiner or distributor from whom they lease their equipment.

Changes in the spot prices for crude oil are quickly and almost completely reflected in the spot prices for wholesale gasoline. From our econometric model of gasoline price adjustment, we found that, on average, a 1-cent-a-gallon[13] change in the spot price of WTI crude oil—whether the price of crude oil is increasing or decreasing—causes the spot price of gasoline delivered in New York Harbor to change by about 0.83 cents a gallon.[14] All of the change in the price of the wholesale gasoline occurs within the first week following the change in the price of crude oil.

Rack Prices

Rack prices are the prices paid by distributors and dealers for their gasoline supplied by refiners at the refiner's wholesale terminal, or "rack." Rack prices can be either contract or noncontract prices, but commonly are the former. Typically, rack prices are set daily by refiners and are generally influenced by prices in the spot and futures markets, as well as by the extent of competition among refiners within a particular market. As contract prices, rack prices include a certain premium associated with the relative certainty of the supply and their stability in comparison to spot prices. Therefore, average rack prices are generally higher than spot prices under normal market conditions. But quoted rack prices may often be higher than the actual prices paid by the purchasers because suppliers often offer purchasers rebates and discounts.

There are two types of rack prices—branded and unbranded. Branded rack prices are paid by distributors for gasoline supplies from major refiners selling under their trademark, while unbranded rack prices are paid for gasoline supplies primarily from independent refiners. Normally, unbranded rack prices tend to be lower than branded rack prices because the former are for generic gasoline and the latter include a premium reflecting the recognized brand name. In addition, when refiners sell distributors branded gasoline, the contracts tend to be less flexible but guarantee a more secure supply than when refiners sell unbranded gasoline. Thus, branded rack prices also include a premium for this additional security of the supply. On the other hand, a purchaser of unbranded gasoline has more flexibility to shop for lower prices and may or may not have a contractual arrangement with a refiner. Therefore, a buyer of unbranded gasoline may not be guaranteed a secure supply or lower prices, particularly during a market shock.

[13]Crude oil prices are reported in cents per gallon, rather than dollars per barrel, so that the units of measure are comparable to gasoline's. Depending on a refinery process, 1 gallon of crude oil may yield more than 1 gallon of gasoline. But since the yield is not 1 for 1, the relationship between the price of crude oil and the price of gasoline cannot be expected to be 1 for 1.

[14]The price data used for our analysis cover the period from January 1984 until March 1991. The findings based on our econometric model will be discussed in more detail in ch. 4 and app. II.

Dealer-Tankwagon Prices

DTW prices are contract prices paid by lessee dealers and some open dealers to suppliers—refiners or distributors—for branded gasoline delivered at the dealers' outlets. In general, DTW prices are less volatile and are higher than spot and rack prices. DTW prices, which are set by suppliers, include the cost of transporting the gasoline to the retail stations. DTW prices also include a premium associated with the strength of the suppliers' brand name, as well as with the costs of using credit cards or other costs. Suppliers set their DTW prices using the futures and/or spot prices for gasoline as a reference as well as the DTW prices of other suppliers in the market area.

The contractual agreement between the supplier and the dealer stipulates, among other things, a minimum purchase, which allows the dealer little flexibility to shop around for lower prices. Dealers are willing to pay the premium attached to DTW prices because of the relative stability of these prices and the security of the supply, even during periods of volatile prices and constrained supplies. As is the case with rack prices, quoted DTW prices may be higher than the actual prices paid by the customers because of rebates and discounts offered by suppliers.

Transfer Prices

Transfer prices are internal prices at which refiners or distributors supply gasoline to their company-owned and -operated stations at the retail level. Oil companies generally regard their transfer prices as proprietary information and do not publicly disclose them. Several oil companies told us that transfer prices are valued at market prices. However, transfer prices for refiner-owned and -operated stations may be based on the cost of refining a gallon of gasoline and for distributor-owned and -operated stations—such as chain retailers or convenience stores—on the spot and/or rack prices paid by distributors.

Wholesale Prices for Home Heating Oil Also Influenced by Contractual Arrangements

According to EIA, before the 1970s market shocks, the wholesale market for home heating oil relied largely on long-term supply contracts characterized by low and generally stable prices. In the late 1970s and 1980s, however, buyers and sellers at the wholesale level favored the use of the more flexible and more volatile spot and futures markets.[15]

Today's heating oil contracts now stipulate a secure supply but at flexible prices. That is, the contracts generally establish a minimum monthly

[15]As is the case with the buyers and sellers of crude oil and other petroleum products, only a small percentage of all heating oil is actually supplied through the futures market. The buyers and sellers of heating oil use the futures market as a hedge against uncertainties about prices, rather than as a source of supply.

volume of heating oil to be purchased, without fixing the price. These contracts usually last 1 year. Suppliers can change prices as frequently as they choose, although they normally do not change prices more than once a day. Wholesalers are generally not required to purchase heating oil if they find the contract price unacceptable. However, if wholesalers do not purchase the minimum monthly volume specified in their contract, their allocated monthly supply may be reduced or their contract terminated.

Contract prices for home heating oil are rack prices, typically set by the supplier—either the refiner and/or terminal operator—to be competitive with the contract prices of other suppliers within the market area. Though gasoline may be unbranded or branded, home heating oil is now solely unbranded. So there is only one set of rack prices for it. These prices are listed in trade publications and can be surveyed electronically. According to industry officials, rack prices for home heating oil, like contract prices for gasoline, are often set using prevailing spot and/or futures prices as a reference.

For example, in a typical home heating oil contract, a refiner may set the rack price by using the futures or spot price on the expected date of delivery and adding a certain premium. However, one wholesale buyer whom we talked to told us that refiners may and often do diverge from the stipulated pricing formulas at the time of delivery without much explanation.

Jet Fuel Prices Generally Are Established Through Bidding

Jet fuel is primarily bought and sold through contracts with suppliers, but transactions on the spot market have increased over the past few years because prices there are generally lower and airlines interested in cutting costs can benefit from these purchases. According to a refiner and commercial airline officials with whom we spoke, commercial airlines seeking to establish a contractual arrangement for jet fuel with one or more suppliers typically solicit bids from competing refiners for the best deals to supply a specific volume of fuel over a 1-year period, on average. Under these bid contracts, airlines can purchase jet fuel either at prices refiners set using their pricing formulas or at prices refiners post at airports. Like home heating oil, jet fuel is unbranded.

Refiners and commercial airline representatives told us that large commercial airlines have generally opted for contracts that use pricing formulas to establish the price of jet fuel. These pricing formulas peg the contract price of jet fuel to its spot price on the day of delivery or—since there is no futures trading of jet fuel on NYMEX—to the near-month futures price of home heating oil, gasoline, or crude oil, adjusted in either case by a premium or discount. The price on the Gulf Coast spot market is the spot price most widely used as a reference point for contract prices of jet fuel.

In competing for supply contracts, suppliers can offer the airlines different-sized discounts in their bids. According to several airlines we contacted, commercial airlines that purchase large volumes of jet fuel have significant negotiating power with potential suppliers. Moreover, according to representatives of an airline association, the negotiations of the largest buyers in a region will tend to set the prices the other airlines pay for jet fuel. These prices are reported by refiners to airline industry journals.

Some airlines also purchase jet fuel at the prices refiners post at a given airport. According to one refiner, posted prices are influenced by the degree of competition within that market. In general, the presence of many suppliers—refiners, traders, and brokers—at large airports helps to ensure lower posted prices. On the other hand, at smaller airports where suppliers have little or no competition, or where there is no pipeline, jet fuel prices tend to be higher.

Retail Prices Also Determined by Seasonal Demand, Lack of Short-term Substitutes, and Local Competition

Crude oil and wholesale prices establish the basis for retail prices. Seasonal demand also plays a role at the retail level. But since over the short term, there are no substitutes for gasoline and home heating oil, their consumption is not very sensitive to price changes. Finally, the degree of competition in the local market plays an essential role in causing prices to vary from average trends.[16] Therefore, changes in retail prices for gasoline and home heating oil—only a small percentage of jet fuel is sold at the retail level—may differ from changes in wholesale prices in the short term under normal market conditions.[17]

Seasonal Demand Affects Retail Prices for Gasoline and Home Heating Oil

The highest demand for gasoline generally occurs during the summer months because of increased driving. Gasoline prices, therefore, generally rise in the spring to reflect an expected increase in demand. However, a

[16]Other factors that could affect the local supply of petroleum products, such as a shutdown by a refinery, could also influence retail prices in the short term.

[17]FBOs' retail prices for jet fuel tend to be more volatile than refiners' prices for jet fuel, according to officials from a major airline.

downturn in economic activity can dampen this seasonal increase in demand and the retail prices of gasoline.

The demand, at the retail level, for home heating oil is concentrated in the winter months. Hence, retail prices for it generally rise beginning in September to reflect this demand. However, if an unusually warm winter occurs, this seasonal trend may not be as dramatic as it usually is.

Lack of Substitutes for Gasoline and Home Heating Oil Over the Short Term Also Affects Retail Prices

The amount of gasoline used depends little on changes in its price, and currently there are no economically viable substitutes for gasoline. As a result, according to economists' estimates, gasoline consumption will decrease only 1.3 percent if the price increases by 10 percent.[18]

The demand for home heating oil over the short term is also relatively insensitive to price increases. Although electricity and natural gas can be substituted for home heating oil over the long term, homeowners cannot, during a winter, easily switch to these other fuel sources to heat their homes.

Retail Gasoline Prices Influenced by Extent of Local Competition

According to industry officials, while retailers will normally seek to set their prices to cover their costs and make a profit, retail gasoline prices, in the short term, are influenced essentially by the extent of competition within a local market.

Typically, a gasoline retailer closely watches the pricing by other retailers within the vicinity and keeps the retail price competitive so as to preserve market share and profitability.[19] Moreover, the fewer the retail stations that are equally accessible to motorists within a given vicinity, the more likely the chance that retail prices will be, on average, higher than in areas with more competitors. A gasoline distributor with whom we spoke claimed that rural outlets can more easily pass on any increases in wholesale costs because there is less competition than in urban areas.

[18]The price elasticity of demand for gasoline is estimated to be –0.13, or inelastic in the short term. For a more complete survey of estimates of the price elasticity of demand for gasoline, see Carol A. Dahl, "Gasoline Demand Survey," The Energy Journal, Vol. 7, No. 1 (1986).

[19]The prices charged by all of the retailers within a market may not always be the same. Indeed, there will normally be minor differences among retailers' prices. However, a retailer who does not increase prices when others have increased theirs substantially may develop a shortage of gasoline, and a retailer who does not decrease prices when others have lowered theirs substantially may lose some market share.

According to some oil industry representatives and experts, there is often "price leadership" in the marketplace. One retailer in a given area may adopt an aggressive pricing strategy by frequently changing prices, and other retailers in the area will generally tend to follow that retailer's lead. For example, as some industry representatives and experts pointed out, a typical price leader may choose to lower prices in an attempt to increase market share, and an integrated oil company owning large domestic reserves of crude oil may lower prices at company-owned and -operated stations in an attempt to move large volumes of gasoline.

Retail Prices for Gasoline Are Generally Slow to Respond to Changes in Wholesale Prices

Retail prices for gasoline often do not reflect the daily fluctuations in wholesale and/or crude oil prices. The example in table 3.2 illustrates how retail prices for gasoline reflect what the local market will bear: A distributor that also operates a retail station had the branded rack price fluctuate by several cents over roughly 3 weeks in a normal market, but the distributor's retail price for regular unleaded gasoline, excluding taxes, remained unchanged. This "stickiness" of the retail price can occur for a variety of reasons, including the fact that some retailers will generally delay a price change until it is initiated by another retailer within the local market.[20]

[20]This "wait and see" behavior on the part of the retailer is discussed more fully in ch. 4.

Table 3.2: Wholesale and Retail Prices for a Distributor of Branded Gasoline

Cents per Gallon

Date	Wholesale (branded rack) price	Retail price[a]
1/1/92	0.576	0.660
1/2/92	0.576	0.660
1/3/92	0.584	0.660
1/4/92	0.584	0.660
1/5/92	0.584	0.660
1/6/92	0.584	0.660
1/7/92	0.582	0.660
1/8/92	0.580	0.660
1/9/92	0.567	0.660
1/10/92	0.557	0.660
1/11/92	0.544	0.660
1/12/92	0.544	0.660
1/13/92	0.544	0.660
1/14/92	0.546	0.660
1/15/92	0.549	0.660
1/16/92	0.545	0.660
1/17/92	0.547	0.660
1/18/92	0.553	0.660
1/19/92	0.553	0.660
1/20/92	0.553	0.660
1/21/92	0.556	0.660
1/22/92	0.551	0.660

[a]Retail prices exclude taxes.

Moreover, the results of our econometric model of gasoline price adjustment also show that changes in the retail price, on average, lag behind changes in the wholesale price on the spot market. More specifically, the results indicate that a 1 cent-per-gallon change in the spot price of gasoline, either an increase or decrease, results in an 0.87 cent-per-gallon change in the average retail price of gasoline, but this result occurs over a 4-month period. More than one-half of this change at the retail level—0.49 cents—occurs within 4 weeks after the change in the spot price.

Retail Home Heating Oil Prices Also Influenced by Local Competition

According to a retail heating oil distributor, distributors use a "cost-plus formula" to determine the prices they charge their residential customers. The formula adds the wholesale cost of the fuel, operating costs, and a certain markup that represents the net profit margin. Distributors can change the markup and the retail price in response to conditions in the local market. In establishing markups, retailers consider customers' use of heating oil over the past few years and predict upcoming purchases.

Therefore, even if wholesale costs within a given area are similar, retail prices may still vary slightly among various distributors because of their different operating costs and markups. Moreover, the speed with which retail prices react to changes in wholesale prices is determined by local retail competition.

Residential Customers Generally Buy Heating Oil Through "Automatic Delivery" or on "Will Call" Basis

Residential customers may buy heating oil through arrangements that offer "automatic delivery" or on a "will call" basis. According to industry officials whom we talked to, most residential customers have automatic delivery agreements with their suppliers.

In general, customers receiving automatic deliveries tend to have a contract with their suppliers, while customers getting oil on a "will call" basis do not have a contractual agreement with any one particular supplier. But while a contract may guarantee residential customers a relatively secure supply of heating oil, the contract may not guarantee a constant or lower price. Prices for these customers may change from one delivery to the next.

On the other hand, customers buying oil on a "will call" basis have the option to compare the prices of several retail distributors within the area in order to obtain the lowest available price. But while these customers may generally be able to find a sufficient amount of oil under normal market conditions or during gluts, they are more vulnerable if market shocks in the winter cause supplies to be scarce.

Some heating oil distributors now offer their residential customers the option to lock in their entire supply of heating oil for the heating season at a preseason guaranteed price as insurance against the price increases that can occur during market shocks. Residential heating oil customers who purchase their home heating oil through guaranteed-price contracts may have to pay for their home heating oil up front. Most distributors who offer this option hedge their inventory through their supplier who buys and/or sells futures contracts. According to one distributor, this option has been increasingly offered to customers since the 1989 Heating Oil Crisis. Two retail distributors told us that a relatively small percentage of their residential customers have used this option.

While the option of obtaining a fixed price may guarantee supplies and assure consumers that they will pay lower prices during market shocks, it is possible that residential customers who choose this option may, over the course of the winter, end up paying higher average prices. Flexible retail prices may average out to be lower, especially during winters that are warmer than normal.

Pricing of Crude Oil and Petroleum Products During Oil Market Shocks

An oil market shock—an event or rumor that substantially alters the actual or expected supply of and demand for crude oil or petroleum products—will produce rapid and similar changes in domestic prices for crude oil and prices for petroleum products at the wholesale and retail levels. An oil market shock can cause these prices to rise sharply (a "negative" shock) or fall sharply (a "positive" shock).[1] Inventories of crude oil and petroleum products—at all levels of the oil market—are quickly valued at shock-induced prices, regardless of their production or acquisition costs. All prices change quickly to reflect actual and potential changes in the scarcity and value of crude oil and petroleum products. The existence of futures markets for crude oil and petroleum products has increased the speed of price changes during market shocks.

Moreover, the demand for certain petroleum products—gasoline, home heating oil, and jet fuel—can vary. These differences in demand may largely account for differences in the level of price increases and decreases among these three products during market shocks.

With respect to gasoline, many consumers believe that during oil market shocks, retail prices rise more quickly and to a greater extent than they fall in relation to increases and decreases in the price of crude oil. This uneven adjustment in prices is known as "price asymmetry." Discussions with oil market experts and econometric models of changes in gasoline prices provide evidence that asymmetry does occur. The models that have found asymmetry differ, however, as to whether the asymmetry takes place between the crude oil and wholesale levels or between the wholesale and retail levels, and there are also different explanations for the asymmetry. Our model suggests that during market shocks, wholesale gasoline prices adjust asymmetrically to changes in crude oil prices and that this adjustment may be largely explained by crude oil inventory levels and refineries' capacity to increase production during shocks. However, our model did not find evidence of asymmetry between wholesale and retail prices. Industry officials and experts and other models' results point to such factors as uncertainty, retailers' knowledge of consumers' psychology and buying patterns, and the inelasticity of the demand for gasoline as possible reasons for asymmetry between the crude oil and wholesale and/or retail levels.

[1]Prices can also rapidly fall during the downside of a negative shock, such as when crude oil prices dropped sharply during the Persian Gulf Crisis in January 1991.

Considered broadly, market shocks produce different costs and benefits for market participants, and the effect market shocks can have on the U.S. economy can be great and lasting.

Shock-Induced Prices Reflect Current and Potential Value of Crude Oil and Petroleum Products, Not Historical Costs

During both positive and negative shocks, existing inventories of crude oil and petroleum products are typically priced at the current shock-induced market values, regardless of the historical costs. The rapid changes in prices occur because the opportunity cost of selling existing inventories changes. The prices of storable products, such as petroleum, reflect not only current forgone alternative uses, but future forgone alternative uses. Thus, the current prices of crude oil and petroleum products already in inventory adjust to account for future events—such as further changes in the supply or demand—because the current owners of the oil or products could choose to hold onto them, awaiting prices available in the future. This explains why station operators, who may already have some gasoline acquired at lower or higher costs, immediately adjust their retail prices to reflect the new value of their inventory.

Even if inventories of crude oil and petroleum products are high during a negative shock, prices at all levels of the oil market will rise to reflect the current market value of the oil and the products. For example, the prices of crude oil and petroleum products increased rapidly in the United States upon the news of the Iraqi invasion of Kuwait on August 2, 1990, even though inventories were historically high at the time.[2] Oil prices immediately rose to reflect the loss of the oil supplied by Iraq and Kuwait. There were also expectations that there might be an additional loss in the world's oil supply if Saudi Arabia became involved in the conflict, and prices also reflected this uncertainty. If the price is expected to increase in the near future, the opportunity cost of a current sale is not the price today, but is the higher price available in the near future. Thus, oil prices rose almost instantaneously to reflect the increased opportunity cost of a sale.

If a seller sets its prices below the market prices and others do not follow, the higher demand for the seller's products will likely exceed its capacity to replenish its supply, so that inventory of the products will be depleted rapidly. This situation occurred during the Persian Gulf Crisis, when one major integrated oil company decided not to raise its wholesale and retail

[2]According to EIA, at the end of July 1990, the total inventory of crude oil and petroleum products in the United States was 1.7 billion barrels, about 60 million barrels (mmb) more than at the same time the year before and the highest level in any year since 1973. As discussed later, however, high inventories can also have a dampening effect on price increases during a negative shock.

gasoline prices to the prevailing market prices. Because other competitors did not freeze their own prices, the demand for the gasoline of this company exceeded its production capacity. The company was then forced to adopt a rationing strategy. According to this company's representatives, the price freeze was only sustained for about 2 weeks before the company raised its prices to reflect the prevailing market values. However, according to company officials, this pricing did increase the company's retail gasoline sales by 23 to 25 percent during the 2-week period. If, on the other hand, a seller sets its prices above the market prices and others refuse to increase theirs, it will lose sales. Thus, there is pressure to set prices close to the market prices.

During a positive shock—such as the 1986 collapse in crude oil prices [3] —or when prices are falling on the downside of a negative shock, crude oil and petroleum products already in inventory that were acquired at higher prices will likely also be sold at the current market price, as indicated by the futures and/or spot markets. This could result in decreased profits. However, as discussed in more detail later, during market shocks the prices of petroleum products may fall more slowly than they rise in relation to crude oil prices, thus lessening any decrease in profits for sellers of the products.

Futures Market Has Increased the Speed of Prices' Response to Market Shocks

Prices of crude oil and petroleum products respond faster to oil market shocks today than they did before the 1980s, when the contract market predominated. The primary reason for this quick response is the existence of viable futures markets, which have increased the role of current information in pricing.

As discussed in chapters 2 and 3, information about events that can cause an actual or potential change in the supply of and demand for oil are quickly translated into price changes on the international futures exchanges. Furthermore, futures prices are easily and quickly accessible to a wide range of participants at all levels of the oil industry through high-speed electronic transmissions. Since the futures market is used as a reference for setting prices in the spot and contract markets for both crude oil and petroleum products, sales transacted in these other markets during market shocks will immediately reflect the shock-induced price changes.

[3] The 1986 collapse in world prices for crude oil mostly resulted from Saudi Arabia's "flooding" of the oil market.

During Market Shocks, Differences in the Demand for Wholesale Petroleum Products Lead to Various Changes in Their Price

Changes in crude oil prices due to oil market shocks are, in general, quickly transmitted to the wholesale prices of three petroleum products—gasoline, jet fuel, and home heating oil. However, the prices of the different petroleum products respond in various degrees to oil market shocks because of differences in the demand for each fuel at the time. In theory, rapidly rising and higher demand should produce quicker and larger price increases or smaller price reductions.

Differences in Demand for Petroleum Products May Lead to Various Increases in Wholesale Prices During a Negative Shock

A negative shock in the world market for crude oil may rapidly increase the demand not only for crude oil, but also for certain petroleum products at the wholesale level, as purchasers speculate or take precautions, expecting a reduction in future supplies and/or higher prices. The demand at the wholesale level for certain fuels, however, may increase more than expected, depending on the current or expected end-use demand, as the following scenario reveals.[4] The spot price of wholesale jet fuel rose by a greater percentage than the spot prices of home heating oil and gasoline during the Persian Gulf Crisis. The variability in price increases for the three petroleum products was related to the different change in demand for each product, as table 4.1, based on data on the first 3 months of the crisis, shows.

Table 4.1: Weekly Average Change in Demand and Spot Prices for Crude Oil and Wholesale Petroleum Products During the Gulf Crisis, 8/3/90 to 11/2/90

Petroleum product	Weekly average percentage change in quantity demanded[a]	Weekly average percentage change in price[b]
Crude oil	[c]	+4.12
Gasoline	+0.01	+3.17
Home heating oil	+0.58	+3.59
Jet fuel	+1.51	+5.30

[a]For this analysis, we used EIA's data for the "product supplied" as an approximation of the quantity demanded.

[b]The price data used were the spot price of WTI crude oil, spot prices for deliveries of unleaded gasoline and heating oil to New York Harbor, and the spot price of jet fuel.

[c]Data on the quantity of crude oil supplied were not available.

Source: Based on data from EIA.

[4]Since federal controls on oil prices and allocations were lifted by 1981, the potential for fuel shortages, particularly gasoline shortages, has diminished because prices adjust quickly to allocate supply and demand. Hence, consumers are now less likely to make precautionary purchases, by topping off gasoline tanks during a negative shock, for instance.

As seen in table 4.1, jet fuel prices increased more than gasoline and home heating oil prices during the Gulf Crisis, at an average weekly rate of 5.3 percent, even surpassing the increase in crude oil prices. This price increase for jet fuel may be explained by the higher rate at which demand for the product increased during the same period, increasing by a weekly average rate of 1.51 percent. According to EIA, during the 90 days following the invasion of Kuwait, the demand for jet fuel in the United States had increased by almost 9 percent from the previous year. But the drastic increase in the price of jet fuel in the United States was not necessarily accounted for by increases in the domestic demand alone. EIA and several oil companies also stated that the higher increase in the price of jet fuel in the United States was largely due to the increase in the worldwide demand for jet fuel as a result of the buildup of allied military forces in the Gulf.

End-use demand for gasoline and home heating oil also may have played a role in the observed changes in the demand and prices at the wholesale level.[5] Many oil industry officials and experts told us that consumers' demand for gasoline in the United States was weak relative to that for home heating oil and jet fuel during the Gulf Crisis. Moreover, much of this period did not coincide with the seasonal buildup in the inventories of wholesale gasoline. This may account for why wholesale gasoline prices did not increase as much as wholesale prices for jet fuel and home heating oil. While consumers were not using much home heating oil during the period, the demand at the wholesale level increased, at least partly, in preparation for the winter months. These differences in demand could explain why heating oil prices rose more than gasoline prices. The increase in heating oil prices was still less than that for jet fuel prices, however.

Differences in Demand for Petroleum Products May Also Lead to Various Decreases in Wholesale Prices During a Positive Shock

A positive shock, which causes crude oil prices to rapidly decline, generally stimulates increases in consumption. However, the demand for certain wholesale petroleum products may decrease during a positive shock because purchasers may anticipate even lower prices in the future. Table 4.2 illustrates the relationship between the changes in the demand and prices for wholesale gasoline and wholesale home heating oil during a positive shock, using data from the first 3 months of the 1986 collapse in crude oil prices.[6]

[5]We did not analyze the relationships between demand and prices at the retail level because of a lack of data on demand at this level.

[6]EIA did not collect weekly data on jet fuel prices during this period.

Table 4.2: Weekly Average Change in Demand and Spot Prices for Crude Oil and Wholesale Petroleum Products During the 1986 Collapse in Oil Prices, 1/10/86 to 3/28/86

Petroleum product	Weekly average percentage change in quantity demanded[a]	Weekly average percentage change in price[b]
Crude oil	[c]	-6.56
Gasoline	-0.31	-4.64
Home heating oil	-0.30	-3.21

[a]For this analysis, we used EIA's data for the "product supplied" as an approximation of the quantity demanded.

[b]The price data used were the spot price of WTI crude oil and spot prices for deliveries of unleaded gasoline and heating oil to New York Harbor.

[c]Data on the quantity of crude oil supplied were not available.

Source: Based on data from EIA.

As table 4.2 shows, the spot prices of gasoline and home heating oil declined by an average of 4.64 percent and 3.21 percent per week, respectively, during the period, reflecting the drop—although not 1 for 1—in the spot price of crude oil. Although the prices of these petroleum products declined, the purchases of the products also declined. This decline in purchases may be partly due to precautionary buying by wholesale purchasers, reducing their demand for petroleum products in expectation of a further decline in prices. The decline in demand would then induce further decreases in the prices of petroleum products.

Wholesale and Retail Prices May Increase More Quickly and Completely in Relation to Increases in Crude Oil Prices Than They Decrease

Discussions with oil company representatives and other oil market experts and the results of econometric models, including our own model, provide evidence that gasoline prices may not respond with the same speed and to the same extent when crude oil prices rise as when they fall during shocks. In other words, changes in the wholesale and retail price of gasoline in response to changes in crude oil prices during shocks may be "asymmetric." There are differences among the results of econometric models and the opinions of industry representatives and experts about where in the supply chain asymmetry occurs and the reasons for it. In the home heating oil market, asymmetry may also exist, according to a model developed by the American Petroleum Institute (API).

Industry Officials View Wholesale Gasoline Prices' Adjustment as Rapid

Many oil industry officials whom we interviewed told us that increases and decreases in the spot price of crude oil are quickly and almost completely transmitted to the spot prices for wholesale gasoline during shocks. Most of these officials believe that the wholesale prices respond to changes in crude oil prices immediately and that within about 3 days, nearly all the changes are transmitted. However, some of these industry officials believe that decreases in crude oil prices are not always passed on to them as fully as are increases.

Industry Representatives and Experts Believe That Retail Gasoline Prices Rise More Quickly and Completely Than They Fall During Shocks

According to many oil industry representatives and oil market experts we interviewed, while wholesale prices respond immediately and fully to changes in crude oil prices, retail prices, on average, will react quickly to changes in crude oil and wholesale prices during shocks, but not as fully. These representatives and experts estimated that it could take up to 6 to 8 weeks for changes in the price of crude oil or wholesale gasoline to be fully passed on to the retail level.

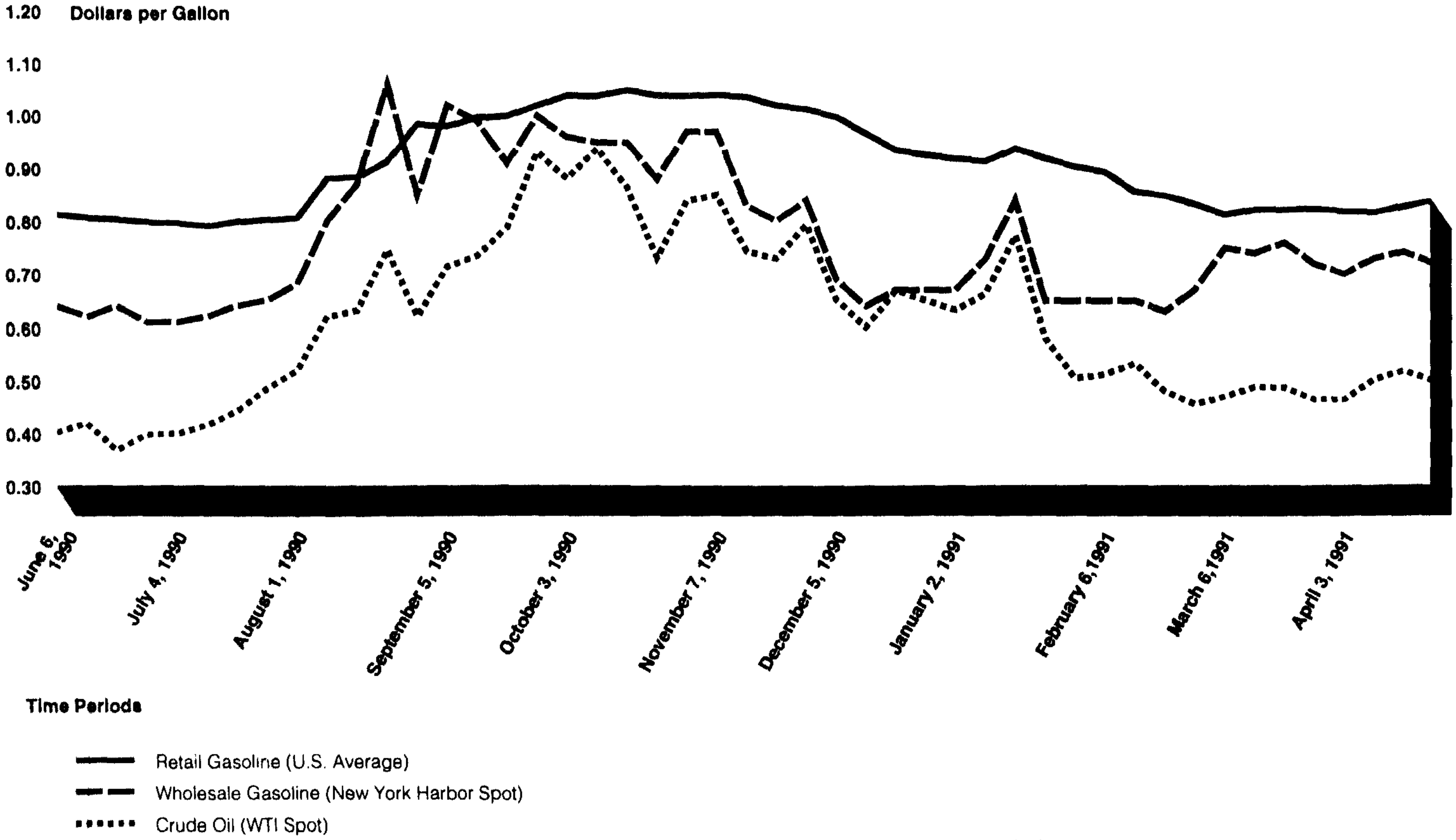
Many of the oil industry representatives and oil market experts we interviewed also believe that the retail price of gasoline probably increases faster and more when crude oil and wholesale prices rise than it decreases when they fall during market shocks. A few of those interviewed, however, argued that retail gasoline prices fall with the same speed and magnitude as they rise during market shocks.

Furthermore, industry representatives and oil market experts pointed out that although retail prices may rise quickly in response to an increase in crude oil or wholesale prices, the increase in retail prices may not always fully reflect the increase in crude oil or wholesale prices. The representatives and experts argued that retailers exercise caution to avoid a backlash from consumers and decreased retail sales.

While retail prices may be slow to follow when crude oil or wholesale prices fall, competition, some of the industry representatives and experts explained, eventually forces the retail prices down, although not always at the same rate as crude oil or wholesale prices decrease. Many oil industry officials we interviewed said that retail prices may fall more slowly because the industry is attempting to recoup lower margins that they may have had when prices were rapidly rising.

As figure 4.1 shows, the average retail price of gasoline rose fairly quickly in response to the increases in the spot prices of crude oil and wholesale petroleum products following Iraq's invasion of Kuwait on August 2, 1990. Many of the industry representatives we interviewed indicated that retail gasoline prices might have been higher if the President had not made an appeal to oil companies to restrain price increases. However, wholesale and retail gasoline prices tended to fall more slowly when crude oil prices were falling from about January until April 1991.

Figure 4.1: Spot Prices for Crude Oil and Wholesale Gasoline and Retail Prices for Gasoline During the Gulf Crisis, 6/6/90 to 4/3/91



Note: Prices are weekly averages. Taxes are not included.

Sources: Based on data from API, Oil and Gas Journal, and The Wall Street Journal.

GAO's Model Found Evidence of Asymmetry in Gasoline Prices During Shocks

Since nearly all of the gasoline sold in the United States is sold through a reseller—and not directly from a refiner to a retailer—we tested for the adjustment of retail gasoline prices to changes in crude oil prices by separating the relationship into two segments: between crude oil and wholesale gasoline prices and between wholesale and retail gasoline prices. Our model's results show that wholesale gasoline prices adjust asymmetrically to changes in crude oil prices and that retail prices adjust symmetrically to changes in wholesale prices during market shocks.[7] Our model's results also suggest that the asymmetry may largely be attributed to the level of crude oil inventories and the excess production capacity available at refineries, combined with changes in the demand.

GAO's Model Found That Changes Between Crude Oil and Wholesale Gasoline Prices Are Asymmetric During Shocks

Our econometric model tested the relationship between spot prices of crude oil and wholesale gasoline. The model considered, in addition to prices, the extent to which refineries' capacity was being utilized and crude oil inventory levels, as factors that could affect the speed and magnitude of wholesale prices' adjustment during shocks. In developing our model, we believed, on the basis of our discussions with oil industry representatives, that these two factors could significantly influence the adjustment.

For our model, we obtained weekly spot prices for WTI crude oil; spot prices for wholesale gasoline delivered to New York Harbor; and a national average of retail gasoline prices, excluding taxes. These data cover the period from January 1984 until March 1991. We used weekly data, instead of the monthly data that were used by some of the other models we surveyed because we believed that weekly spot prices, as a leading market indicator, more accurately captured the frequent price changes occurring during market shocks. One limitation of using spot prices, however, is that they do not account for all sales transactions of crude oil and wholesale gasoline. Appendix II contains a detailed description of our model's methodology and statistical analysis.

Our model's results show that the spot price of wholesale gasoline adjusts almost immediately—within the first week—to changes in the spot price of crude oil during both negative and positive shocks, as well as on average.[8] For every 10-cent-a-gallon increase in the spot price of crude oil during a shock, within a week the spot price of wholesale gasoline increases by 10.2 cents, while a 10-cent decrease in the spot price of crude oil leads to a decrease of 8.0 cents in the spot price of wholesale gasoline. Thus, according to our model, in terms of magnitude, the spot price of

[7]For the purposes of our model, we defined a market shock as a week in which the change in crude oil prices was at least 8.25 percent. We chose this percentage change because it was equal to two standard deviations from the mean of the price change distributions.

[8]Our comparisons of prices, during market shocks and on average, were made at the means of the relevant economic variables.

wholesale gasoline adjusts asymmetrically to changes in the spot price of crude oil during shocks.[9]

The amount of excess production capacity at refineries, as measured by utilization rates,[10] can influence the amount by which the price of gasoline changes during a market shock. High utilization rates partially explain why the wholesale price of gasoline may increase more when crude oil prices are rising than it decreases when crude oil prices are falling rapidly. By including a variable for utilization rates, our model found that higher utilization rates lead to a higher increase in prices, on average, during negative market shocks. Refineries' utilization rates increased in the United States from about 70 percent in the early 1980s to nearly 90 percent in more recent years. This means that during a negative shock, if buyers at the wholesale level increase their demand in order to build up their inventories as a precaution against further price increases, refineries cannot significantly increase their output to satisfy this demand. Thus, prices will go up to allocate available supplies. However, following a positive shock, there is not usually a large and sudden decrease in demand similar to the increase in demand during a negative shock. Even if there were such a decrease in demand, refineries could reduce their output.

The level of inventories of crude oil and wholesale gasoline may also influence changes in the wholesale price of gasoline during an oil market shock. Our model's results show that the higher the inventory levels, the less prices' response will be during negative shocks and the more prices' response will be during positive shocks. However, when we combined both of these variables—utilization rates and inventories—we found that prices' response is larger during negative shocks than during positive shocks because the effect of high utilization rates outweighs the dampening effect high inventories have on prices.

Inventories of crude oil and wholesale petroleum products have declined, if not in absolute terms, at least relative to total consumption, over the past decade. Since the early 1980s, uncertainties about prices have made it more costly for oil companies to hold high levels of "physical inventories." Oil companies increasingly have turned to futures market contracts, or "paper inventories," as a hedge against these uncertainties. Given lower inventories, increases in the demand at the wholesale level, which may be

[9]This result does not provide an indication of the profitability of a barrel of oil, even at the wholesale level.

[10]The "refinery capacity utilization rate," expressed as a percentage, is measured by gross crude oil inputs into U.S. refineries divided by the total operable capacity of the refineries. Excess production capacity is that portion of the operable capacity not currently in use.

induced by a negative shock, cannot readily be met by refining crude oil drawn from inventories.[11] Similarly, increases in demand at the retail level cannot be satisfied by drawing from inventories of wholesale petroleum products. Low inventories of wholesale gasoline may also reduce the downward pressure on gasoline prices during a positive shock. As observed during the Gulf Crisis, however, even high inventory levels may not prevent prices from rising during a negative shock. However, high inventory levels may have prevented the price increases that followed Iraq's invasion from being even higher than they were.

GAO's Model Found That Changes Between Wholesale and Retail Gasoline Prices Are Symmetric During Shocks

Just as our model examined wholesale prices' adjustment to changes in crude oil prices, it tested how quickly and completely average retail prices respond to changes in the spot prices of wholesale gasoline. In addition to considering prices, our model included a variable—wholesale gasoline inventories—that we believed, on the basis of our discussions with oil industry representatives, could influence the speed and/or magnitude of retail prices' adjustment during shocks. However, we did not find that wholesale gasoline inventories have a significant asymmetric effect on prices' adjustment at the retail level during market shocks.

In terms of the speed of prices' response, our model's results show that the average retail price of gasoline substantially lags in responding to changes in the spot price of wholesale gasoline during market shocks. While the retail price begins to adjust immediately, following the wholesale price—with about one-half of the change occurring within 4 weeks—the total response is spread over a 4-month period, whether the wholesale price is rising or falling, as is also the case on average. That is, our model found no evidence that the average retail price of gasoline adjusts faster to increases than to decreases in the spot price of wholesale gasoline.

With respect to the magnitude of prices' response, the model's results similarly show that for every 10-cent-per-gallon change in the spot price of wholesale gasoline, the average retail price changes by about 8.7 cents per gallon during market shocks, whether the wholesale price is increasing or decreasing. The response is the same on average. That is, our model also found no asymmetry in the magnitude of retail prices' adjustment to changes in wholesale prices.

[11]Not all inventory is available to be drawn down during shocks. Market shocks can be exacerbated by low levels of available inventory—that is, the level of inventory above the minimum operating inventory. This minimum is the level of inventory below which problems begin to occur at refineries. According to the National Petroleum Council, the minimum operating inventory for gasoline, for example, is about 205 mmb.

Other Studies Found Asymmetry to Occur Mostly Between Wholesale and Retail Gasoline Prices

Other studies based on econometric models of gasoline price adjustment found mixed evidence of asymmetry. Three of the four studies we reviewed that examined gasoline prices in the United States found evidence of asymmetry.[12] However, these three studies found that the asymmetric response primarily occurred between wholesale and retail prices in the U.S. gasoline market. But one of these studies (Borenstein et. al) also found asymmetry between crude oil and wholesale gasoline prices in some tests, while another study (Karrenbrock) also found symmetry between wholesale and retail gasoline prices in some tests. Only one of the four studies (Norman and Shin) found no asymmetric response in retail gasoline prices to changes in either crude oil or wholesale prices.[13]

These studies differ from ours in some respects. The differences among the studies may account for the different conclusions about the presence and location of asymmetry in the supply chain. First, the three studies that found evidence of asymmetry at the wholesale to retail levels used different price data from ours. Two of the three studies (French and Karrenbrock) used monthly average price data, while the other study (Borenstein et. al) used daily futures prices, daily spot prices, and weekly wholesale (rack) prices. The fourth study (Norman and Shin), which did not find evidence of asymmetry, used the same data—weekly spot prices—as GAO's model, but differed in other ways from our model. Second, the four studies did not include the factors that we included in our model: crude oil and wholesale gasoline inventory levels and refineries' utilization rates. Third, these studies did not differentiate market shocks from the average and therefore could not determine whether prices behave differently during market shocks. Fourth, two of the four studies (Karrenbrock and Norman and Shin) did not test for asymmetry between crude oil and wholesale gasoline prices.

The first study (Karrenbrock) found that, on average, it takes 2 months for retail prices of gasoline to thoroughly adjust to changes in wholesale prices in either direction. However, the study found that most—65 to

[12]The three studies that found evidence of asymmetry in the U.S. gasoline market are Severin Borenstein, A. Colin Cameron, and Richard Gilbert, "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" National Bureau of Economic Research, Working Paper No. 4138 (Aug. 1992); Mark W. French, "Asymmetry in Gasoline Price Changes" (Unpublished article, Aug. 1991); and Jeffrey D. Karrenbrock, "The Behavior of Retail Gasoline Prices: Symmetric or Not?" Federal Reserve Bank of St. Louis Review, Vol. 73 (July/Aug. 1991), pp. 19-29. A fifth model that we reviewed—Robert W. Bacon, "Rockets and Feathers: The Asymmetric Speed of Adjustment of U.K. Retail Gasoline Prices to Cost Changes," Energy Economics, Vol. 13 (July 1991) pp. 211-18—found evidence of asymmetry in the gasoline market in the United Kingdom.

[13]Donald A. Norman and David Shin, "Price Adjustment in Gasoline and Heating Oil Markets," API, Research Study #060, (Aug. 1991).

69 percent—of an increase in wholesale prices is passed on to consumers during the first month, while only a small portion—22 to 32 percent—of a decrease in wholesale prices is passed on during the first month. The second study (French) found that while, on average, wholesale prices respond symmetrically to changes in crude oil prices, retail prices adjust faster to increases in wholesale prices than to decreases. This study found that, on average, increases in wholesale prices are 2 times as large as price decreases. The third study (Borenstein et. al) found that retail prices also respond more quickly to increases in the price of crude oil and wholesale gasoline than to decreases. Finally, the fourth study (Norman and Shin), conducted for API, found that retail prices decline at the same rate as they increase in response to changes in crude oil or wholesale prices.

Several Factors May Cause the Asymmetry at the Retail Level

Discussions with industry officials and oil market experts, as well as the results of the models we reviewed, identify various factors that are important determinants of gasoline pricing and may help to explain why retail prices may adjust asymmetrically to changes in the prices of crude oil and/or wholesale gasoline. These factors include uncertainty about decreases in crude oil and wholesale gasoline prices during shocks, retailers' knowledge of consumers' psychology, retailers' knowledge of consumers' buying patterns, and the short-term inelasticity of the demand for gasoline.[14]

Uncertainty About Crude Oil and Wholesale Prices

Uncertainty about how long a change in crude oil and wholesale gasoline prices will last influences if and when sellers change their retail prices. For example, if a positive shock and, therefore, price decreases in crude oil and wholesale gasoline are perceived to be temporary, there is likely to be little or no decrease in retail prices. Indeed, if the price decreases are seen as temporary, sales of crude oil, which can be held in inventory at a low cost, will be curtailed in anticipation of higher prices. On the other hand, if the positive shock and the subsequent decreases in crude oil and wholesale prices are viewed as "permanent" or more long-term, retail prices will eventually be lowered.

According to one industry expert, retailers usually adopt a "wait and see" attitude when crude oil and wholesale prices are falling. Thus, although their wholesale costs may be declining, since they are not certain how soon prices may be going back up, most retailers within a given market

[14]Our model did not include the first three listed factors as variables because they cannot be easily quantified.

wait for one among them to reduce prices. Once one retailer has reduced prices, others may follow.

Retailers' Knowledge of Consumers' Psychology

Market psychology influences retailers' perception of consumers' reaction to retail gasoline prices, especially when decreases in crude oil and wholesale prices are preceded by shock-induced increases. Retail prices rise quickly following sharp increases in the prices of crude oil and wholesale gasoline. Over time, consumers may become accustomed to the high retail prices. According to an industry expert, when high retail prices carry over from periods during which the prices of crude oil and wholesale gasoline are rising to periods during which these prices are falling, consumers psychologically accept the high retail prices as normal. To the extent that this is true, retailers may be able to delay reducing their prices when crude oil and wholesale prices fall, without losing sales.

Retailers' Knowledge of Consumers' Buying Patterns

According to a major oil company, gasoline consumers tend to buy from the stations that are convenient to them. These include stations located close to consumers' places of residence, on the way to and from work, and on frequently traveled routes and stations whose company credit cards they are carrying. Thus, at many stations, the demand is relatively stable. When the competition for a station, perhaps in a rural area, is not strong, the demand is particularly stable, as consumers have few opportunities to shop for the lowest prices. Retailers recognize these buying patterns and price their gasoline in ways that reflect them. In general, when consumers do not rigorously shop for the lowest price, they do not exert the pressure necessary—by reducing their purchases—to force retailers to lower prices in the short run when crude oil and wholesale prices are declining.

Inelasticity of the Demand for Gasoline

The inelasticity of the demand for gasoline may help to sustain high retail prices when crude oil and wholesale prices are declining. Over a short period, consumers generally do not increase their consumption of gasoline in reaction to a decrease in prices. Thus, retailers may have little incentive to lower their prices immediately when crude oil and wholesale prices decline if they expect other retailers to match their price reductions.

Retail Home Heating Oil Prices Also May Not Fall as Quickly and to the Same Extent as They Rise

Home heating oil prices may also not respond with the same speed and magnitude during positive shocks as they do during negative shocks. Depending on the period of the shock, the prices of heating oil at the retail level may react differently because of seasonal consumption patterns. A negative shock during a cold winter may exacerbate the increases in the retail price of heating oil. A positive shock during a cold winter season may not necessarily induce a decline in retail prices for heating oil, even though crude oil and possibly wholesale prices may be falling.

API's model, cited earlier, found that retail prices for heating oil respond symmetrically to changes in crude oil prices and that retail prices appear to respond asymmetrically to changes in wholesale prices. API's study stated that further analysis of the heating oil market, of the roles played by seasonal demand and unusual weather, for instance, is necessary before any strong conclusions about adjustments by heating oil prices can be made.

Market Shocks Produce Different Costs and Benefits for Market Participants

The pricing during both negative and positive oil market shocks confers different costs and benefits on market participants and the U.S. economy. Large increases in oil prices generally benefit the major oil-exporting countries and oil-producing companies but have a negative effect on consumers and the domestic economy. However, higher oil prices may reduce demand and encourage conservation and the use of alternative fuels, over the long term. On the other hand, price decreases benefit the marketing and retailing of petroleum products as consumers buy more and may lead to economic growth.

Benefits and Losses Accrue to Oil Market Participants During Shocks

Various sectors of the oil market fare differently depending on the nature of the oil market shock. Perhaps the largest beneficiaries of increases in oil prices are the major oil-exporting countries. For example, at the onset of the Persian Gulf Crisis, net imports of crude oil and petroleum products to the United States averaged nearly half of the total consumption. Thus, about half of the United State's total expenditures on oil during this time went to the country's oil trading partners. According to EIA, the largest beneficiaries of the increases in the price of crude oil during the Persian Gulf Crisis were foreign governments owning the oil that was produced or in inventory.[15] The exploration, development, and production arms of integrated oil companies and independent crude oil producers also benefit from price increases because the value of their crude oil goes up. However, according to EIA, the independent oil producers reaped the highest profits during the Gulf Crisis, not the major integrated oil companies.

[15]Petroleum Prices and Profits in the 90 Days Following the Invasion of Kuwait, EIA (SR/OA/90-01, Nov. 1990). Moreover, it is estimated in the 1991-92 National Energy Strategy that between August 1 and December 1, 1990, U.S. consumers spent $21 billion more for crude oil and petroleum products than would have been spent absent the crisis. Of that amount, $8 billion was paid to foreign producers.

Independent refiners who sell mostly at the wholesale level are generally able to reap profits when crude oil prices are rising. However, independent refiners that also own their own retail gasoline outlets, as well as the retail gasoline operations of integrated oil companies, usually have decreased margins—that is, the difference between wholesale and retail prices. EIA also reported that income to independent, or "nonintegrated," refiners rose during the Gulf Crisis, while the refining and marketing operations of 11 major integrated oil companies declined. EIA stated that those companies with a significant portion of their enterprise devoted to retail sales were hurt by the restraint in raising retail gasoline prices during the Gulf Crisis, but that companies moving little of their gasoline through their own retail outlets did not see lower profits.

A positive shock will tend to reduce revenues for the oil-exporting countries. Lower crude oil prices also generally increase profits for the marketing and retail sectors of the oil industry, including the refining, marketing, and retail divisions of integrated oil companies and independent refiners. On the other hand, the value of crude oil owned by the exploration, development, and production arms of integrated oil companies and independent producers declines. Independent distributors who operate retail gasoline stations also enjoy higher profits because their retail prices tend to fall less rapidly than their wholesale costs.

Effects of Market Shocks on U.S. Economy Vary

Under a negative oil market shock, the accompanying price increases may seriously damage the U.S. economy in several ways.[16] First, they may contribute to an increase in the United States' trade deficit through an increased expenditure for oil imports. We calculated, using the 1990 rate of net imports of 7.1 mmbd, that a negative shock increasing the price of oil by $5 per barrel would add about $13 billion annually to the United States' expenditure for imported oil. Furthermore, increases in oil prices may reduce spending by businesses and consumers on other goods and services. To the extent that the increased cost of petroleum products reduces spending on other goods and services, this may lead to higher unemployment and a loss in economic output. For example, several studies have estimated that the loss in economic output from a $5 increase in the price of a barrel of oil could, in the year following, range from 0.1 percent to 0.5 percent of the United States' annual GNP, while another study found that the cumulative loss in the GNP from such a market shock could be as high as 2 percent.

[16]The response of the monetary authorities to a market shock can influence the performance of the economy. In this section, we assume no change in monetary policy following a market shock.

On the other hand, a negative oil market shock creates a strong incentive for conservation, thus promoting an energy-efficient economy. Also, to the extent that high prices encourage a reduction in demand, pollution resulting from oil will be reduced. Moreover, high oil prices make alternative fuels, such as ethanol, more desirable by drawing attention to the long-term benefits of alternative fuels.

The benefits and costs of a positive shock are, more or less, the opposite of those of a negative shock. Lower oil prices will help to reduce the United States' expenditure on oil imports and contribute to an improved trade balance and an increase in spending on other goods and services. However, a positive shock is not in itself necessarily sufficient to prevent or lessen unemployment. Sustained lower oil prices may reduce the incentive for energy conservation and encourage inefficient consumption of petroleum products. Finally, a sudden collapse in oil prices may not necessarily stimulate the economy, especially once the economy approaches full employment.[17]

[17]In "The Economic Cost of Oil Shocks" (Unpublished article, Aug. 21, 1990), William W. Hogan points out that the collapse of oil prices in 1986 yielded only a modest economic dividend.

Federal Authorities to Respond to Oil Supply Disruptions

The 1975 Energy Policy and Conservation Act (EPCA), as amended—enacted in the wake of the 1973-74 Arab oil embargo—provides the federal government with a key authority for addressing oil supply disruptions. EPCA authorized the creation of the Strategic Petroleum Reserve (SPR) to reduce the impact of severe interruptions of petroleum supplies and to help fulfill the country's obligations in international energy emergencies. The United States also coordinates its responses during oil market shocks with the other 22 nations belonging to the International Energy Agency (IEA), established under the 1974 Agreement on an International Energy Program (IEP).[1]

Despite the availability of the SPR, current U.S. policy emphasizes initially relying on free market forces in an oil supply disruption. This approach could be followed, if necessary, by an early and large release of oil from the SPR to limit the adverse economic effects of the disruption. This policy, however, provides little specific guidance on how long market forces should be allowed to operate before the SPR is used or what conditions should dictate the use of the reserve. During the Persian Gulf Crisis, the first major release of oil from the SPR was authorized on January 16, 1991—in conjunction with the start of the allied air war and over 5 months after Iraq invaded Kuwait.

The use of the SPR during the Persian Gulf Crisis revived the long-standing debate over the appropriate conditions for the reserve's release. This debate continues because the SPR, along with policies governing its use, was developed in a different context—before the domestic oil market was deregulated and before spot and futures markets began to play an important role in influencing oil prices. Given these changes, some oil market experts question whether the SPR was used appropriately during the Persian Gulf Crisis.

[1]The 21 original member countries of the IEA are Australia, Austria, Belgium, Canada, Denmark, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Both Finland and France joined the IEA in 1992.

Energy Policy and Conservation Act Provides a Key Federal Authority for Responding to Oil Supply Disruptions

EPCA provides a key authority for the federal government to address oil supply disruptions. In addition to EPCA, eight other federal laws, identified by DOE, establish the principal federal authorities for responding to various energy emergencies.[2]

EPCA and Other Laws Granting Authority for Handling Energy Emergencies

EPCA authorized the creation and use of the SPR to reduce the impact of severe interruptions of petroleum supplies and to fulfill the country's obligations under the IEP. Under EPCA, the President can order releases from the SPR upon determining that there is an actual or imminent "severe energy supply interruption." EPCA defines a "severe energy supply interruption" as a national energy supply shortage that the President determines "(1) is, or is likely to be, of significant scope and duration, and of an emergency nature; (2) may cause major adverse impact on national safety or the national economy; and (3) results, or is likely to result, from an interruption in the supply of imported petroleum products, or from sabotage or an act of God." As enacted in October 1992, the Energy Policy Act of 1992 (P.L. 102-486) amended EPCA to increase the President's power to use the SPR in an emergency. The 1992 act gave the President the authority to release oil from the SPR if a severe increase in the price of petroleum products has resulted from such an emergency and the price increases are likely to cause a major adverse impact on the national economy.

The SPR program, which has already been extended several times, will be up for reauthorization in 1994. Other provisions in EPCA authorize the President to control federal energy production and grant broad authority to limit the export of energy supplies during an emergency.

Another federal law, the Naval Petroleum Reserves Production Act of 1976, allows for production from the Naval Petroleum Reserves (NPR), oil fields representing a potential source of additional oil in an energy emergency. However, since production from the NPR is small compared to the amount of oil that is readily available from the SPR, the federal government has relied on the NPR primarily as a revenue-generating mechanism, rather than as a source of an emergency supply of oil.

[2]Several federal agencies other than DOE are responsible for overseeing the domestic oil market. These agencies' use data from DOE's EIA for monitoring the oil market and enforcing antitrust laws. These agencies and their activities will be discussed in app. IV.

Production from the NPR was not expanded during the Persian Gulf Crisis. In fiscal year 1991, the three NPR sites produced an average of 80,368 barrels of oil a day and net revenues of $454 million.

Table 5.1 summarizes EPCA and other major statutes providing authority during energy emergencies, as identified by DOE.

Table 5.1: Principal Statutes Providing Authority for the Federal Government to Respond to Energy Emergencies

Statute	Relevant energy sector	Summary of emergency authority
EPCA, as amended (42 U.S.C. section 6201 et seq.)	Oil and petroleum products	Established the SPR and sets conditions for its use in international and domestic supply interruptions Amended to authorize an increase in SPR's storage capacity to 1 billion barrels Authorizes U.S. participation in the IEP Provides broad authority to exercise control over energy exports
Defense Production Act of 1950, as amended (50 U.S.C. app. 2061 et seq.)	All sectors	Authorizes the President to, among other things, require the allocation of materials and facilities in the civilian market. The Congress has declared energy to be a strategic and critical material.
Naval Petroleum Reserves Production Act of 1976, as amended (10 U.S.C. section 7420 et seq.)	Oil and petroleum products	Authorizes the Secretary of Energy to require petroleum production for defense purposes from the NPR. This production must also be approved by the President and authorized by a joint resolution of the Congress.
Natural Gas Act, as amended (15 U.S.C. section 717 et seq.)	Natural gas	Permits DOE, upon application, to authorize imports and exports of natural gas Authorizes the Federal Energy Regulatory Commission (FERC) to take additional regulatory actions to ensure interstate natural gas service
Natural Gas Policy Act of 1978, as amended (15 U.S.C. section 3301 et seq.)	Natural gas	Allows the President to authorize purchases of and to allocate supplies of natural gas in interstate commerce
Federal Power Act, as amended (16 U.S.C. section 791a et seq.)	Electric power	Permits DOE to order temporary connections of facilities and the generation, delivery, interchange, transmission, or power wheeling of electric energy during an emergency Authorizes FERC to order interconnections and power wheeling to promote energy efficiency and the system's reliability

(continued)

Statute	Relevant energy sector	Summary of emergency authority
Public Utilities Regulatory Policies Act of 1978, as amended (16 U.S.C. section 2601 et seq. and 15 U.S.C. section 717z)	Electric power, natural gas	Allows the President to prohibit the burning of natural gas by any electric power plant or major fuel-burning installation
Powerplant and Industrial Fuel Use Act, as amended (42 U.S.C. section 8301 et seq.)	Coal, electric power, natural gas, petroleum	Grants the President authority to allocate coal for use by any power plant or major fuel-burning installation Permits the President to prohibit any power plant or major fuel-burning installation from using natural gas or petroleum
Atomic Energy Act of 1954, as amended (42 U.S.C. section 2011 et seq.)	Atomic energy	Authorizes the Secretary of Energy to suspend any licenses granted under the act if necessary for the common defense and security of the United States

Source: DOE's Office of General Counsel.

Size and Cost of the SPR

At the onset of the Persian Gulf Crisis, the SPR contained nearly 590 mmb of crude oil. By the end of 1991, after a test sale and drawdown were conducted during the Persian Gulf Crisis, the SPR contained 568.5 mmb. As of August 1992, the inventory level of the SPR had increased to 569.5 mmb. As of February 1992, DOE stated that the SPR could be drawn down and the oil distributed at a maximum rate of 3.9 mmbd for 60 days.[3] After that, the maximum daily rate could then be reduced systematically over a period of 185 additional days, with a final rate of 300,000 barrels a day (bd). The SPR sites have a combined drawdown capability of 4.5 mmbd. The off-site commercial distribution capability, however, is currently limited to 4.0 mmbd. DOE is seeking to enhance its off-site commercial distribution capability so that the SPR can be drawn down at 4.5 mmbd.[4]

According to DOE, a total of about $20.7 billion has been appropriated for the SPR through fiscal year 1992. But we calculate that the total appropriations for the SPR through fiscal year 1992 are about $58.3 billion, in 1992 dollars. The facilities to store 750 mmb of oil in the SPR were completed in 1991. In February 1992, DOE estimated that the cost of filling

[3]With government stocks of crude oil, the United States meets its obligation under the agreement establishing the IEP to hold emergency stocks equal to 90 days' worth of previous year's net imports.

[4]The 1982 SPR Drawdown Plan is the implementing document created to guide the drawing down, sale, and distribution of oil from the SPR.

the SPR from its level then of 568.5 mmb to 750 mmb could be about $3.6 billion. This estimate is based on the assumption that the oil would cost $20 per barrel.[5] DOE cannot estimate with certainty when the SPR will contain 750 mmb of inventory.

The 1990 amendments to EPCA (P.L. 101-383) further expanded the target size of the SPR to 1 billion barrels, as indicated in table 5.1.[6] This new target capacity represents the maximum possible level permitted under the 1975 act. DOE estimates that expanding the storage facilities of the SPR from a capacity of 750 mmb to a capacity of 1 billion barrels will require 7 to 8 years and $1.5 billion to $1.9 billion in additional funds, in 1991 dollars. Ultimately, the total cost of filling the SPR to 1 billion barrels and the length of time needed to do so will depend on future decisions about the rate at which the reserve is filled, financing alternatives, and oil prices in the future.

U.S. Participation in the IEA

EPCA also provides for U.S. participation in the IEA, an organization of 23 oil-consuming industrialized nations. Established by the IEP agreement of 1974, the IEA is designed to coordinate the actions of its member countries during energy emergencies.

In general, the United States and other IEA members agree to (1) maintain oil stockpiles equivalent to 90 days' net imports and (2) develop contingency plans to restrain the demand for oil in an energy emergency. To date, IEA members have adopted a variety of approaches to meet these commitments. In an energy emergency, the IEA may call upon member nations to (1) draw down their oil stockpiles and/or implement measures to restrain demand or (2) participate in an oil-sharing plan, depending on the severity of the emergency at hand. Under the IEP agreement, an energy emergency is defined as a situation in which an individual country or group of countries experiences a disruption of its oil supplies or a shortfall of at least 7 percent in the daily rate at which its oil is supplied. The IEA can, however, ask for emergency responses to be implemented in lesser instances.[7]

[5]Assuming a price for crude oil of $20 a barrel, we calculate that the market value of the oil contained in the SPR, as of August 1992, was about $11.4 billion.

[6]DOE expects to provide, in September 1993, detailed plans to the Congress for expanding the SPR to 1 billion barrels.

[7]See International Energy Agency: Response to the Oil Supply Disruption Caused by the Persian Gulf Crisis (GAO/NSIAD 92-93, Jan. 21, 1992) for further discussion of IEA's emergency oil-sharing program and the system of coordinated emergency responses. See also the list of related GAO products at the end of this report.

SPR's Use During the Persian Gulf Crisis Demonstrated Policy Uncertainties

U.S. actions during the Persian Gulf Crisis illustrated certain difficulties in implementing the country's policy for dealing with energy emergencies. Essentially, U.S. policy emphasizes relying on free market forces. In addition, since 1984, the federal government has considered the "early use" of the SPR as its best means to offset the negative economic effects of an oil market shock. "Early use," however, is not clearly defined. During the Persian Gulf Crisis, the first major drawdown of the SPR was authorized in January 1991—over 5 months after Iraq invaded Kuwait and 3 months after oil prices peaked in October 1990. The effectiveness of this drawdown and other emergency actions taken by DOE is unclear.

Coordination with the IEA is part of the U.S. strategy for coping with oil supply disruptions. The United States believes international cooperation is essential because the world oil market is highly integrated. Accordingly, although the SPR may be used unilaterally, the U.S. government is committed to using it only in cooperation with IEA partners. The decision to use the SPR during the Persian Gulf Crisis, as well as the timing of the drawdown itself, was made cooperatively with other IEA members.

U.S. Policy and Actions During the Gulf Crisis

During the first months of the crisis, the federal government relied on the market forces of supply and demand to allocate oil. DOE maintains that rapidly rising oil prices during a disruption will lead to significant and beneficial reductions in oil consumption. According to DOE, this approach fulfills the requirement the United States has as a member of the IEA to restrain demand.[8] The federal government regarded this approach as an effective initial response to the loss of 4.3 mmbd from Iraq and Kuwait. The United States also appealed to industry and the general public to reduce oil consumption during the crisis.

Shortly after the invasion, DOE testified before the Congress that it intended to use the SPR to redress any supply shortages in the United States. DOE stressed, however, that there was no significant shortfall of oil in the U.S. market at the time because of offsetting factors such as high levels in world inventories and excess production capacity. These factors, along with fears of losing Saudi Arabian oil in the future prevented the immediate use of the SPR, according to DOE. DOE's position concurred with the IEA's assessment of the crisis at the time, which concluded that direct intervention in the form of a strategic stock drawdown was not yet needed.

[8] At the beginning of the Gulf Crisis, the President appealed to oil companies to restrain increases in retail prices. Therefore, to the extent that this appeal was successful, it may have had the effect of reducing the beneficial reductions in consumption that higher prices bring.

In addition to allowing free market forces to determine the prices of crude oil and petroleum products, an approach that balanced supply and demand early in the crisis, DOE (1) announced, among other things, short- and medium-term measures to encourage increased domestic energy production, fuel switching, and voluntary energy conservation and (2) intensified its collection and analysis of relevant data to meet the need for up-to-date information on oil markets.

Between August 1990 and January 1991, DOE's use of the SPR was limited to an offering of 5 mmb in a test sale, an action that was authorized under the 1990 amendments to EPCA. According to DOE, this test sale, ordered by the President on September 26, 1990, was intended to demonstrate the adequacy of the SPR system should the administration be forced to use the reserve during the Gulf Crisis. In the test sale, 3.9 mmb of oil were delivered to 11 oil companies. Spot prices for WTI crude oil during this period peaked at over $40 a barrel in mid-October 1990, fell to below $25 a barrel by early January 1991, and rose again to $32 a barrel by mid-January.

The United States worked closely with other IEA members during the Gulf Crisis. On January 11, 1991, anticipating additional shortfalls resulting from the outbreak of war in the Persian Gulf, the IEA Governing Board approved a contingency plan to increase the supply of oil on the world market by 2.5 mmbd. During a January 28 meeting, the IEA Governing Board agreed that the contingency plan was to remain in effect and was to be implemented flexibly throughout the crisis. Table 5.2 summarizes the commitments of participating countries under the IEA's contingency plan to increase the supply of oil on the world market. This goal was to be reached by having participating countries supply oil from governmental and commercial inventories, adopt measures to restrain demand, and encourage utilities and businesses to switch to fuel besides oil. On January 16, 1991, in conjunction with the beginning of allied military actions in the Persian Gulf, the President ordered the first sustained drawdown of the SPR to fulfill the United States' commitment under the IEA's plan. A total of 33.75 mmb, equivalent to 1.125 mmbd for 30 days, was offered for sale. Of this amount, 17.2 mmb was ultimately purchased by 13 U.S. companies.

DOE officials we interviewed acknowledged that the demand for the "sour" portions of the SPR's oil offered in the January drawdown was weak.[9]

[9]"Sour" crude oil has a higher sulphur content than "sweet" crude oil. Refining sour crude oil requires the capability to remove the sulphur, and not all refineries have this capability.

However, DOE maintained that the overall response to the sales was favorable and demonstrated relative stability in the market at the time. Some oil company officials told us that they simply did not need the "sour" crude oil offered for sale from the SPR.

Table 5.2: Commitments of Participating Countries Under the IEA's Contingency Plan

Country	Volume (bd)	Method of Implementation
United States	1,125,000	Sale of crude oil from the SPR
Japan	350,000	Reduction of companies' obligations to hold stocks from 82 days to 78 days
Germany	187,000	Release of stockholding entity's stocks of gasoline, middle distillates, heavy fuel oil (170,000 bd); balance to be achieved by demand restraint
Italy	130,000	Reduction of 1.2 percent in companies' stocks (75,000 bd); demand restraint (24,000 bd); fuel switching (31,000 bd)
France[a]	126,000	Companies' drawdown of heating oil (45 percent of total volume); balance to be achieved by demand restraint by enforcing speed and temperature restrictions
United Kingdom	120,000	Stock drawdown apportioned among companies; government to monitor industry's compliance
Canada	115,000	Not specified
Spain	62,000	Primarily demand restraint measures because of low stock levels
The Netherlands	32,000	Release of stockholding entity's stocks of crude oil (25,000 bd); method for balance not specified
Others[b]	253,000	Various methods
Total	**2,500,000**	**2,000,000 bd in stocks; 400,000 bd through demand restraint; 100,000 bd through fuel switching**

[a]At the time of the Persian Gulf Crisis, France was not a member of the IEA but participated in the contingency plan.

[b]"Others" include the IEA members Australia, Austria, Belgium, Denmark, Greece, Ireland, Luxembourg, New Zealand, Norway, Portugal, Sweden, Switzerland, and Turkey. Finland participated in the IEA's contingency plan, but was not a member at the time of the crisis, joining in 1992. Finally, Iceland, though not a member, also participated.

Source: Energy Situation Analysis Report, EIA (Jan. 30, 1991).

According to DOE officials, the January 1991 decision to draw down the SPR was made to allay anxieties about the continuing crisis and to fulfill the United States' commitment to the IEA. In DOE's view, an actual supply shortage did not exist at the beginning of January because excess production capacity was adequate to offset the initial loss of supply. DOE recognized, however, that because of the loss of a supply "cushion" and the advent of open hostilities in the Persian Gulf, expectations about the future supply of oil could push prices as high as $90 per barrel. The decision to draw down the SPR was based on a presidential finding of "the existence of a potential national energy supply shortage constituting a severe energy supply interruption." The Secretary of Energy, in announcing this decision, explained, "Our purpose [in drawing down the SPR] is to take precautionary action early and in doing so, counter any possible disruption of supplies from the Persian Gulf." The Secretary further stated that the drawdown would send a clear signal to oil markets that supplies would be adequate and that this would minimize price increases and buildups of inventories.

Effectiveness of DOE's Actions

Between January 16 and 17, 1991, the spot price of crude oil dropped from $32 to $21.45 a barrel, the largest 1-day decline since the beginning of the crisis.[10] DOE has acknowledged that the true effect of the drawdown cannot be separated out from other contributing factors, including, most significantly, the early success of the allied air force against Iraq. DOE officials credited the agency's emergency actions with temporarily increasing oil production but could not quantify the extent of the increase. DOE also was unable to provide specific information concerning the results of its efforts to encourage fuel switching and conservation.

Debate Continues Over Criteria for Drawing Down the SPR

The experience of the Persian Gulf Crisis has renewed a long-standing debate over the best strategy for dealing with international disruptions of oil supplies. Specifically, the implementation of the United States' oil emergency policy during the crisis has raised questions, yet to be resolved, about when to draw oil from the SPR.

Several oil company officials and oil market experts whom we interviewed criticized the administration's use of the SPR during the Persian Gulf Crisis. Citing the effect of expectations on petroleum prices in a crisis, some oil market experts argued that an earlier drawdown, or even the mere announcement of one, would have calmed anxieties and lessened the price increase that occurred in the early months of the Gulf Crisis. These experts believed, contrary to the administration's view at the time, that the price increases experienced in the early months of the crisis were large enough to justify using the SPR.

[10]Crude oil futures prices on NYMEX also fell by $10.60 a barrel. This was the biggest 1-day drop on record at the exchange.

In September 1990, we testified before the House Committee on Government Operations on the need to reevaluate the policy on drawing down the SPR to ensure that it is being used effectively to offset the severe economic impacts of oil price increases.[11] We recognized, however, the complexity of the factors involved in the President's decision not to release oil from the SPR at the time.

Several oil market experts have explained that the criteria for drawing down the SPR are based on the occurrence of an actual shortage, a situation that is unlikely in today's deregulated oil market. According to this view, oil supply disruptions will be felt largely as price increases rather than as shortages, and the policy governing the SPR's use need to be revised to better correspond to this reality.

Proposals for reforming this policy suggest tying a release to a chosen economic signal, or "trigger," such as a change in market prices for petroleum products. Some economists have advocated selling options to make oil from the SPR available for purchase on a continuous or regular basis, a process that would involve a set trigger price.[12] Some of the oil market experts we interviewed continue to support this idea. The primary benefit of such an approach, they explain, is that any political bias towards delaying the use of the SPR would be eliminated from the decision-making and initiating a drawdown would become an economic decision. In a 1985 review of alternative methods for selling oil from the SPR, we discussed potential advantages and disadvantages of using options and noted that some presidential control over the SPR may still be needed to deal with unforeseen circumstances in an emergency.[13] There has been little consensus on exactly what kind or what level of trigger is best. One possible approach that would reconcile different viewpoints would be to use a trigger as the basis for releasing a portion of the oil in the SPR while maintaining presidential control over the remainder.

The 1982 SPR Drawdown Plan, which is still in force, outlines the federal government's supply-oriented approach for deciding when and to what extent the SPR should be drawn down. DOE has traditionally maintained that oil from the SPR should only be released during an actual or imminent

[11] Long-term Policies Needed to Address Energy Use and Price Volatility (GAO/T-RCED-90-105, Sept. 5, 1990).

[12] An option gives the buyer the right to buy or sell a specific quantity of a commodity at a specific price within a specific period of time, regardless of the market price of that commodity.

[13] Evaluation of the Department of Energy's Plan to Sell Oil From the Strategic Petroleum Reserve (GAO/RCED-85-80, June 5, 1985).

shortage. The plan requires that decisions about releases be left to the President's discretion and not be automatically triggered by a predetermined formula. Specifically, the plan states

> The President will decide . . . when to use the SPR and at what rate. It does not seem feasible or appropriate at this time to establish a specific "trigger" or formula which will automatically determine if the SPR is to be used and at what interval and rate because of the wide range of unpredictable conditions which might characterize an energy supply disruption.
>
> The primary purpose of the SPR sales and distribution process will be to provide additional supplies of petroleum to domestic energy markets on a timely basis, to substitute for supplies interdicted due to a major fuel supply disruption.

DOE remains opposed to establishing a trigger for using the SPR. It believes that the President should continue to have broad discretion because decision-making in an energy emergency, DOE officials explain, is very scenario-specific and involves numerous judgment calls. DOE officials told us that making releases contingent upon a specific economic trigger, regardless of other strategic considerations, would overly constrain the federal government's ability to respond in an emergency.

Our review of the relevant literature and discussions with industry experts suggest that the feasibility of a trigger for using the SPR needs to be considered within the broader international context of oil supply disruptions. Because the importance of international coordination during oil supply disruptions remains paramount, any trigger must be compatible with the policies of other members of the IEA.

Since the Persian Gulf Crisis, DOE's policy statements concerning the SPR suggest a broadening view of the conditions under which oil may be released from the reserve. DOE officials told us in November 1991 that the policy was flexible enough to allow the SPR to be drawn down in response to a presidential finding of not only an actual or imminent shortage, but also a significant increase in oil prices. In DOE's view, the President is free to interpret price increases as an indication of an imminent shortage in making his determination. As previously discussed in the chapter, the Energy Policy Act of 1992 has now made this authority explicit.

Companies, Agencies, and Organizations Contacted by GAO

Integrated Oil Companies and Independent Refiners

Amerada Hess Corporation
Amoco Oil Company
Ashland Oil, Inc.
ARCO Products Company, Division of Atlantic Richfield Company
BHP Petroleum (Americas) Inc.
Chevron U.S.A./Chevron Corporation
Conoco Inc.
Crown Central Petroleum Corporation
Exxon Company, U.S.A.
Marathon Oil Company
Mobil Oil Corporation
Shell Oil Company
Sun Refining and Marketing Company
Texaco Inc.
The Coastal Corporation
Unocal Corporation

Independent Heating Oil and Gasoline Distributors and Terminal Operator

Buckley & Scott
F.C. Haab Co., Inc.
Hughes Oil Company
MacValley Oil Company
Meenan
Mid-States Petroleum, Inc.
Northeast Petroleum
Robinson Oil Company, Inc.
Sprague Energy Company

Jet Fuel Distributor

Atlantic Aviation Service, Inc.

Airlines

USAir
United Airlines

Federal Agencies

Commodity Futures Trading Commission (CFTC)
Department of Energy (DOE)
Department of Justice
Department of Transportation
Department of Treasury, Internal Revenue Service
Federal Trade Commission (FTC)

State Agencies

California Energy Commission
Massachusetts State Energy Office

Organization

New York Mercantile Exchange (NYMEX)

Oil Traders and Crude Oil Gatherer

J. Aron & Company
Phibro Energy
The Permian Corporation

Trade Publications

Petroleum Argus
Petroleum Intelligence Weekly

Universities (Current or Former Faculty Members)

Harvard University, John F. Kennedy School of Government
Harvard University, Graduate School of Business
Massachusetts Institute of Technology

Consultants

Charles River Associates Incorporated
Delta International
Gulf Consulting Services

Associations

Air Transport Association of America
American Petroleum Institute (API)
Institute for International Economics
Michigan Petroleum Association/Michigan Association of Convenience Stores
Michigan Petroleum Council
National Association of Attorneys General
National Association of Convenience Stores
Petroleum Marketers Association of America (PMAA)
Society of Independent Gasoline Marketers of America
Service Station Dealers of America
Service Station Dealers Association of Michigan, Inc.
Virginia Gasoline Marketers and Automotive Repair Association

Consumer Group

Citizen Action

Econometric Model of Price Adjustment in the Gasoline Market

This appendix presents our model of price adjustment in the gasoline market. We developed the model to analyze the relationship between changes in the price of crude oil and subsequent changes in the wholesale and retail prices of gasoline, on average and during market shocks. In our model, we addressed two fundamental questions about the gasoline market: (1) How quickly and to what extent is a change in the price of crude oil reflected in the wholesale price of gasoline and subsequently in the retail price of gasoline? (2) Do wholesale and retail prices of gasoline change at the same speed and by the same amount when the price of crude oil rises as when it falls? In other words, is price adjustment in the gasoline market symmetric?

This appendix contains six sections; the first three sections describe the existing research, the methodology used to develop our model, and the sources of data, while the last three sections present adaptations of the model that allowed us to provide empirical estimates in answer to the two fundamental questions raised above. More specifically, in the first section we review the results and methodology of existing models of price adjustment. In the second, we describe how we developed our econometric model by drawing on information that we gathered from petroleum industry experts, from existing studies, and from our own analysis. Our model was developed to (1) determine the length of the time lag between price changes in one segment of the oil market and resulting price changes elsewhere in the oil market and (2) test, using three different methods, whether gasoline prices change at the same speed and by the same amount when the price of crude oil rises as when it falls. In the third section, we discuss the sources and limitations of the data that we used and the influence that different choices of data may have had on our results. The fourth section provides estimates of the length of time between changes in the price of crude oil and the wholesale price of gasoline and between changes in the wholesale price of gasoline and the retail price of gasoline. In the fifth section, we adapt the general model, explained in the second section, to study the relationship between the price of crude oil and the wholesale price of gasoline, and we report estimates for three separate tests of the relationship between these prices on average and during market shocks. In the sixth section, we again adapt the general model to study the relationship between the wholesale and retail prices of gasoline, and we again report estimates for three separate tests of the relationship between these prices on average and during market shocks.

Other Studies Found Mixed Evidence of Asymmetry

Three of four studies that we reviewed on the responsiveness of the retail price of gasoline to changes in the price of crude oil or wholesale gasoline provide mixed evidence of asymmetry in the U.S. gasoline market.[1] Also, the amount and source of price adjustment found differ among and within the studies. A fifth study that we reviewed, used British data and found asymmetry in the gasoline market in the United Kingdom. Therefore, while the study is relevant for its methodology, its results are not directly relevant to the U.S. gasoline market.[2] Price adjustments are asymmetric if price changes that are equal in magnitude and speed but opposite in direction cause different adjustments in the speed and magnitude of the resulting price changes. In other words, if in tracking the price of crude oil or wholesale gasoline, the retail price of gasoline rises more quickly or by a larger amount than it falls, the price adjustment is asymmetric.

Because nearly all gasoline in the U.S. is sold through a reseller, each of the four U.S. studies cited above broke the link between crude oil and retail gasoline prices. All four studies examined the latter segment of the supply chain—the relationship between wholesale and retail prices of gasoline—and two of the four studies also examined the first segment—the relationship between the prices of crude oil and wholesale prices of gasoline. Though three of the four studies (Borenstein et al., French, and Karrenbrock) found some evidence of asymmetry in the way that the retail gasoline prices adjust to changes in wholesale gasoline prices or crude oil prices, the results of the three studies were mixed. The remaining study (Norman and Shin) concluded that price changes between crude oil and retail gasoline, and between wholesale and retail gasoline are symmetric.

The three studies that identified asymmetry found that it occurred primarily between wholesale and retail prices rather than between crude oil and wholesale prices. However, one study (Karrenbrock) of the three, reported that by some measures, adjustments by retail prices to wholesale prices were symmetric. Of the two studies that examined the relationship between the price of crude oil and the wholesale price of gasoline, one

[1]Severin Borenstein, A. Colin Cameron, and Richard Gilbert, "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" National Bureau of Economic Research, Working Paper No. 4138 (Aug. 1992); Mark W. French, "Asymmetry in Gasoline Price Changes" (Unpublished article, Aug. 1991); Jeffrey D. Karrenbrock, "The Behavior of Retail Gasoline Prices: Symmetric or Not?" Federal Reserve Bank of St. Louis Review, Vol. 73 (July/Aug. 1991), pp. 19-29; and Donald A. Norman and David Shin, "Price Adjustment in Gasoline and Heating Oil Markets," API, Research Study #060 (Aug. 1991).

[2]Robert W. Bacon, "Rockets and Feathers: The Asymmetric Speed of Adjustment of U.K. Retail Gasoline Prices to Cost Changes," Energy Economics, Vol. 13 (July 1991), pp. 211-18. The methodology used in the API study cited in footnote 1 was adopted from Bacon's study.

study (French) found the price adjustment to be symmetric, while the other (Borenstein et al.) found evidence both of symmetry and asymmetry at this level.

Empirical research on price adjustment asymmetries uses one of two basic methodologies.[3] The majority of the previous research that we identified, including the research in other industries, uses a cost-markup approach in which prices are presumed to follow a constant markup over cost so that as input prices change output prices also change by a constant amount, though the change in output prices may occur after a lag. Separating price increases from price decreases allows researchers to determine if the price adjustments depend upon whether prices are increasing or decreasing. A second approach, used in some research, adopts a stock-adjustment model in which price is treated as a stock. A difference between the actual price and a target price, possibly the long-run equilibrium price, causes a partial adjustment toward the target price during each time period. Including a quadratic term in the examination of the adjustment allows any differences between price increases and decreases to be observed.

The four studies on price adjustment in the U.S. gasoline market, cited previously, differ from ours in several ways. The studies do not report the average length of time for adjustments from one price to the next independently of their tests for asymmetry. They also do not separate market shocks from the average and thus cannot determine whether different adjustments take place during market shocks. By building our own model, starting from the existing research, we were able to directly address these objectives. Additionally, we included in our model relevant economic variables, not included in the other studies, that may help explain the presence of asymmetry. Moreover, since the existing research provides mixed results, we felt that another independent analysis of these issues was warranted.

Our Price Adjustment Model Built on Existing Studies and Market Analysis

In developing our econometric model, we drew on information that we gathered from oil industry experts, from existing studies, and from our own analysis. Our model was developed to (1) determine the length of the time lag between price changes in one segment of the gasoline market and resulting price changes elsewhere in the market, using a cost-markup approach, and (2) test, using three different methods, whether gasoline

[3]Research on price adjustment has also been performed in agriculture and banking. The general methodologies of studies in these areas are similar to those used in petroleum research.

prices change at the same speed and by the same amount when the price of crude oil rises as when it falls on average and during market shocks. Table II.1 provides a summary of the variables that we used.

Table II.1: Definitions of Variables

Variable	Definition	Mean	Standard deviation
P_t	Output price—used only in analytical; formulations; no data used	[a]	[a]
IC_t	Input cost—used only in analytical formulations; no data used	[a]	[a]
FS_t	Fuel stocks—used only in analytical formulations; no data used	[a]	[a]
C_t	Crude oil price, measured in cents per gallon	45.0	11.2
W_t	Wholesale gasoline price, measured in cents per gallon	53.8	12.3
R_t	Retail gasoline price, measured in cents per gallon	71.1	9.72
PR_t	Penetration rate of information technologies, measured as a logistic time trend	0.499	0.312
CU_t	Refinery capacity utilization rate, measured as the percentage of total capacity that is in operation	80.9	2.74
OS_t	Crude oil stocks, measured in thousands of barrels	341,000	14,100
GS_t	Wholesale gasoline stocks, measured in thousands of barrels	248,000	9,280
$D1_t$	Dummy variable taking on a value of 1 for rapidly rising crude prices and 0 otherwise	0.061	0.240
$D2_t$	Dummy variable taking on a value of 1 for rapidly falling crude oil prices and 0 otherwise	0.077	0.267

(continued)

Variable	Definition	Mean	Standard deviation
$D4_t$	Dummy variable taking on a value of 1 for rapidly rising wholesale prices and 0 otherwise	0.066	0.249
$D5_t$	Dummy variable taking on a value of 1 for rapidly falling wholesale prices and 0 otherwise	0.066	0.249

Note: In upcoming equations, a "Δ" before any variable refers to the change, from t-1 to t, in that variable. A "t" is an index of time periods.

[a]Not relevant.

Gasoline Price Changes Depend on Input Costs

Previous research that we reviewed focusing on price changes in the gasoline market typically begins by specifying a relationship in which a product's price is a function of contemporaneous and prior, or lagged, input costs.[4] This distributed lag relationship is characterized generally in equation 1, where P_t measures output price, IC_t measures input cost, S is the number of prior periods during which past input costs affect the current output price, and η_t is an independently and identically distributed (iid) random term:

$$1. \quad P_t = \alpha + \sum_{\tau=0}^{S} \beta_\tau IC_{t-\tau} + \eta_t$$

$$\text{where } 0 \leq s \leq t.$$

Simply put, the current output price is a function of current and past input costs and a random term. A first difference of equation 1 shows that price changes are determined by cost changes:[5]

[4]Strictly, price changes are determined by changes in supply or demand or both, rather than just cost changes. However, under some circumstances, it is an accepted practice to model price changes as depending only on cost changes.

[5]By assumption, the random term in equation 1 is iid. Therefore, we simplified the random term in equation 2, where $\varepsilon_t = \eta_t - \eta_{t-1}$ and Ω represents the covariance matrix. In this case, each element may be nonzero, though each is related to elements on the main diagonal by the serial correlation coefficient. However, this error term is serially correlated by construction. Therefore, equation 2 and any subsequent formulations with the same error structure must be adjusted for a first order autoregressive process (AR(1)) in order to obtain consistent parameter estimates. Nonetheless, if there were perfect serial correlation in the error terms for equation 1, then the first difference procedure would eliminate the serial correlation and the AR(1) correction procedure would be unnecessary.

$$2.\quad \Delta P_t = \sum_{\tau=0}^{S} \beta_\tau \Delta IC_{t-\tau} + \varepsilon_t,$$
$$\text{where } \varepsilon_t \sim (0, \sigma^2_{\eta_t}\Omega).$$

An underlying assumption of this simple model is that market fundamentals, such as structure, remain unchanged during the period of analysis.[6] The coefficients of equation 2 may be estimated to determine the time lag between price changes in crude oil and wholesale markets and the effect of those changes in wholesale and retail markets, respectively.

Test 1: Model Extended to Test for Asymmetric Price Adjustment

To test for asymmetric price adjustment, we modified the distributed lag relationship in equation 2 by separating the independent variable into two components. In equation 3, β_τ measures the typical price change, and β_τ^+ measures the additional price change that occurs when an input price increases:[7]

$$3.\quad \Delta P_t = \sum_{\tau=0}^{S} (\beta_\tau \Delta IC_{t-\tau} + \beta_\tau^+ \Delta IC_{t-\tau}^+) + \varepsilon_t$$

$$\text{where}\quad \Delta IC_t^+ = \begin{cases} \Delta IC_t \text{ if } IC_t > IC_{t-1} \\ 0 \text{ otherwise.} \end{cases}$$

Asymmetry may be observed in several forms. A price adjustment would be asymmetric if the total price change depended upon whether price increased or decreased. Asymmetry would also occur if, for example, a price increase was transmitted to the next level more quickly than a price decrease. Thus, symmetry implies that the β_τ^+ coefficients are individually statistically equal to 0 and jointly statistically equal to 0 for any group of coefficients. If these coefficients are not individually and jointly statistically equal to 0, then there would be evidence of asymmetry.

[6]If the unspecified market characteristics are invariant over time, they are treated as fixed effects in equation 2 and eliminated by the first difference procedure.

[7]The usual practice in the studies we reviewed is to separate the price change into periods of price increases and price decreases. The procedure that we adopted is mathematically equivalent to the usual practice. However, statistical significance tests of asymmetry are easier to compute using our method.

Test 2: Model Extended to Test for Different Responses During Market Shocks

Lag coefficients in the simple distributed lag in equation 2 are assumed to be invariant over time. However, the magnitude of the estimated coefficients could be allowed to vary over time.[8] Each lag coefficient, β_τ, in equation 2 may be replaced with $\beta_{\tau t}$ as a function of the factors that cause lag coefficients to vary from period to period. On the basis of our discussions with oil industry experts, we believed that three characteristics of the petroleum industry could affect the magnitude of lag parameters that measure the speed or size of price adjustments. First, the availability of market information, such as that provided by futures markets, could affect lag parameters in some markets. Second, the availability of excess production capacity at refineries could affect the speed of a price response during a negative market shock if it caused a short-term increase in demand. Third, inventory levels could mitigate the price response during either a negative or a positive market shock.[9] These variables in our model build on the previous studies by allowing us to estimate different adjustments on average and during market shocks and by allowing us to identify economic factors that may explain potential differences in adjustments on average and during market shocks.

Availability of Market Information

The median length of any distributed lag and the magnitude of each lag parameter may be determined in part by the speed with which news of events in upstream markets reaches downstream markets and the manner in which that information is utilized. Industry experts reported that between some markets, the flow of information to participants has improved during recent years. For example, increased activity in relevant futures markets combined with the increased use of computer-based pricing services—in other words "information technologies"—may have caused some lag parameters to change. Therefore, during recent years, we would expect a crude oil price change, for example, to be transmitted to the wholesale level more completely in contemporaneous periods and periods immediately following the price change. Events in periods in the more distant past we would expect to account less for a price change.

Since theory provides no a priori means of measuring the effect of a change in the availability of market information, in our model we assume that the rate at which these information technologies penetrated the market was low following decontrol and is currently high. As explained

[8]According to industry experts, the appropriate lag length depends upon industry and market characteristics. We discuss lag length in the context of each separate lag structure, later in the appendix.

[9]As defined in ch. 4, a negative market shock is one that is associated with substantial price increases, while a positive market shock is associated with substantial price decreases.

later, we assume that the rate at which oil companies and wholesale market participants adopted information technologies follows a logistic time trend over the sample period. This assumption allows us to model the adoption of technology and represents a compromise between a linear time trend and a specific date of adoption.

Availability of Excess Production Capacity at Refineries

A second factor expected to affect lag parameters is the utilization by the industry of its refining capacity. The existence of excess production capacity, as measured by the refinery capacity utilization rate in the oil industry, enables refineries to increase output more easily in the event of an increase in demand for their product.[10] A negative market shock is often associated with an increase in precautionary or speculative demand. For example, during the week following the Iraqi invasion of Kuwait, DOE found that the amount of gasoline purchased at the wholesale level increased by 1.2 million barrels per day (mmbd) in spite of the price increase. When there is excess capacity, an increase in demand may be met easily and at prevailing production costs. However, in an industry at or near capacity, increases in demand generally cause a large or rapid increase in price.

Level of Inventories

A third factor potentially affecting lag length is the level of inventories, or fuel stocks. When the market faces a sudden decrease in the supply of crude oil or wholesale gasoline, there is upward pressure on wholesale and retail gasoline prices, respectively. When this occurs, inventories may temporarily serve the function of excess capacity as they enable increases in the supply at current production levels. During a negative market shock, if inventory levels are high, the effect on prices may be partially offset by reductions in inventory holdings, while if inventory levels are low, no such effect is possible.[11] Similarly, during a positive market shock, the converse may be true: If inventory levels are low the effect on prices may be partially offset by the replenishing of inventory holdings.

Extension of the Model

In equation 4 below, we have rewritten lag coefficients from equation 2 to include a penetration-rate variable, PR_t, which reflects the increased flow of information over time. The penetration rate variable is measured by the logistic time trend. The estimated coefficients, $\gamma_{\tau 1}$, we would expect to be positive when they are contemporaneous with the shock and the closer

[10]Excess production capacity refers to the ability of a firm or industry to increase output with existing capital.

[11]Generally, inventory levels depend upon storage costs, the interest rate, and expectations about the inventory's future market price vis-à-vis the current price. If no unexploited opportunities for intertemporal arbitrage are available and the interest rate remains fixed, inventories will fall as prices increase and rise as prices decrease.

the period is to the shock, and 0 or negative the further the lag period is from the shock. We defined CU_t as the petroleum refinery capacity utilization rate and arbitrarily defined

$$D1_t = \begin{cases} 1 \ \ if \ \Delta IC_t > 2\sigma_{\Delta IC_t} \\ 0 \ \ otherwise \end{cases}$$

as a dummy variable for rapid crude oil price increases. The σ represents the standard deviation from the mean of the price change distribution which we used for estimation during the period 1984-91. Therefore, the dummy variable equals 1 if and only if a 1-week price increase is relatively large. In this fashion, the response parameters, β_τ, can vary with capacity utilization following market shocks. Thus, when contemporaneous with the shock, $\gamma_{\tau 2}$ is expected to be positive while previous values may be 0 or negative. Finally, FS_t measures fuel stocks, and

$$D2_t = \begin{cases} 1 \ \ if \ |\Delta IC_t| > 2\sigma_{\Delta IC_t} \ \ and \ \Delta IC_t < 0 \\ 0 \ \ otherwise \end{cases}$$

is a dummy for shock-induced price decreases.[12] Thus, the response parameters, β_τ, can vary with inventory levels following market shocks. The coefficients $\gamma_{\tau 3}$ are estimates of the shock-induced price response that is associated with fuel stocks, while the coefficients, $\gamma_{\tau 4}$, are the additional effects that occur when the shock results in a price increase. We expect that $\gamma_{\tau 3}$ will be negative, especially during periods close to the shock, while $\gamma_{\tau 4}$ will be positive during periods close to the shock. In addition, because $\gamma_{\tau 2}$ and $\gamma_{\tau 4}$ both correspond to negative or positive shocks, the sign and significance of the sum of these coefficients multiplied by values of the corresponding variables represent the overall shock-induced effect for price increases. Equation 4 specifies the factors that may affect lag coefficients:[13]

[12]The dummy variable $D1_t$ is for rapidly increasing prices, while the dummy variable $D2_t$ is for rapidly decreasing prices.

[13]An iid error term would provide an errors-in-variables specification. Ordinary least squares estimation of any equation including such a specification would be inconsistent. Consistent parameter and standard error estimates could be obtained through an instrumental variable procedure. Such a procedure was performed, and it had no meaningful impact on the estimates reported in ch. 4 or later in this appendix.

$$4.\quad \beta_{\tau t} = \gamma_{\tau 0} + \gamma_{\tau 1} PR_{t-\tau} + \gamma_{\tau 2} D1_{t-\tau} CU_{t-\tau} + \gamma_{\tau 3} (D1_{t-\tau} + D2_{t-\tau}) FS_{t-\tau} + \gamma_{\tau 4} D1_{t-\tau} FS_{t-\tau}.$$

By substitution of equation 4 into equation 2, the variable response model is specified in equation 5:

$$5.\quad \Delta P_t = \sum_{\tau=0}^{S} [\gamma_{\tau 0} \Delta IC_{t-\tau} + \gamma_{\tau 1} PR_{t-\tau} \Delta IC_{t-\tau} + \gamma_{\tau 2} D1_{t-\tau} CU_{t-\tau} \Delta IC_{t-\tau} + \gamma_{\tau 3} (D1_{t-\tau} + D2_{t-\tau}) FS_{t-\tau} \Delta IC_{t-\tau} + \gamma_{\tau 4} D1_{t-\tau} FS_{t-\tau} \Delta IC_{t-\tau}] + \epsilon_t.$$

This formulation of the model allows for different responses to price increases and decreases during shock periods. However, the dummy variables in equation 5 are interactive with fundamental economic variables such as the refinery capacity utilization rate and may not appear autonomously.

Test 3: Model Generalized to Combine Previous Tests

In the previous two sections, we explained how we extended equation 2 of our model to test for asymmetry that might occur independently of market conditions and to test for a variable response depending upon market conditions. These extensions of the distributed lag specification may be combined if regressors in equation 5 are separated into periods of price increases and decreases in a manner similar to the changes that resulted in equation 3. However, since the dummy variables are already associated with a direction of price change, only noninteractive terms are included in equation 6:

$$6.\quad \Delta P_t = \sum_{\tau=0}^{S} [\gamma_{\tau 0}\Delta IC_{t-\tau} + \gamma^{+}_{\tau 0}\Delta IC_{t-\tau}$$
$$+ \gamma_{\tau 1} PR_{t-\tau}\Delta IC_{t-\tau} + \gamma^{+}_{\tau 1} PR_{t-\tau}\Delta IC_{t-\tau}$$
$$+ \gamma_{\tau 2} D1_{t-\tau} CU_{t-\tau}\Delta IC_{t-\tau}$$
$$+ \gamma_{\tau 3} (D1_{t-\tau} + D2_{t-\tau}) FS_{t-\tau}\Delta IC_{t-\tau}$$
$$+ \gamma_{\tau 4} D1_{t-\tau} FS_{t-\tau}\Delta IC_{t-\tau}] + \epsilon_t .$$

Characteristics of the Data May Affect Empirical Results

We obtained price data from the API, as collected from other sources, for the period January 1984 through March 1991. These data included spot prices for West Texas Intermediate (WTI) crude oil and wholesale unleaded regular gasoline delivered to New York Harbor and a national average of retail prices of unleaded regular gasoline. Each of the three price series was measured weekly for the 378-week period. The crude oil and wholesale gasoline data series consisted of each Wednesday's closing price as reported in the Wall Street Journal. The retail gasoline price, reported by Oil and Gas Journal, was an unweighted weekly average of the average retail price in selected cities across the country. All prices excluded all taxes.

From API, we also obtained data on the utilization of refiners' capacity and on inventories of crude oil and wholesale gasoline. API directly collects these data from operators of refineries, bulk terminals, and pipelines and from importers. The refinery capacity utilization rate represents the percentage of the potential production capacity in use during any given week. Crude oil and wholesale gasoline inventories include all stocks held by refiners and distributors.

The price data have some limitations because spot market transactions may not be representative of all transactions in the gasoline market. But while most crude oil and wholesale gasoline is sold under contract and not through the spot market, the vast majority of contract prices are tied to spot prices. Thus, in spite of their potential limitations, spot prices are widely cited and commonly accepted as representative measures of petroleum prices. Moreover, since our price data are for the widely cited prices of WTI crude oil and New York Harbor gasoline, they may be more representative of the underlying price dynamics than some contract prices would be because there may be discounts to contract prices and the spot prices are generally representative of the relevant opportunity costs.

We accepted the limitations of these data in order to use data that reflect more frequent measurements than the publicly available contract data. Some of the existing studies that have tested for price adjustment in the gasoline market used contract or average prices that were collected monthly.[14] Because some petroleum prices change very quickly, we chose a data source that provided weekly observations. We felt that the benefit from more frequent observations outweighed the cost of using data that might be less representative than the ideal.

We seasonally adjusted each of the six data series on a monthly basis using a standard procedure that expresses each observation as a deviation from its monthly mean with the overall mean added to preserve the level.[15] We also detrended each data series. Finally, we adjusted each price series for inflation using the Consumer Price Index. These procedures removed from the data any effects of cyclic or seasonal patterns, overall trends for each data series, and inflation. Adopting these procedures allowed us to answer the two basic questions we posed at the beginning of this appendix without explicitly modeling these factors.

Wholesale Price Reflects Crude Oil Price Changes Almost Immediately While Retail Price Adjusts More Slowly

We estimated the average time required for a price change at one level of the industry to affect the price at the next level. Estimates from our model demonstrate that a change in the price of crude oil causes an almost immediate change in the price of wholesale gasoline. While the retail price of gasoline begins to respond to wholesale price changes immediately, the full effect occurs much more slowly.[16]

Wholesale Price Reflects Crude Oil Price Changes Within 1 Week

In our model, the spot wholesale price of gasoline responded only to changes in contemporaneous and once-lagged crude oil prices. From our discussions with industry experts, whose views are presented in chapter 4, we expected that the wholesale price would respond almost immediately. In order to reflect these expectations, the markup model in equation 2 was specified to measure the average time differential between changes in the

[14]Different price data may provide different answers to the two basic questions posed at the beginning of the appendix. In particular, contract prices generally respond more slowly than spot prices to market events.

[15]A. S. Goldberger, A Course in Econometrics (Cambridge, Mass: Harvard University Press, 1991), pp. 186-89.

[16]Our estimates measure the average price change from one level to the next on average and during market shocks. Any individual price change may differ from the average price change.

price of crude oil and changes in the wholesale price of gasoline. In equation 7, W_t is the wholesale price of gasoline and C_t is the price of crude oil:[17]

$$7. \quad \Delta W_t = \alpha + \beta_0 \Delta C_t + \beta_1 \Delta C_{t-1} + \epsilon_t .$$

Table II.2 contains parameter estimates for equation 7.[18] These estimates reveal that a 1-cent-per-gallon change in the price of crude oil causes a 0.83-cent-per-gallon change in the wholesale price of gasoline within 1 week.[19] Additional lag coefficients were individually and jointly statistically insignificant, implying that the entire price response generally occurs during the first week following a crude oil price change.[20]

Table II.2: Wholesale Price Response

Dependent Variable Is ΔW_t

Independent Variable	Coefficient estimates
Intercept	0.009 (0.097)
ΔC_t	0.830 (20.339)
ΔC_{t-1}	–0.008 (–0.193)
ρ	–0.115 (–2.221)
Adjusted R^2	0.537

Notes: The number of observations is 375.

The t-statistics are in parentheses.

[17]We chose to add an intercept to each of the estimated equations so that we could report the adjusted R^2.

[18]Our estimation procedure transformed the data to correct for a first-order autoregressive process.

[19]Crude oil is not refined into gasoline on a 1-for-1 basis. Depending upon refineries' processes, it may take more than 1 gallon of crude oil to produce 1 gallon of gasoline. As a result, the relationship between the price of crude oil and the price of gasoline cannot be expected to be 1-for-1. A priori, the price of gasoline may change more or less than 1 cent for every 1-cent change in the price of crude oil.

[20]Studies that we reviewed on the gasoline price adjustment process do not explicitly report estimates of lag length independently of their tests for asymmetry. However, our analysis of these studies suggests that our estimate of the time required for the wholesale gasoline price change is consistent with these studies' findings.

Retail Price Responds to Wholesale Price Changes Over 4-Month Period

According to industry experts, the retail price of gasoline reacts to cost changes in the wholesale price much more slowly than the wholesale price reacts to changes in the crude oil price. Participants in wholesale markets are usually well-informed of market events and frequently have a large financial interest in relatively small price differentials in most transactions. As a result, the wholesale price changes quickly to reflect all current market information. In contrast, at the retail level, various factors may tend to decrease the speed of the price response. For example, individual retail purchasers do not look for the lowest price as diligently as individual wholesale purchasers because each retail purchase is relatively small, and in some markets, company-operated retail outlets may be able to slow the rate of price change in their area.

We estimated the average time length between changes in the wholesale price of gasoline and the retail price of gasoline.[21] The markup model in equation 2 was specified as equation 8 where R_t represents the average retail price of gasoline:[22]

$$8. \quad \Delta R_t = \alpha + \sum_{\tau=0}^{16} \beta_{t-\tau} \Delta W_{t-\tau} + \epsilon_t .$$

As seen in table II.3, the observable short-run response requires a lag of 17 weeks, including the week contemporaneous with the wholesale price change. However, more than one-half of the eventual response is realized within the first 4 weeks. Additional explanatory variables that lagged beyond 17 weeks did not add significantly to the sum of lagged coefficients.[23]

[21] The length of the reported lag was determined by first specifying an arbitrarily long lag, then decreasing the lag one period at a time until omitted lag coefficients were either individually or jointly statistically significant.

[22] As an alternative to the lag specification in equation 8, the retail-wholesale lag may be specified as a polynomial distributed lag (PDL). We specified and estimated a PDL with results that were qualitatively similar to the reported results.

[23] Our estimates of the time required for the retail gasoline price change seem to be several weeks longer than estimates implied in the research we reviewed. We cannot positively identify the cause of this difference, but different procedures for determining the length of a lag could yield different results. Importantly, these minor differences would not result in different conclusions.

Table II.3: Retail Price Response

Dependent Variable is ΔR_t

Independent variable	Coefficient estimates	Cumulative sum of lag coefficients
Intercept	–0.006 (–0.118)	
ΔW_t	0.132 (7.595)	0.132 (7.595)
ΔW_{t-1}	0.129 (7.398)	0.261 (10.239)
ΔW_{t-2}	0.086 (4.918)	0.347 (11.002)
ΔW_{t-3}	0.092 (5.240)	0.438 (12.224)
ΔW_{t-4}	0.054 (3.069)	0.492 (12.338)
ΔW_{t-5}	0.066 (3.788)	0.558 (12.754)
ΔW_{t-6}	0.040 (2.321)	0.598 (12.657)
ΔW_{t-7}	0.031 (1.761)	0.629 (12.459)
ΔW_{t-8}	0.008 (0.457)	0.637 (11.792)
ΔW_{t-9}	0.015 (0.858)	0.652 (11.317)
ΔW_{t-10}	0.068 (3.783)	0.719 (11.791)
ΔW_{t-11}	0.042 (2.309)	0.761 (11.914)
ΔW_{t-12}	0.023 (1.268)	0.784 (11.759)
ΔW_{t-13}	0.046 (2.516)	0.830 (11.873)
ΔW_{t-14}	–0.018 (–0.991)	0.812 (11.096)
ΔW_{t-15}	0.009 (0.504)	0.821 (10.786)
ΔW_{t-16}	0.046 (2.515)	0.867 (10.911)
ρ	–0.101 (–1.890)	
Adjusted R^2	0.321	

Notes: The number of observations is 360.

The t-statistics are in parentheses.

Wholesale Price Responds Asymmetrically to Changes in the Price of Crude Oil During Shocks

We developed three tests in order to determine whether the wholesale price of gasoline rises more quickly or by a larger amount after an increase in the price of crude oil—caused by a negative market shock—than it falls after a decrease in the price of crude oil—caused by a positive market shock. Below, we present the formulation of an econometric equation for each of the three tests. Then, for each test, there is a brief explanation of the conditions necessary for determining symmetry or asymmetry. Finally, a section of results provides the findings from each test along with a table summarizing the econometric results.

Our results indicate that during market shocks, the wholesale price of gasoline increases more after an increase in the price of crude oil than it decreases after a decrease in the price of crude oil. The additional wholesale price increase may be a result of high refinery capacity utilization rates—in other words, low excess production capacity—and increases in wholesale and, possibly, retail demand during times of rapidly increasing petroleum prices. We found that, on average, the effect of high refinery capacity utilization rates tended to offset the effect that crude oil inventories would have on the price changes. The additional price increase was not observed independently of the variables we considered. In other words, according to our estimates, the wholesale price adjustment was symmetric when we did not include these variables.

Test 1: Average Response Separated Into Periods of Increasing and Decreasing Prices

One commonly accepted technique for determining whether a price adjustment is symmetric or asymmetric separates the distributed lag into periods of increasing and decreasing prices, as in equation 3. This allows for the average price response, during market shocks and on average, to be examined in relation to the direction of the price change. Equation 9 separates the relationship between the price of crude oil and the price of wholesale gasoline into two components:

$$9.\quad \Delta W_t = \alpha + \beta_0 \Delta C_t + \beta_1 \Delta C_{t-1} + \beta_0^+ \Delta C_t^+ + \beta_1^+ \Delta C_{t-1}^+ + \epsilon_t .$$

The lag coefficients β_0 and β_1 measure the typical wholesale price change resulting from a crude oil price change, while β_0^+ and β_1^+ measure the additional change attributable to price increases. If either β_0^+ or β_1^+ is statistically different from 0, then this test would provide evidence of asymmetry.

Test 2: Market Shocks Differentiated From the Average

We tested for the presence of asymmetry during market shocks by interacting dummy variables for shocks with economic variables that we believed might be related to differences in the way prices adjust during shocks and on average. By following the analysis previously outlined, we adapted equation 4 to study the relationship between the price of crude oil and the wholesale price of gasoline, where OS_t represents crude oil stocks:[24]

$$10.\quad \beta_{\tau t} = \gamma_{\tau 0} + \gamma_{\tau 1} PR_{t-\tau} + \gamma_{\tau 2} D1_{t-\tau} CU_{t-\tau} + \gamma_{\tau 3} (D1_{t-\tau} + D2_{t-\tau}) OS_{t-\tau} + \gamma_{\tau 4} D1_{t-\tau} OS_{t-\tau}.$$

By substitution into equation 7 as appropriate, a variable response model for the crude-wholesale price relationship is specified in equation 11:

$$\begin{aligned} 11.\quad \Delta W_t = \alpha &+ \gamma_0 \Delta C_t + \gamma_5 \Delta C_{t-1} + \gamma_1 PR_t \Delta C_t + \gamma_6 PR_{t-1} \Delta C_{t-1} \\ &+ \gamma_2 D1_t CU_t \Delta C_t + \gamma_7 D1_{t-1} CU_{t-1} \Delta C_{t-1} \\ &+ \gamma_3 (D1_t + D2_t) OS_t \Delta C_t + \gamma_8 (D1_{t-1} + D2_{t-1}) OS_{t-1} \Delta C_t \\ &+ \gamma_4 D1_t OS_t \Delta C_t + \gamma_9 D1_{t-1} OS_{t-1} \Delta C_{t-1} + \epsilon_t. \end{aligned}$$

If the sum of the coefficients, γ_2 and γ_4, multiplied by the corresponding variable means is positive and statistically different from 0, there would be evidence that the price increases more during shocks than on average.

Test 3: Test for Asymmetry on Average and During Market Shocks

We combined the first two tests in order to form a third test for asymmetry. The separated and variable response specifications were combined in equation 12:

[24] The cumulative distribution of the logistic function is $F(z) = e^z/(1+e^z)$ for $-\infty < z < \infty$. The sample included observations for 378 weeks. Assuming that the market penetration rate of these information technologies began at 5 percent and ended at 95 percent meant that we needed to rescale the time variable so that z = 0 between the 179th and 180th weeks, z = -2.9444 during week 1, and z = 2.9444 during week 378.

$$
\begin{aligned}
12.\quad \Delta W_t = \alpha &+ \gamma_0 \Delta C_t + \gamma_0^{+} \Delta C_t^{+} + \gamma_5 \Delta C_{t-1} + \gamma_5^{+} \Delta C_{t-1}^{+} \\
&+ \gamma_1 PR_t \Delta C_t + \gamma_1^{+} PR_t \Delta C_t^{+} \\
&+ \gamma_6 PR_{t-1} \Delta C_{t-1} + \gamma_6^{+} PR_{t-1} \Delta C_{t-1}^{+} \\
&+ \gamma_2 D1_t CU_t \Delta C_t + \gamma_7 D1_{t-1} CU_{t-1} \Delta C_{t-1} \\
&+ \gamma_3 (D1_t + D2_t)\, OS_t \Delta C_t \\
&+ \gamma_8 (D1_{t-1} + D2_{t-1})\, OS_{t-1} \Delta C_{t-1} \\
&+ \gamma_4 D1_t OS_t \Delta C_t + \gamma_9 D1_{t-1} OS_{t-1} \Delta C_{t-1} + \epsilon_t .
\end{aligned}
$$

If γ_0^{+} or γ_1^{+} is positive and statistically different from 0 or if the sum of the coefficients γ_2 and γ_4, when multiplied by the corresponding variables is positive and statistically different from 0, there would be evidence that the price increases more during shocks than on average.[25]

In Comparison to Crude Oil Price, Wholesale Price Rises More Than It Falls During Shocks

According to estimates of our model in table II.4, that exclude the shock-specific economic variables, the average wholesale price rises and falls at the same rate and by the same amount following crude oil price changes that are equal in size but opposite in direction. This result is generally consistent with those of the studies cited earlier that focused on the relationship between the prices of wholesale gasoline and crude oil.

During market shocks, however, the wholesale price of gasoline increases by a larger amount when the price of crude oil increases than it decreases when the price of crude oil decreases. Specifically, the wholesale price increases by 0.22-cents-per-gallon more than it decreases. This additional amount depends on the extent to which excess production capacity is available at refineries and the level of crude oil inventories; the amount was computed at the means of these variables. These parameter estimates are only statistically significant when interacted with a dummy variable indicating the presence of a shock.[26] We interpret this result as being consistent with increases in wholesale and, possibly, retail demand for

[25]Similar asymmetries could exist in the lagged period.

[26]The variable that was included to measure possible increases in the response of the wholesale price to changes in the crude oil price, PR_t—the penetration rate of information technologies—did not generally provide the expected results. In particular, the contemporaneous value of the estimated coefficient is statistically insignificant. This may occur for any of several reasons. First, it is possible that no such effect exists. Second, in the detrending of the data, the effect may have been removed. Third, the first difference procedure may have also removed the effect from the data. Finally, a logistic time trend may not have been the correct measure of this effect.

about prices. The increase in demand at the retail level causes an increase in the demand affecting inventories and the level of refinery capacity utilization at the crude oil and wholesale levels. At each level, customers demand more from their suppliers during shocks. When there is little excess production capacity and crude oil inventories are low, the increase in demand cannot be met at the prevailing prices, and, as a result, the price must increase. The additional price increase is observed at the wholesale level and is subsequently passed on to the retail level.

The studies that we reviewed did not directly focus on shocks, nor did they include these variables in their analysis. However, the authors of two of the three studies that reported finding some evidence of asymmetry between wholesale and retail prices (Borenstein, et al. and French) proposed an hypothesis to explain their findings. Both studies suggested that increases in end-use demand associated with negative shocks could explain asymmetric adjustments. Thus, while our model focuses on more specific questions than the ones addressed by the studies that we reviewed, this hypothesis is consistent both with our prior expectations based on our analysis of the process of price adjustment and with the expectations of these studies.

Table II.4: Results of Tests for Asymmetry Between Crude Oil and Wholesale Prices

Dependent Variable Is ΔW_t

Independent Variable	Test 1	Test 2	Test 3
Intercept	−0.078 (−0.529)	−0.037 (−0.348)	0.123 (0.621)
ΔC_t	0.833 (12.317)	0.797 (7.915)	1.003 (6.018)
ΔC_{t-1}	−0.050 (−0.749)	0.186 (1.845)	0.112 (0.674)
$PR_t \Delta C_t$		−0.168 (−1.310)	−0.064 (−0.321)
$PR_{t-1} \Delta C_{t-1}$		−0.291 (−2.288)	−0.397 (−2.070)
ΔC^+_t	0.002 (0.013)		−0.398 (−1.390)
ΔC^+_{t-1}	0.096 (0.807)		0.109 (0.385)
$PR_t \Delta C^+_t$			−0.209 (−0.608)
$PR_{t-1} \Delta C^+_{t-1}$			0.254 (0.749)
$D1_t CU_t \Delta C_t$		0.061 (2.856)	0.063 (2.933)
$D1_{t-1} CU_{t-1} \Delta C_{t-1}$		−0.031 (−1.456)	−0.031 (−1.428)
$(D1_t + D2_t) OS_t \Delta C_t$		2.761×10^{-7} (0.950)	-3.131×10^{-7} (−0.809)
$(D1_{t-1} + D2_{t-1}) OS_{t-1} \Delta C_{t-1}$		2.785×10^{-8} (.096)	3.433×10^{-7} (0.873)
$D1_t OS_t \Delta C_t$		-1.370×10^{-5} (−2.71)	-1.306×10^{-5} (−2.555)
$D1_{t-1} OS_{t-1} \Delta C_{t-1}$		7.397×10^{-6} (1.44)	6.749×10^{-6} (1.293)
ρ	−0.115 (−2.235)	−0.092 (−1.758)	−0.092 (−1.731)
Adjusted R^2	0.535	0.554	0.557

Notes: The number of observations is 375.

The t-statistics are in parentheses.

Retail Price Responds Symmetrically to Wholesale Price Changes During Shocks

We also addressed the second major question, if the speed and magnitude of retail price changes depend on whether the wholesale price is rising or falling. Our results indicate the price adjustment between the wholesale and retail price of gasoline is symmetric. However, an asymmetric price adjustment between crude oil and wholesale gasoline prices combined with a symmetric adjustment between wholesale and retail gasoline prices may be interpreted as an asymmetric price adjustment between crude oil and retail gasoline prices during shocks.

Once again, we used three tests to determine whether the price adjustment is asymmetric. Below, we describe each of the three tests briefly and specify the corresponding econometric equations. Next, we present our findings for the wholesale-retail relationship.

Test 1: Average Response Separated Into Periods of Increasing and Decreasing Prices

Separating the distributed lag into periods of increasing and decreasing price, as in equation 3, for the wholesale-retail relationship, results in equation 13:

$$13. \quad \Delta R_t = \alpha + \sum_{\tau=0}^{16} (\beta_\tau \Delta W_{t-\tau} + \beta_\tau^+ \Delta W_{t-\tau}^+) + \epsilon_t .$$

Test 2: Market Shocks Differentiated From the Average

As with crude-wholesale lags, the lagged response may change during the period of interest. However, the factors affecting lag structure are somewhat different for the wholesale-retail lag. The response parameter may be a function of wholesale gasoline stocks in the same manner in which wholesale gasoline prices depend to some extent on the size of crude oil stocks.[27] The response parameter may vary inversely with the level of wholesale gasoline stocks. Defining

[27]The information variable is not included in this equation because purchasers at the retail level do not generally use information as efficiently as purchasers at the wholesale level.

$$D4_t = \begin{cases} 1 \ if \ \%\Delta W_t > 2\sigma \\ 0 \ otherwise \end{cases}$$

and

$$D5_t = \begin{cases} 1 \ if \ |\%\Delta W_t| > 2\sigma \ and \ \Delta W_t < 0 \\ 0 \ otherwise, \end{cases}$$

we can modify equation 4 to accommodate this change as follows, where GS_τ is the wholesale gasoline stock level:

$$14. \quad \beta_{t\tau} = \gamma_{0\tau} + \gamma_{1\tau}(D4_{t-\tau} + D5_{t-\tau})\,GS_{t-\tau} + \gamma_{2\tau}D4_{t-\tau}GS_{t-\tau}.$$

Substitution of equation 14 into equation 8 as appropriate provides the lag structure to be estimated in equation 15:

$$15. \quad \Delta R_t = \alpha + \sum_{\tau=0}^{16} (\gamma_{0\tau}\Delta W_{t-\tau} + \gamma_{1\tau}(D4_{t-\tau} + D5_{t-\tau})\,GS_{t-\tau}\Delta W_{t-\tau} + \gamma_{2\tau}D4_{t-\tau}GS_{t-\tau}\Delta W_{t-\tau}) + \epsilon_t.$$

Test 3: Test for Asymmetry on Average and During Shocks

A combination of these two tests forms the third test for asymmetry. The simple separation of the independent variable into rising and falling periods was combined with the variable for gasoline inventories to form equation 16:

$$16.\quad \Delta R_t = \alpha + \sum_{\tau=0}^{16} (\gamma_{0\tau}\Delta W_{t-\tau} + \gamma_{0\tau}^{+}\Delta W_{t-\tau}^{+} + \gamma_{1\tau}(D4_{t-\tau} + D5_{t-\tau})\, GS_{t-\tau}\Delta W_{t-\tau} + \gamma_{2\tau} D4_{t-\tau} GS_{t-\tau}\Delta W_{t-\tau}) + \epsilon_t .$$

Retail Prices Symmetrically Track Wholesale Price Changes During Shocks

According to estimates of our model, the retail gasoline price responds symmetrically to changes in the price of wholesale gasoline during shocks, even when wholesale gasoline stocks are included as a variable. Table II.5 summarizes the econometric results for each of the three tests. Each of the asymmetry coefficients is statistically insignificant, indicating that there is no statistical evidence of asymmetry between the spot price of wholesale gasoline and the average retail price of gasoline.[28] This implies that any asymmetry observed between the price of crude oil and wholesale gasoline is subsequently passed on to the retail level symmetrically.

Table II.5: Results of Tests for Asymmetry Between Wholesale and Retail Prices

Dependent Variable Is ΔR_t

Independent variable	Test 1	Test 2	Test 3
Intercept	0.108 (0.916)	0.022 (0.382)	0.118 (0.776)
ΔW_t	0.117 (3.592)	0.166 (5.654)	0.172 (2.946)
ΔW_{t-1}	0.162 (4.910)	0.068 (2.368)	0.094 (1.612)
ΔW_{t-2}	0.083 (2.497)	0.125 (4.316)	0.062 (1.057)
ΔW_{t-3}	0.084 (2.505)	0.075 (2.578)	0.094 (1.606)
ΔW_{t-4}	0.086 (2.585)	0.063 (2.142)	0.107 (1.826)
ΔW_{t-5}	0.076 (2.277)	0.065 (3.599)	0.083 (2.437)
ΔW_{t-6}	0.003 (0.105)	0.043 (2.404)	–0.001 (–0.039)
ΔW_{t-7}	0.034 (1.038)	0.034 (1.931)	0.041 (1.221)
ΔW_{t-8}	0.040 (1.192)	0.007 (0.406)	0.037 (1.106)
ΔW_{t-9}	0.026 (0.784)	0.018 (1.012)	0.031 (0.931)

(continued)

[28]One coefficient, corresponding to a 15-week lag, was statistically significant at the .10 level. We interpreted this result as an anomaly.

Dependent Variable Is ΔR_t

Independent variable	Test 1	Test 2	Test 3
ΔW_{t-10}	0.062 (1.713)	0.050 (3.289)	0.058 (1.609)
ΔW_{t-11}	0.059 (1.619)	0.040 (2.177)	0.051 (1.409)
ΔW_{t-12}	–0.004 (–0.108)	0.020 (1.063)	–0.004 (–0.115)
ΔW_{t-13}	0.060 (1.648)	0.051 (2.687)	0.069 (1.875)
ΔW_{t-14}	–0.045 (–1.238)	–0.017 (–0.093)	–0.046 (–1.245)
ΔW_{t-15}	0.070 (1.948)	0.006 (0.301)	0.064 (1.739)
ΔW_{t-16}	0.014 (0.403)	0.050 (2.699)	0.018 (0.496)
ΔW^+_t	0.038 (0.698)		–0.005 (–0.050)
ΔW^+_{t-1}	–0.074 (–1.328)		–0.045 (–0.453)
ΔW^+_{t-2}	–0.001 (–0.023)		0.128 (1.272)
ΔW^+_{t-3}	0.025 (0.433)		–0.041 (–0.410)
ΔW^+_{t-4}	–0.071 (–1.254)		–0.113 (–1.087)
ΔW^+_{t-5}	–0.018 (–0.320)		–0.037 (–0.641)
ΔW^+_{t-6}	0.088 (1.563)		0.086 (1.494)
ΔW^+_{t-7}	–0.009 (–0.158)		–0.014 (–0.235)
ΔW^+_{t-8}	–0.070 (–1.244)		–0.067 (–1.181)
ΔW^+_{t-9}	–0.023 (–0.398)		–0.027 (–0.491)
ΔW^+_{t-10}	0.015 (0.248)		0.017 (0.283)
ΔW^+_{t-11}	–0.025 (–0.411)		–0.013 (–0.210)
ΔW^+_{t-12}	0.037 (0.624)		0.036 (0.597)
ΔW^+_{t-13}	–0.012 (–0.208)		–0.014 (–0.239)
ΔW^+_{t-14}	0.054 (0.898)		0.051 (0.834)

(continued)

Dependent Variable Is ΔR_t

Independent variable	Test 1	Test 2	Test 3
ΔW^{+}_{t-15}	–0.116 (–1.948)		–0.105 (–1.738)
ΔW^{+}_{t-16}	0.057 (0.997)		0.046 (0.785)
$(D4_t+D5_t)GS_t\Delta W_t$		-2.401×10^{-7} (–1.339)	-2.091×10^{-7} (–0.859)
$(D4_{t-1}+D5_{t-1})GS_{t-1}\Delta W_{t-1}$		4.158×10^{-7} (2.339)	3.292×10^{-7} (1.354)
$(D4_{t-2}+D5_{t-2})GS_{t-2}\Delta W_{t-2}$		-7.421×10^{-8} (–0.418)	2.656×10^{-8} (0.109)
$(D4_{t-3}+D5_{t-3})GS_{t-3}\Delta W_{t-3}$		-5.995×10^{-10} (–0.003)	-3.895×10^{-8} (–0.160)
$(D4_{t-4}+D5_{t-4})GS_{t-4}\Delta W_{t-4}$		6.413×10^{-8} (0.364)	-9.685×10^{-8} (–0.397)
$D4_tGS_t\Delta W_t$		1.667×10^{-7} (0.863)	1.329×10^{-7} (0.355)
$D4_{t-1}GS_{t-1}\Delta W_{t-1}$		-2.078×10^{-7} (–1.042)	-1.085×10^{-7} (–0.292)
$D4_{t-2}GS_{t-2}\Delta W_{t-2}$		-2.582×10^{-7} (–1.286)	-5.463×10^{-7} (–1.451)
$D4_{t-3}GS_{t-3}\Delta W_{t-3}$		1.909×10^{-7} (0.946)	3.271×10^{-7} (0.877)
$D4_{t-4}GS_{t-4}\Delta W_{t-4}$		-1.566×10^{-7} (–0.787)	2.508×10^{-7} (0.651)
ρ	–0.094 (–1.725)	–0.079 (–1.456)	–0.070 (–1.261)
Adjusted R^2	0.314	0.329	0.317

Notes: The number of observations is 360.

The t-statistics are in parentheses.

Our results differ somewhat from the majority of the evidence provided in other studies we reviewed. While the results of previous research are mixed, the studies that found asymmetry found evidence of it between the wholesale price of gasoline and the retail price of gasoline. However, one study (Norman and Shin) found the wholesale to retail relationship to be symmetric.

Several factors may account for these differences in results between our model and the majority of the existing studies. The existing studies generally used different data than the data used in our model. Some used either contract prices or an average of contract and spot prices as the price data for wholesale gasoline, while we used spot wholesale prices. There are also major conceptual differences between our model and the other studies in modeling the price relationships and the variables that enter those relationships.

Independent Gasoline Distributors' and Dealers' Concerns About Unfair Competitive Practices

This appendix discusses (1) the concerns of independent gasoline distributors and dealers that major refiners placed them at a competitive disadvantage during the Persian Gulf Crisis and have been engaging in unfair competitive practices, such as predatory pricing,[1] and (2) state laws and proposed state and federal legislation to address these concerns.

Concerns About Predatory Behavior by Major Refiners

Representatives of several trade associations that represent both lessee and open dealers point to their decreasing numbers as evidence that they are being forced from the market by major refiners. These dealers have long-standing complaints that major refiners are attempting to gain control over gasoline retailing through company-operated stations, mostly concentrated in urban markets, and are engaging in predatory pricing. Lessee dealers also argue that certain terms in their franchise agreements with refiners—such as a requirement to stay open 24 hours a day—serve to increase their costs of business and further undermine their competitiveness. The allegations of predatory pricing by major refiners resurfaced during the Persian Gulf Crisis.

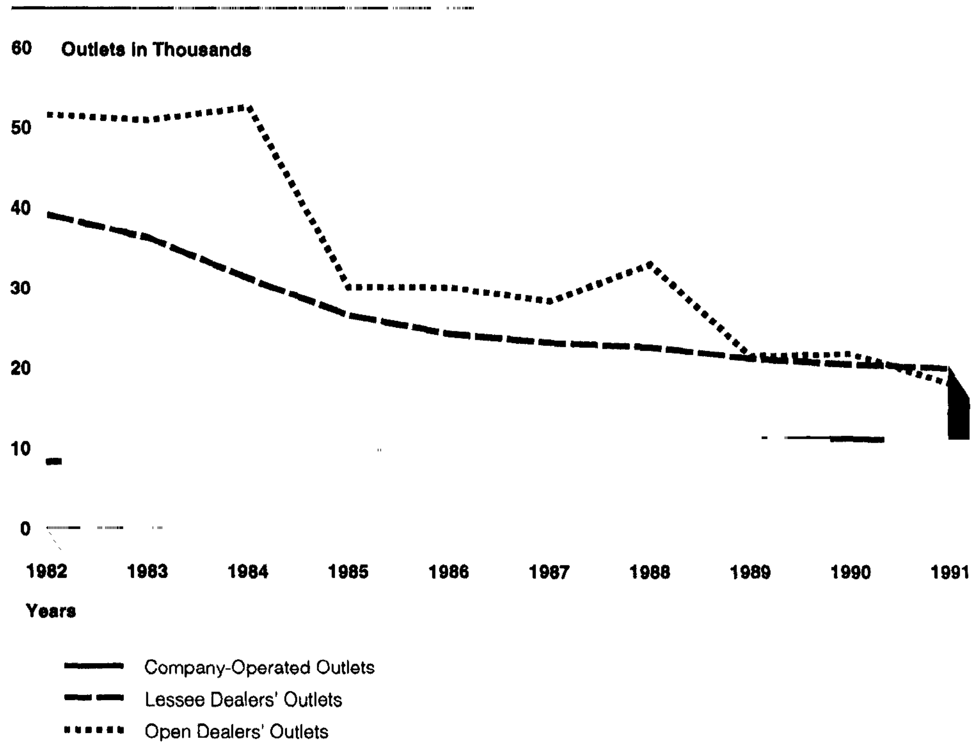
As can be seen in figure III.1, based on data reported to the Energy Information Agency (EIA) by major energy producers,[2] the number of lessee and open dealers supplied by these major energy producers declined from 1982 to 1991, while the number of their company-operated stations increased.[3] The number of open dealers' stations declined more significantly during this period—by about 65 percent—and lessee dealers' stations decreased by about 49 percent. The number of company-operated stations, conversely, increased by about 31 percent from 1982 to 1991. Despite the decline in the number of lessee and open dealers since 1982, they still each outnumber company-operated stations. According to the major energy producers reporting to EIA in 1990-91, company-operated stations accounted for about 22 percent of their outlets, while lessee and open dealers made up about 41 percent and about 37 percent of their outlets, respectively.

[1]Predatory pricing occurs if a firm holds its market price below some measure of its own cost and sacrifices current profits to eliminate competition in the market in the short run and reduce competition in the long run. Monopolizing or attempting to monopolize through predatory pricing is prohibited under U.S. antitrust case law.

[2]There are 23 companies that reported to EIA's Financial Reporting System (FRS) in 1990-91. According to EIA, these companies account for over 80 percent of all the gasoline sold in the United States and 25 percent of all retail gasoline outlets. These data cover outlets directly supplied by refiners, but not outlets that are indirectly supplied by distributors.

[3]See ch. 3 and fig. 3.1 for a discussion of the different types of gasoline distributors and dealers.

Figure III.1: Number of Gasoline Outlets of Major Energy Producers, by Type of Dealer, 1982-91

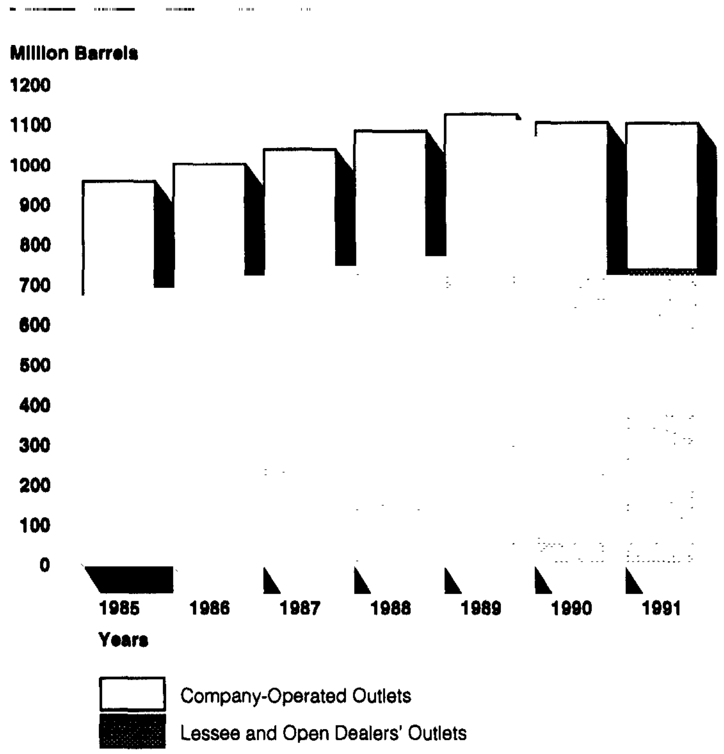


Note: These data are reported by major energy producers that respond to EIA's Financial Reporting System (FRS)

Source: Based on data from EIA's FRS.

As seen in figure III.2, lessee and open dealers also still account for the largest volume of retail sales by the major energy producers. However, the volume sold through their company-operated stations has increased by about 27 percent since 1985. Although the volume sold through the lessee and open dealers supplied by the major energy producers increased slightly from 1985 to 1989, it declined from 1989 to 1990—by about 6 percent—while sales through their company-operated stations increased by about 8 percent from 1989 to 1990. However, from 1990 to 1991, the volume sold through dealers increased by about 2 percent, while sales through company-operated stations declined by about 5 percent.

Figure III.2: Volume of Retail Gasoline Sold by Major Energy Producers, by Type of Dealer, 1985-91



Source: Based on data from EIA's FRS.

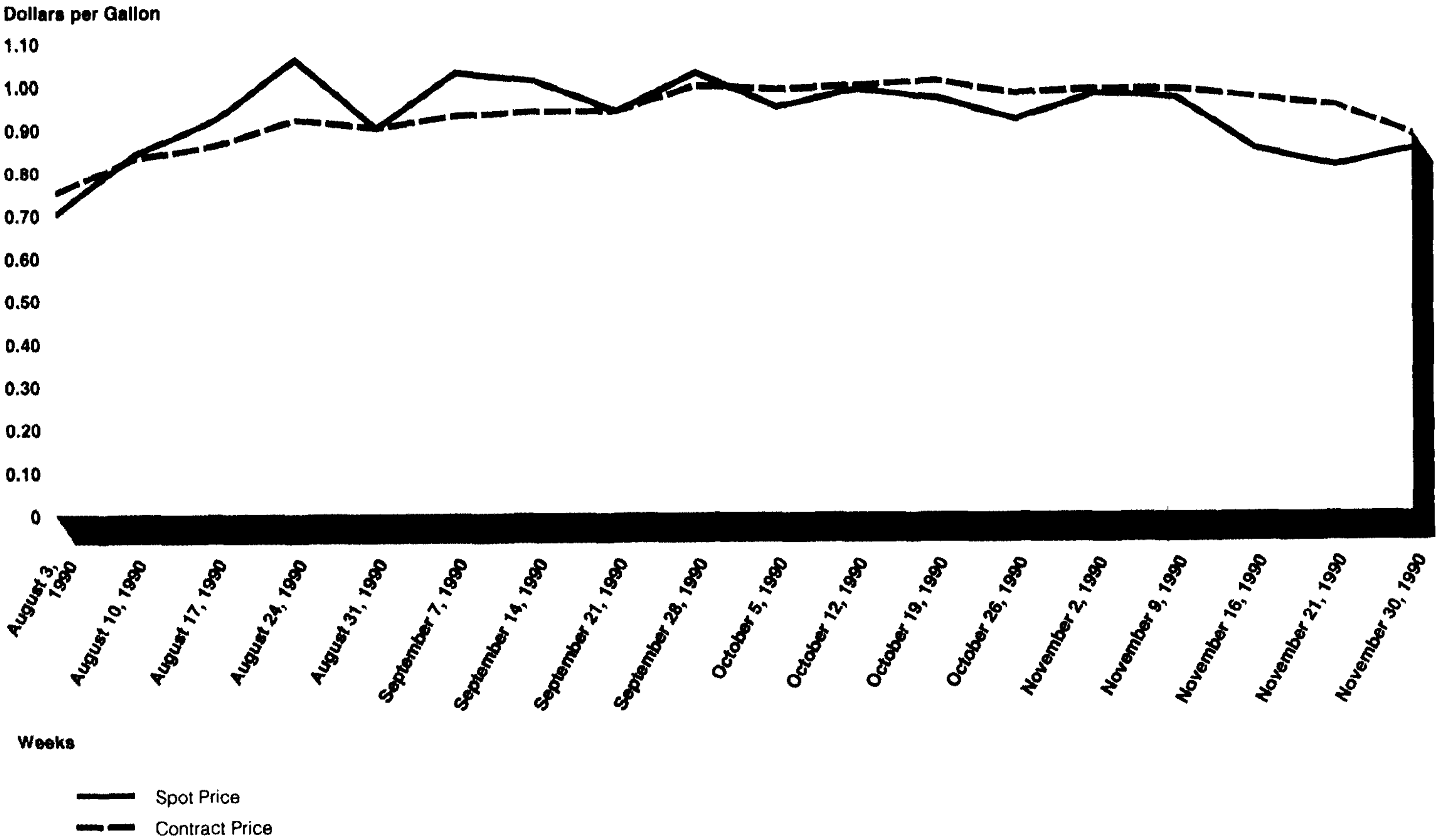
Department of Justice and Federal Trade Commission (FTC) officials said that it has been difficult to prove that oil companies are engaged in predatory pricing through their own company-operated stations. FTC officials cited several legal criteria that must be met in order to prove predatory pricing and said these criteria are rarely met. First, according to FTC officials, in proving this claim, the Commission must show that a firm is likely to capture a monopoly—generally a market share of over 70 percent of any one gasoline market—as a result of the firm's pricing. An FTC official stated that most oil companies do not have enough share of any one gasoline market in the United States to meet this standard. The FTC must then show that an oil company is selling retail gasoline below the company's "average variable cost" at a company-operated station. According to one FTC official, an oil company would have to "back-calculate" its retail, wholesale, refining, and crude oil costs. If an oil company's average cost of production and these other average costs are relatively low, the company's retail price would have to be very low for the company to sell below its average variable cost. It is unlikely, then, this official explained, that an integrated oil company, particularly one with large crude oil reserves, would be selling below its average variable cost even if its retail price is below the prices of its competitors.

Refiners we spoke with confirmed that the number of lessee and open dealers has declined over time. However, the refiners cited other competitive factors, such as the increased costs associated with environmental regulations and the trend toward high-volume stations, as reasons for these dealers' decreasing numbers. These companies said that less efficient outlets have closed, but more efficient high-volume stations have opened. In evidence of this trend, the total volume of gasoline distributed to lessee and open dealers has grown slightly since 1985—by about 8 percent—even though their numbers have decreased drastically.

Adjustment of Spot Prices and Contract Prices for Wholesale Gasoline During Market Shocks

When an oil market shock occurs, spot prices of gasoline tend to adjust more quickly to rapid changes in crude oil prices than do contract prices. Under negative market shocks, the prices that wholesalers who rely heavily on the spot market will pay are generally higher than contract prices, and, under positive shocks, are lower than contract prices. During the first 2 months of the Gulf Crisis—from August 1990 through September 1990—for example, we found that spot prices of gasoline, on average, rose faster than the average contract prices—dealer-tankwagon (DTW) and rack—of gasoline. However, during the following 2 months of the crisis—from October 1990 through November 1990—spot prices for gasoline were generally falling more quickly than contract prices, as seen in figure III.3.

Figure III.3: Spot and Contract Prices for Wholesale Gasoline During the Gulf Crisis, 8/3/90 to 11/30/90



Notes: Prices are weekly averages.

Contract prices are the average of DTW and rack prices. Only the rack price was available for the week of November 30, 1990.

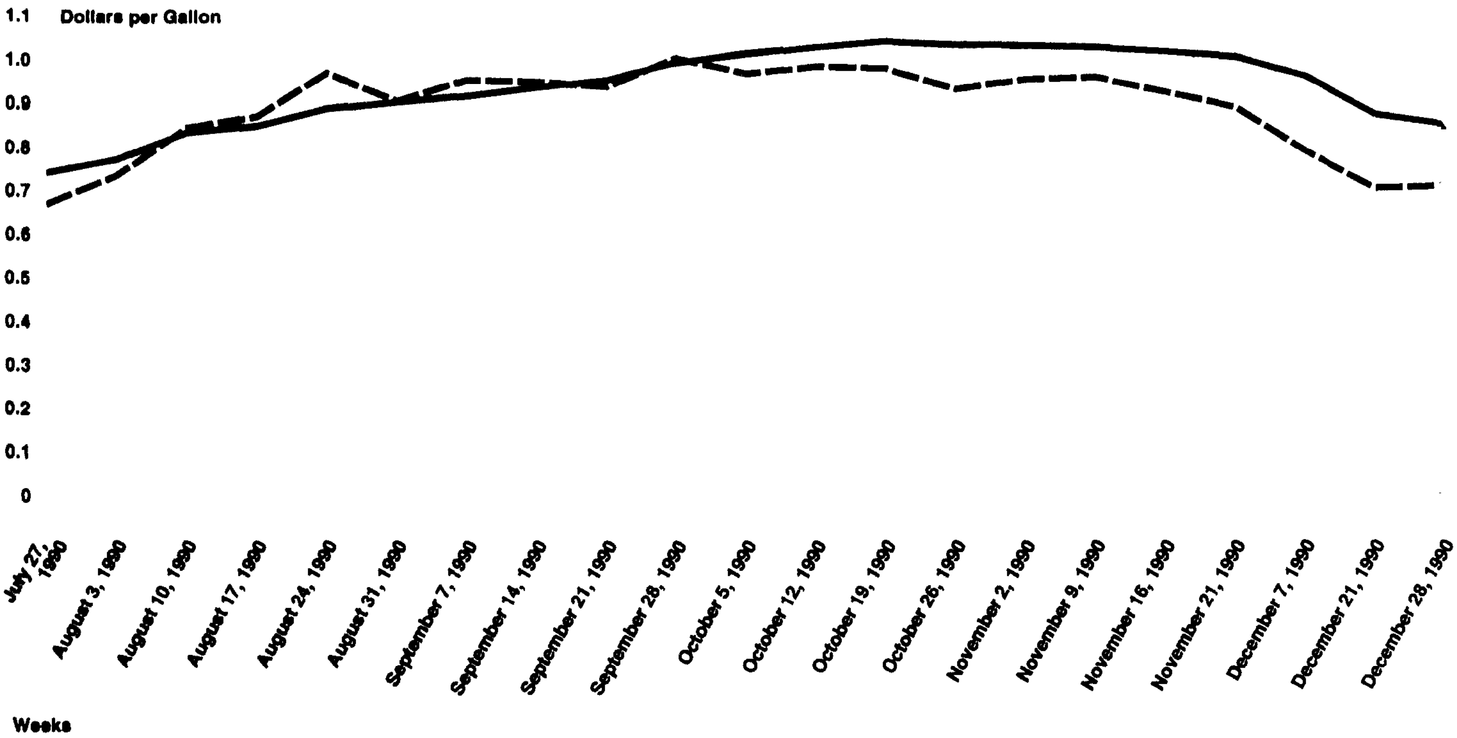
Source: Based on data from EIA and The Oil Daily.

According to refiners and wholesalers, suppliers of gasoline may not, during market shocks, pass on the full increases or decreases in spot and/or futures prices to their wholesale customers with supply contracts. Although some oil companies buy a portion of their gasoline supplies from the spot market, the publicly quoted spot and futures prices are not necessarily the prices paid by companies for their gasoline supplies. In fact, the average wholesale price paid by a product wholesaler for gasoline supplies may be higher or lower than the spot or futures price.

Inversions of Wholesale Gasoline Prices During Gulf Crisis

Independent distributors and dealers—unbranded distributors and open dealers—have made another complaint about pricing during the Persian Gulf Crisis. They claim that the combination of rapidly rising wholesale gasoline prices—particularly spot and unbranded rack prices—and the restraint major refiners exercised in pricing retail gasoline placed independent gasoline distributors and dealers at a disadvantage during the crisis. The average rack prices these distributors and dealers paid to refiners were higher than the DTW prices paid by lessee dealers, whose stations are supplied with gasoline directly by refiners. Normally, DTW prices are higher than rack prices. However, for several weeks during August-September 1990 and March-April 1991, rack prices nationwide actually rose higher than DTW prices. Therefore, the normal relationship between these two wholesale prices became inverted. This inversion is shown in figures III.4 and III.5.

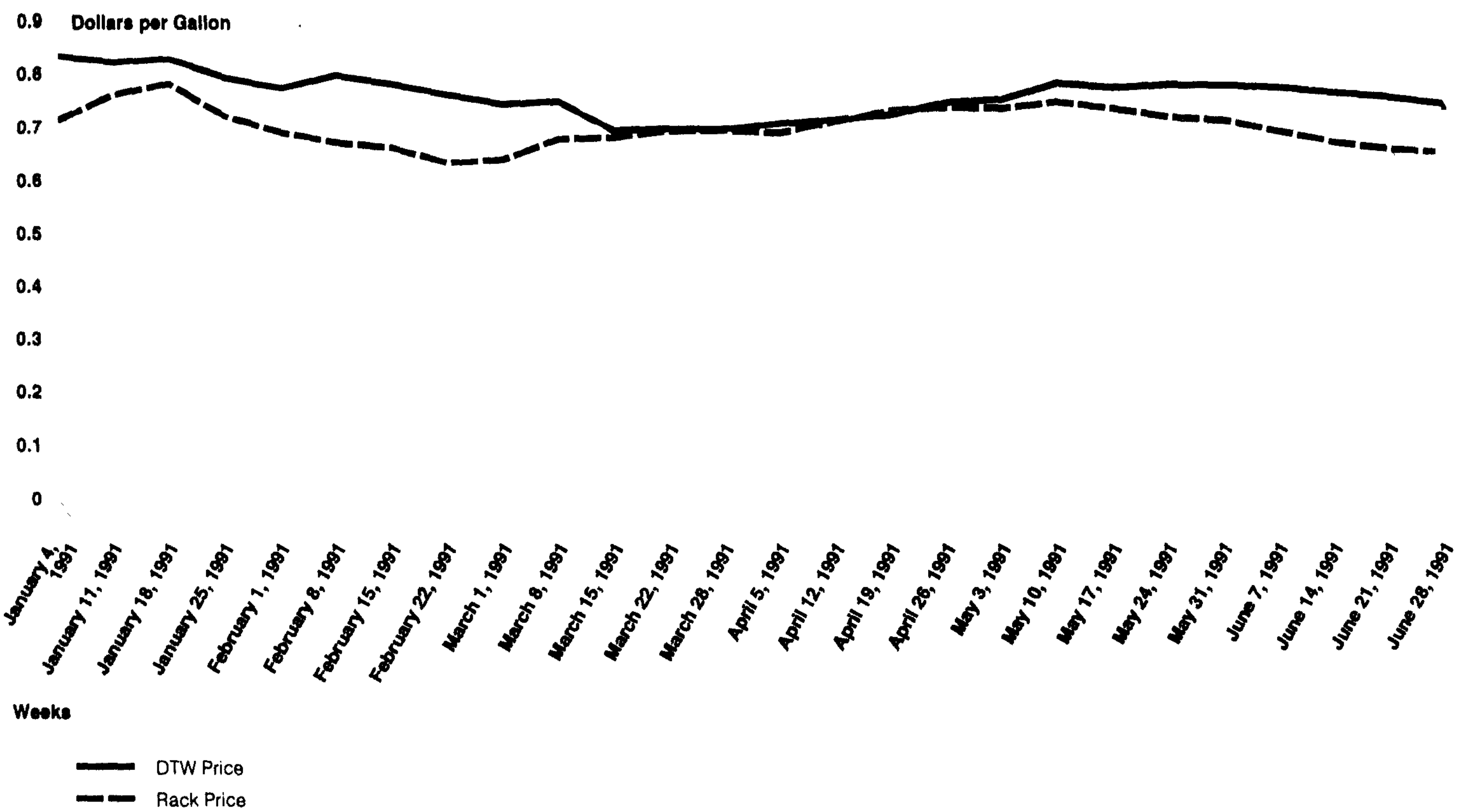
Figure III.4: Inversion of DTW and Rack Prices During 1990



Note: Prices are national averages.

Source: Based on data from The Oil Daily.

Figure III.5: Inversion of DTW and Rack Price During 1991



Note: Prices are national averages.

Source: Based on data from The Oil Daily.

While all wholesale prices of gasoline rose with the increases in crude oil prices during the Gulf Crisis, major refiners did not allow their branded rack and DTW prices to rise as high as the spot prices and their unbranded rack prices. Therefore, unbranded distributors, relying heavily on the spot and unbranded gasoline markets for their supplies, saw their costs rise more than branded distributors'.

Trade associations that represent both distributors and dealers confirmed that distributors' rack prices continued to increase until they surpassed DTW prices during these two periods. Representatives of one trade association acknowledged that while price inversions occasionally occur, the 1990 price inversion—occurring from 6 to 7 weeks—lasted longer than usual. Many distributors could not pass on their increased costs to consumers because of the restraint demonstrated by some major refiners in setting retail prices at company-operated stations. Unbranded distributors, in particular, were forced to price retail gasoline at these lower prices or face the prospect of losing business to company-operated stations and lessee dealers' stations.

Some refiners we spoke with agreed that some distributors experienced cost disadvantages during the Gulf Crisis because of the price inversion. However, it is argued that this is the risk borne by independent gasoline distributors for their lack of contractual obligations and flexibility to shop around for the best price. Normally, unbranded distributors enjoy the lowest costs because they buy at the lowest price from several sources, such as the spot and unbranded rack markets. Therefore, unbranded distributors have given up the protection that a contractual relationship affords when prices are more volatile. For example, some major refiners offered rebates and discounts to their branded distributors and lessee dealers to cushion them from price increases during the Gulf Crisis.

The FTC staff investigated allegations of price discrimination by major refiners—as prohibited under the Robinson-Patman Act[4] —during August and September 1990. The staff found that during this period, there was an inversion between rack prices—particularly, unbranded rack prices—and DTW prices. Although there were a few instances in which refiners charged inverted prices at the same location, the FTC staff concluded that the durations of this practice were probably too short to constitute violations of the Robinson-Patman Act. The FTC staff found that most refiners they investigated did not sell to buyers of branded gasoline and buyers of unbranded gasoline in the same market. Moreover, the FTC staff believed that specific price differences that may have occurred probably reflected discounts or allowances to meet the equally low prices of competing refiners. This investigation was closed by the FTC on December 9, 1991, with a recommendation that no enforcement action be taken.

According to two studies conducted jointly by researchers at Florida State University and API, the inversions of rack and DTW prices were primarily a function of different volatility among different wholesale prices in the

[4]Broadly, the Robinson-Patman Act prohibits sellers from charging similar purchasers of a commodity different prices if the effect may substantially lessen competition or tend to create a monopoly.

gasoline market.[5] Both studies stated that major refiners shielded their branded distributors and dealers from the price increases in the spot market during the Gulf Crisis because of the stronger contractual ties to these distributors and dealers. These studies further concluded that, historically, sharp increases in spot prices have inverted the normal relationships between wholesale prices. These inversions are caused by the greater volatility of rack prices than DTW prices, a condition that reflects the different degrees of contractual protection.

As discussed in chapter 3, the buyer who pays rack prices—particularly, unbranded rack prices—has an advantage over the buyer who pays DTW prices in that the former can buy from multiple suppliers, with the flexibility to vary the amount purchased from each. Under negative market shocks, therefore, average rack prices may overshoot DTW prices because this flexibility weakens the buyers' contractual relationship with individual suppliers.

The DTW price, however, offers the lessee dealer the advantage of having a secure supply and a less volatile price under any market condition. Since the lessee dealer usually sells exclusively the supplier's branded gasoline, the dealer enjoys a stronger contractual bond with the supplier than do buyers who pay rack prices. In addition, major refiners depend on their lessee dealers to market a large volume of their branded retail gasoline. Thus, refiners have a strong incentive to hold down DTW prices relative to other wholesale prices during a negative supply shock. In the case of the Persian Gulf Crisis, this incentive may have been greater because some major refiners were, at the President's request, restraining retail prices at their company-operated stations and most likely wanted to allow their lessee dealers to compete at these lower prices.

Inversions of Prices for Wholesale and Retail Gasoline

Independent distributors and dealers have also alleged that major refiners set retail prices at their company-operated stations lower than the prices at which they are selling gasoline to their own wholesale distributors. Such price inversions are not the nationwide inversions that occurred between rack and DTW prices during the Persian Gulf Crisis, but are usually local occurrences. Since the crisis, allegations of these inversions of the prices of wholesale and retail gasoline have continued.

[5]Philip E. Sorensen, Department of Economics, Florida State University, and Rayola S. Dougher, Lisa A. Hofmann, and Thomas F. Hogarty, Policy Analysis Department, API, "An Economic Analysis of the Distributor-Dealer Wholesale Gasoline Price Inversion of 1990: The Effects of Different Contractual Relations" (April 1991) and "Additional Evidence Relating to the Distributor-Dealer Wholesale Gasoline Price Inversions of 1990-1991: The Effects of Different Contractual Relations" (Sept. 1991).

Representatives of API, DOE, and the Petroleum Marketing Association of America (PMAA) acknowledged to us that inversions of wholesale and retail prices do occur. For example, one API official told us that in August 1990, at the beginning of the Gulf Crisis, the spot price of wholesale gasoline in New York Harbor rose above U.S. average retail prices. These increases in spot prices drove unbranded rack prices—those rack prices of small independent refiners—above retail prices in many areas. Independent distributors that depended on independent refiners were temporarily at a competitive disadvantage, according to this API official.[6] During testimony to the Congress in June 1992, PMAA and other trade associations discussed anecdotal examples alleging that inversions of local wholesale and retail prices—due to unfair pricing by major refiners—have continued since the Persian Gulf Crisis and have exacerbated the financial distress independent distributors have been experiencing for some time.

API and DOE believe that these price inversions are rare, local, and temporary. API further claims that many of PMAA's examples of inversions between wholesale and retail prices in certain locations are misleading and ultimately constitute unrepresentative samples of refiners' behavior. We did not independently assess the validity of PMAA's examples.

Since the Persian Gulf Crisis, according to a representative of PMAA, the demand for gasoline has been decreasing during the recession. As a result, competition at the retail level may have intensified. In this situation, major refiners could reasonably be expected to engage in marketing strategies that would sustain or increase their share of the market in certain areas of the country. Moreover, as discussed in chapter 3, retail prices do not have to conform to wholesale prices in the short term.

A hypothetical example may help to explain how wholesale and retail prices could be inverted in one location. A major refiner could sell branded gasoline to an independent distributor for, say, 80 cents a gallon. At this price, the refiner's margin[7] —the difference between the crude oil price of 60 cents and the wholesale gasoline price of 80 cents—is 20 cents a gallon. This distributor can then sell this gasoline at its own station for 90 cents a gallon, making a 10-cent margin—the difference between the wholesale and retail prices.

[6]The studies by Florida State University and API on the price inversions during the Gulf Crisis do not address the issue of inversions between certain wholesale and retail gasoline prices.

[7]Margins can be used to approximate profits, but margins and profits are not equal.

The major refiner could have a company-operated station in the same local market as the independent distributor's retail station. The refiner could charge its retail customers either 90 cents a gallon, 80 cents a gallon, or even 70 cents a gallon at the company-operated station. At 90 cents a gallon, the retail price of the company-operated station would be the same as the distributor's retail price. At this price, the refiner's margin would be 30 cents. If the refiner sets a price of 80 cents a gallon for its gasoline, the refiner is now pricing at the branded rack price that was charged to the distributor. The refiner is also undercutting the distributor's retail price by 10 cents and accruing a margin of 20 cents. Finally, if the refiner chooses to price its gasoline at 70 cents a gallon, it is now pricing below the wholesale price that was charged to the branded distributor—inverting wholesale and retail prices—as well as pricing below the distributor's retail price in that market by 20 cents. The refiner's margin would then be 10 cents a gallon.

A major refiner can thus choose to accept a reduced margin and still be profitable.[8] This pricing strategy is consistent with competitive market pricing. Such a pricing strategy is not necessarily prohibited by U.S. antitrust statutes. If inversions between certain wholesale and retail prices have become more pervasive nationwide since the Persian Gulf Crisis, they would be financially harmful to certain gasoline distributors and dealers and could cause some distributors and dealers to be driven from the market. Moreover, the observed trend since 1982 is a decreasing number of lessee and open dealers' outlets and an increasing number of company-operated outlets.

Legislation to Address Allegations of Unfair Pricing

Since the 1970s, states have proposed legislation and enacted laws to address concerns of unfair pricing by the petroleum industry. When the Persian Gulf Crisis began, these concerns were renewed and states and the Congress again proposed such legislation. There are five broad types of laws generally proposed to address these concerns: divorcement, open-supply, anti-price-gouging, below-cost sales, and minimum-markup statutes. Divorcement laws prohibit or restrict refiners from operating their own retail gasoline stations. Open-supply laws permit retail dealers to buy gasoline from more than one supplier. Anti-price-gouging statutes prohibit refiners from charging excessively high prices for petroleum products. Below-cost sales laws, which vary, could require that a refiner not sell gasoline for less than the refiner's average cost, while

[8]This example does not address distribution and other relevant costs, which may be different for different firms and thus affect profitability.

minimum-markup laws establish minimum wholesale and retail gasoline margins.

Bills that were introduced to the 102nd Congress after the Gulf Crisis began include H.R. 2966 and S. 2041, the "Petroleum Marketing Competition Enhancement Act"; S. 2043, the "Motor Fuel Marketing Competition Enhancement Act"; and S. 790, the "Motor Fuel Consumer Protection Act of 1991." H.R. 2966, S. 2041, and S. 2043 generally proposed that minimum markups between certain wholesale and retail gasoline prices be required, while S. 790 would prohibit refiners from operating retail stations and would permit, with some exceptions, retailers to buy gasoline from more than one supplier.

According to API, 42 states had legislation regarding gasoline pricing under consideration in 1990. The number of states with such legislative activity dropped to 25 in 1991. Between 1990 and 1991, petroleum pricing legislation was ultimately passed in five states—including below-cost sales and minimum-markup laws in Florida, Montana, and Utah and anti-price-gouging laws in Connecticut and Massachusetts—according to API.

In reviewing the relevant literature and analyses of these laws and discussing the laws with state officials, we found limited conclusive information on these laws' effects on gasoline prices. Maryland—which in 1974 was among the first states to enact a divorcement law—has been the subject of numerous studies on the effect of divorcement.[9] The findings of these analyses, however, are contradictory. While several studies show that retail gasoline prices have been higher in Maryland because of the divorcement law, another study concludes that divorcement has benefited consumers.[10]

[9]Maryland's divorcement law has been enforced since 1979.

[10]We did not evaluate the methodologies used in these analyses.

Availability of Data From the Energy Information Administration and Others for Federal Oversight of the Oil Market

This appendix provides an overview of federal agencies' responsibilities for oversight of the domestic oil market and discusses these agencies' views on the availability of data from EIA and other sources for monitoring the oil market and enforcing antitrust laws.

Agencies' Responsibilities for Oversight

The responsibility for overseeing the domestic oil market is shared by several agencies, including the Commodity Futures Trading Commission (CFTC), the FTC, and the Department of Justice. DOE's EIA is the focal point for the federal government's collection, analysis, and dissemination of statistics on energy. Federal agencies use EIA's data to assess market conditions, particularly during market disruptions.

EIA gathers data on the industry primarily by surveying refiners, wholesalers, and retailers, and the agency reports this information in a variety of weekly, monthly, and annual publications. The CFTC regulates trading on 14 U.S. futures exchanges, including the New York Mercantile Exchange (NYMEX), the commodities market in which energy futures are traded. The CFTC monitors transactions on NYMEX and the participants in the transactions to ensure that futures trading is fair and that it protects the rights of customers and the financial integrity of the marketplace. Justice and the FTC share the authority to investigate charges of collusion in pricing, predatory pricing, and other discriminatory pricing practices in the U.S. marketplace.

Agencies' Need for EIA's and Others' Data

CFTC, Department of Justice, and FTC officials told us that, for their purposes, they need more specific and/or more frequent data than EIA normally collects and/or provides. To meet this need, agency officials explained, they purchase data from private sources.

CFTC officials told us that they utilize data on petroleum prices from a variety of sources, including EIA, API, and Platt's Oilgram newsletter. Although EIA reported daily spot prices for selected petroleum products during the Gulf Crisis, the CFTC purchased from private sources additional data on spot prices. CFTC officials told us, however, that they do not expect EIA to provide all of the data they need to surveil the market and that EIA's data provide a general appraisal of supply and demand.

Officials from the Department of Justice and the FTC told us that they had to purchase data from private sources to support their investigations into allegations of anticompetitive behavior in the gasoline market during the

Persian Gulf Crisis. The officials explained that these investigations, which focused on the prices paid by various participants in the wholesale gasoline market, required having more specific wholesale prices. Since EIA revised its data collection process in 1983, the agency reports a single price for wholesale gasoline, one that incorporates prices paid by distributors of unbranded and branded gasoline (unbranded and branded rack) and by the lessee dealers (DTW). Consequently, EIA's data on wholesale gasoline prices have been of limited use in the Department of Justice's and the FTC's investigations. One FTC official told us, however, that having to purchase data on wholesale prices is not a major concern.

Access to EIA's Company-Specific Proprietary Data

Although EIA does not collect all of the data needed by the CFTC, the Department of Justice, and the FTC, it does collect some data that it has not shared. Department of Justice officials told us that resolution of two investigations of alleged price-fixing—during the December 1989 Heating Oil Crisis and the Persian Gulf Crisis—had been put on hold for several months because Justice was unable to gain access to company-specific proprietary data that EIA collects.

EIA officials told us that they regard their agency as an organization gathering statistical data and believe that any proprietary data it gathers should not be used for law enforcement purposes. Traditionally, EIA has satisfied federal agencies' requests for information by supplying the agencies with aggregate statistics. EIA is concerned that releasing proprietary data for law enforcement purposes could compromise further cooperation by private companies and the overall quality of further data submitted to them by private companies.

In March 1991, the Department of Justice issued a decision that EIA was required by statute to release any data it collects, including company-specific proprietary information, to any federal agency requesting the data for official use. This information would be protected from public disclosure. In recent discussions with Department of Justice officials, we learned that the agency has received some of the data that it had requested from EIA, but none of the company-specific proprietary data. The Department of Justice closed its investigations into the 1989 Heating Oil Crisis and the Persian Gulf Crisis without the benefit of the company-specific proprietary data from EIA. The Department of Justice believes it is legally entitled to company-specific proprietary data from EIA and will seek to obtain such data if appropriate in future investigations.

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