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Assessment of Summer 1997 Motor Gasoline Price Increase

Energy Information Administration
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Contents

Tables

Figures

1. Introduction

Gasoline markets in 1996 and 1997 provided several spectacular examples of petroleum market dynamics. The first occurred in spring 1996, when tight markets, following a long winter of high demand, resulted in rising crude oil prices just when gasoline prices exhibit their normal spring rise ahead of the summer driving season. Rising crude oil prices again pushed gasoline prices up at the end of 1996, but a warm winter and growing supplies weakened world crude oil markets, pushing down crude oil and gasoline prices during spring 1997. The 1996 and 1997 spring markets provided good examples of how crude oil prices can move gasoline prices both up and down, regardless of the state of the gasoline market in the United States. Both of these spring events were covered in prior Energy Information Administration (EIA) reports.[1]

As the summer of 1997 was coming to a close, consumers experienced yet another surge in gasoline prices. Unlike the previous increase in spring 1996, crude oil was not a factor. The late summer 1997 price increase was brought about by the supply/demand fundamentals in the gasoline markets, rather than the crude oil markets.

The nature of the summer 1997 gasoline price increase raised questions regarding production and imports. Given very strong demand in July and August, the seemingly limited supply response required examination. In addition, the price increase that occurred on the West Coast during late summer exhibited behavior different than the increase east of the Rocky Mountains. Thus, the Petroleum Administration for Defense District (PADD) 5 region needed additional analysis (Appendix A). This report is a study of this late summer gasoline market and some of the important issues surrounding that event.

Chapter 2 provides an overview of U.S. fundamental supply/demand balance movements behind the summer 1997 gasoline price increase.

Chapter 3 discusses the market on the West Coast, which is essentially independent of the markets east of the Rocky Mountains.

Chapter 4 provides an in-depth examination of U.S. gasoline production this past summer. The United States experienced record-high production levels and very high capacity utilization rates, but aggregate PADD-level information alone can only provide clues as to how close the industry was to producing at maximum capability. This chapter summarizes a study that examined individual refineries as well as aggregate information to answer this question.

Chapter 5 provides a closer look at gasoline imports to the United States, which played an important role in the price increase in the eastern portion of the country.

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1 Department of Energy, *An Analysis of Gasoline Markets Spring 1996*, DOE/PO-0046, June 1996; Energy Information Administration, *Motor Gasoline Assessment Spring 1997*, DOE/EIA-0613, July 1997.

Chapter 6 focuses on the interrelationships among gasoline prices at various levels in the distribution system and on the futures market. In the futures market, noncommercial traders (speculators) behaved differently during the late summer price runup than in the past. The chapter also revisits the connection between spot and retail prices to see if they maintained their normal relationship through the August runup.

Appendix A lists the states included in each PADD.

Appendix B explores why California prices are frequently higher than average U.S. prices.

Appendix C provides background information on the fundamentals of how crude oil is transformed into refined products. The discussion includes several demonstrations of how those fundamentals are applied in developing the results of Chapter 4.

Appendix D is a description of the EIA capacity data used in Chapter 4.

Appendix E contains the technical background for the statistical analysis relating gasoline retail and spot prices that is summarized in Chapter 6.

Throughout the publication, data mentioned in the text are generally from the following references:

Volume Data: *Petroleum Supply Annual* (DOE/EIA-0340) and *Petroleum Supply Monthly* (DOE/EIA-0109) publications.

Monthly Price Data: *Petroleum Marketing Annual* (DOE/EIA-0487) and *Petroleum Marketing Monthly* (DOE/EIA-0380) publications.

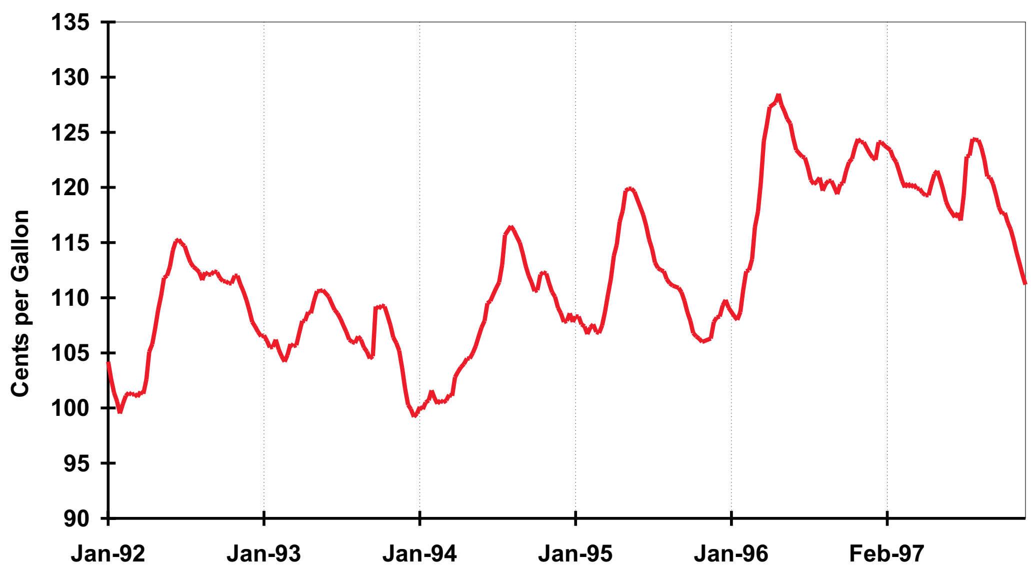
Weekly Retail Price Data: Form EIA-878, "Motor Gasoline Price Survey," published in the *Weekly Petroleum Status Report* (DOE/EIA-0208).

Spot Price Data: Reuters or DRI Platts Data.

2. Fundamentals Drive Up August Prices

U.S. retail gasoline prices have varied widely in recent years (Figure 2.1). They can fluctuate as much as 10 cents per gallon seasonally, excluding other market conditions such as crude oil price changes. Although gasoline prices frequently are driven up by heightened demand relative to supply in August, the size of the increase nationwide in August 1997 was unusual. New York Harbor spot prices for reformulated (RFG) and conventional gasoline rose about 20 cents per gallon from the end of July through August 20, while West Texas Intermediate crude oil prices only rose about 1 cent per gallon. Conventional retail prices increased about 7 cents, while RFG increased over 11 cents per gallon. The smaller increase in retail prices compared to spot prices is mainly due to the typical retail price lag behind spot market price changes (Chapter 6).

Figure 2.1 Weekly Retail Regular U.S. Gasoline Prices

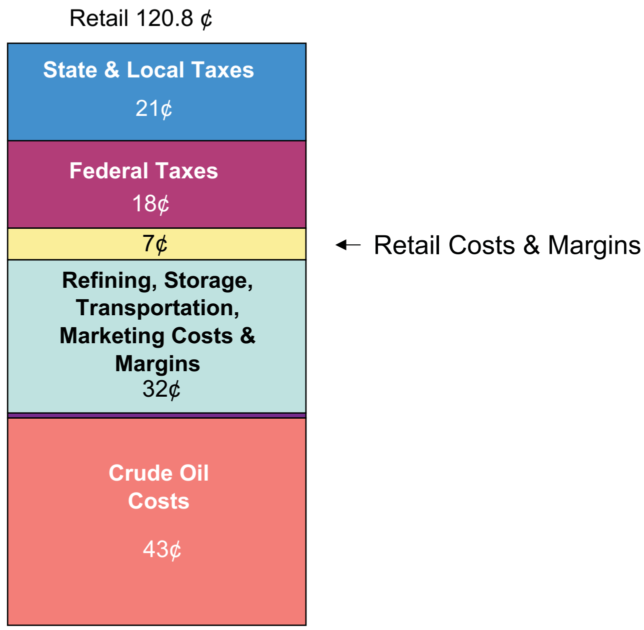


Source: Energy Information Administration, Weekly Retail Outlet Prices, Regular Grade, All Gasoline Formulations (Conventional, Oxygenated, Reformulated), Form EIA-878, "Motor Gasoline Price Survey."

Movements in gasoline prices come from changes in the components of price, which are illustrated in Figure 2.2. In August 1997, crude oil, the primary material from which gasoline is made, cost $18 per barrel (43 cents per gallon), and represented about 36 percent of the retail gasoline price. Refining, distribution, marketing, transportation costs and margins were about 32 cents per gallon, while retail costs and margins amounted to 7 cents per gallon. State and Federal taxes together came to 39 cents per gallon, excluding percentage-based taxes such as gross earnings taxes.

Changes in the components can derive from regular seasonal variations in the market place as well as unexpected market changes. Seasonal variations in price stem mainly from changes in the

Figure 2.2 Gasoline Price Components (Conventional Regular Grade, August 1997, Cents per Gallon)



Source: Energy Information Administration, *Petroleum Marketing Monthly*, DOE/EIA-0380(97/12), Tables 1, 32, EN1. Form EIA-878, "Motor Gasoline Price Survey."

refining, marketing, and distribution margins, while some of the more recent, dramatic, unexpected price increases have come from variations in the crude oil price component.

In 1996 and 1997, consumers saw several large gasoline price changes. A dramatic runup occurred in spring of 1996, mainly due to sharply rising crude oil prices occurring just when gasoline prices were increasing seasonally at the beginning of the summer driving season. In spring 1997, the opposite occurred as crude oil prices fell, pulling gasoline prices downward. Gasoline prices declined for much of the summer. Then in August 1997, consumers experienced another unusual price increase, but with different underlying causes than those behind the prior price changes. While crude oil prices were the main reason for unusual gasoline price behavior in spring 1996 and spring 1997, crude oil prices were static in August 1997. The remainder of this chapter will address the factors driving the August gasoline prices upward.

U.S. Supply and Demand Fundamentals

Prices respond to changes in demand and supply. U.S. demand is met through production, net imports, and changes in inventory levels. If demand outstrips supply from production and net imports, stocks are drawn to meet the imbalance. If stocks are low in this situation and continuing to fall, rising uncertainties over supply adequacy can generate "precautionary buying" price pressure. This section explores how each of the demand and supply elements contributed to the tightening of the market that eventually drove prices up in August.

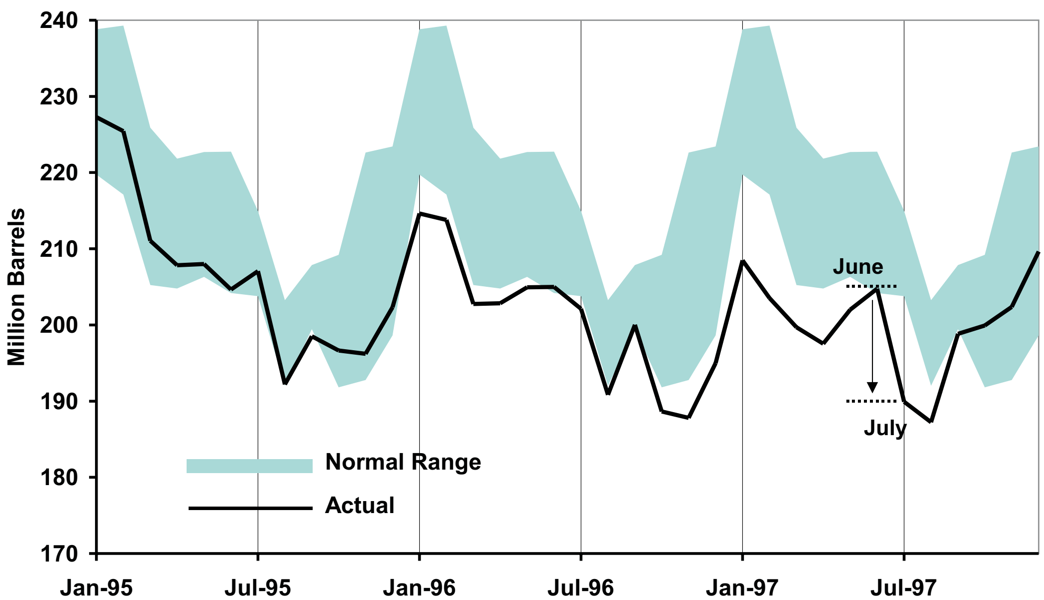
Inventories Plunged in July Indicating Market Imbalance

Stocks are the component of supply that balance demand with refinery output and net imports. As such, they serve as a barometer for judging whether the market balance is tightening or loosening. Buyers watch weekly reports of stock levels for unusual and persistent declines in levels during periods of high demand. If stocks are falling and approach minimum operating levels (i.e., the level needed to keep gasoline flowing from refineries to end users), wholesale buyers sometimes become concerned that supplies may not be adequate over the short term, and willingly bid prices higher to assure that they have product.

Gasoline inventories began 1997 at very low levels, but high production and exceptionally high imports exceeded demand, allowing stocks to recover. In May and June, total gasoline stocks, and RFG stocks in particular, increased to end June at the bottom of the normal range (Figure 2.3). But during July, the situation changed rapidly. Gasoline stocks plummeted, dropping 15 million barrels, compared to an average monthly decline (for the 1992-1996 period) of 4 million barrels. Stocks ended the month at near-record low levels. Gasoline suppliers were left facing August, which is usually the highest demand month of the year, with virtually no discretionary inventory.

As August progressed, production and import levels did not meet domestic demand and export needs. Stocks continued to fall in August, ending the month at the lowest level recorded since 1981. The rest of this section describes how demand and the other supply components contributed to the tightening market in July as exhibited by the stock decline, and the subsequent August price increase.

Figure 2.3 U.S. Finished Gasoline and Gasoline Blending Component Stocks

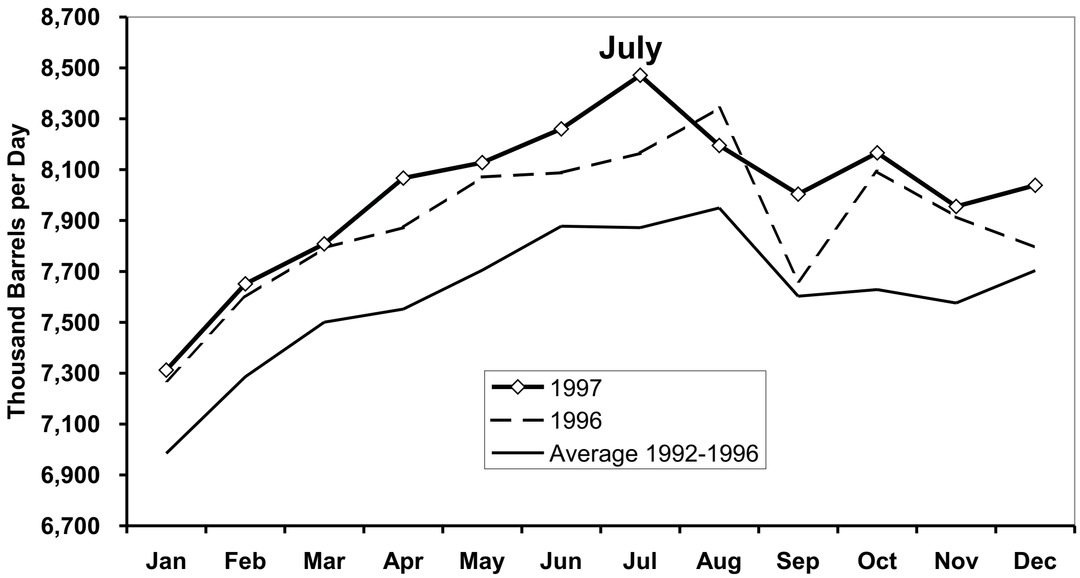


Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(92-96)/2, Table 2. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 2.
Note: Normal range is the 1992-1996 average value for a given month plus or minus one standard deviation of that month's values.

Demand Played a Major Role in July Market Turnaround

Unexpected, very high gasoline demand in July was a major factor behind the August 1997 price increase (Figure 2.4). Through June 1997, demand[1] rose a modest 1.1 percent over levels seen during the first 6 months of 1996. Gasoline demand typically varies little in July from June levels, and usually peaks in August. July 1997 demand shot up 211 thousand barrels per day (2.6 percent) over an already high June demand, reaching a peak not seen since EIA data collection began in January 1981. The year-over-year July increase was almost 4 percent.

Figure 2.4 U.S. Motor Gasoline Demand



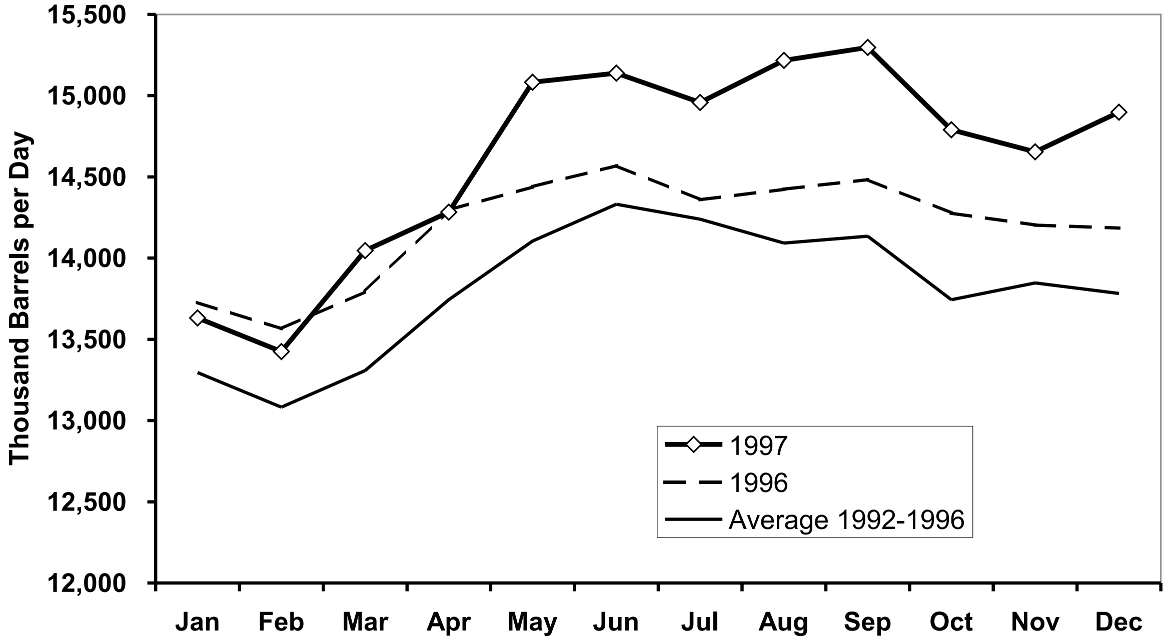
Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual,* DOE/EIA-0340(92-96)/2, Table 3. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 4.

Production Also Contributed to the Market Tightening

As refineries came out of spring maintenance in 1997, stocks were quite low, and seasonal gasoline margins were higher than normal, which encouraged strong production. From April to May, refineries increased crude oil inputs 800 thousand barrels per day (Figure 2.5). The year-over-year increase in May was 640 thousand barrels per day. In PADD 1, which represents only about 10 percent of U.S. capacity, the April to May crude oil input rise was a robust 200 thousand barrels per day, due in part to the return to operation of the Tosco Trainer refinery in May. U.S. operable refinery utilization jumped from 92.6 percent in April 1997 to 97.3 percent in May, as refiners pushed to meet both growing gasoline needs and strong jet fuel and diesel demand. Although

1 Demand in this report is deduced from primary supply and disposition data. It is equal to field production, plus refinery production, plus net imports, minus refinery inputs, minus stock change.

Figure 2.5 U.S. Crude Oil Inputs to Refineries



Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual,* DOE/EIA-0340(92-96)/2, Table 3. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 4.

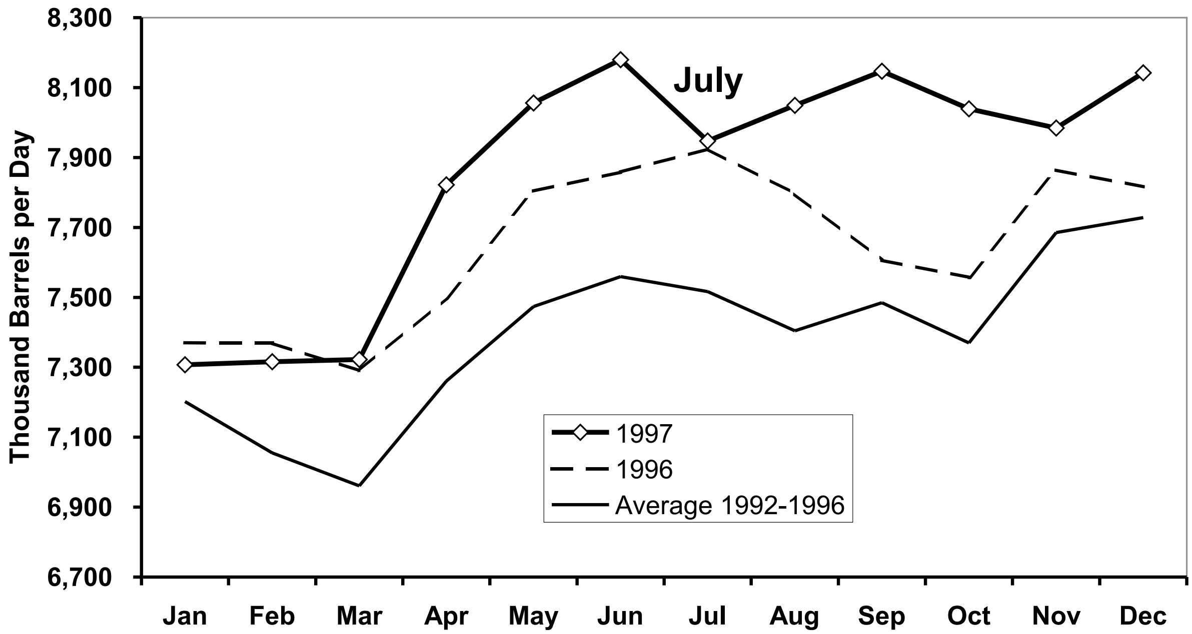
year-over-year gasoline yields in May had dropped, the high crude oil inputs resulted in the highest gasoline production since 1981, and the stock situation began to improve.

In June, crude runs were even higher and refinery utilization tipped 97.7 percent, with PADD's 2 and 3 reaching 103.2 percent and 99.0 percent, respectively, as both high distillate and gasoline demands were being met. These regional utilizations were exceptionally high and perhaps not sustainable. U.S. gasoline refinery production broke the May record to average 8,050 thousand barrels per day. With field production included, total gasoline production averaged 8,180 thousand barrels per day for the month (Figure 2.6). As in May, gasoline yields in many parts of the country were lower than in 1996. Production increases were being achieved with increased crude oil inputs. Gasoline stocks finally grew back into the normal range, as measured by historical stock levels for June, and gasoline margins began to weaken.

With growing inventories, very high capacity utilizations in some areas, weakening margins, and recognition that demand growth through June was lower than expected, refiners in PADD's 1, 2 and 3 reduced production slightly in July. As a result, U.S. production declined from June by 224 thousand barrels per day (2.8 percent). Relative to prior years, July production was still high, and utilization only fell back to 97.1 percent. PADD 2 and PADD 3 July utilizations were 100.1 and 97.1 percent, while PADD 1 utilization, at 94.4 percent, changed little from June.

In summary, production declines in July, as demand unexpectedly shot up, contributed to the market tightening that induced the August price increase. July production reflected refiners'

Figure 2.6 U.S. Refinery and Field Gasoline Production



Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual,* DOE/EIA-0340(92-96)/2, Table 3. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 4.

assessment of the market from the perspective of the weakening market in late June. As July demand overtook those assessments and prices eventually rose, refiners responded with increased production in August. U.S. August utilization was 98.6 percent, with PADD 1 at 93.9 percent, PADD 2 at 102.6 percent and PADD 3 at 99.1 percent. Yet, the magnitude of the August gasoline production increase did not add sufficient supply to draw prices down. Lower gasoline yields in summer 1997 than in 1996, high production, and very high utilizations coupled with sustained high prices led to EIA looking more closely at how refineries operated this past summer (Chapter 4). The aggregate data begged the question of whether at least part of the August price rise was due to the U.S. refineries operating at capacity.

Net Imports Fell Through July, Diminishing Supply

Imports, along with production, help explain why the market tightened in late July. Gasoline imports are an important supply source for the eastern United States. In 1996, over 95 percent of U.S. imports of finished gasoline and blending components came to the East Coast (PADD 1). Imports for the first half of 1996 supplied about 17 percent of East Coast gasoline demand, but for the first half of 1997, imports were even higher, meeting almost 21 percent of the region's needs.

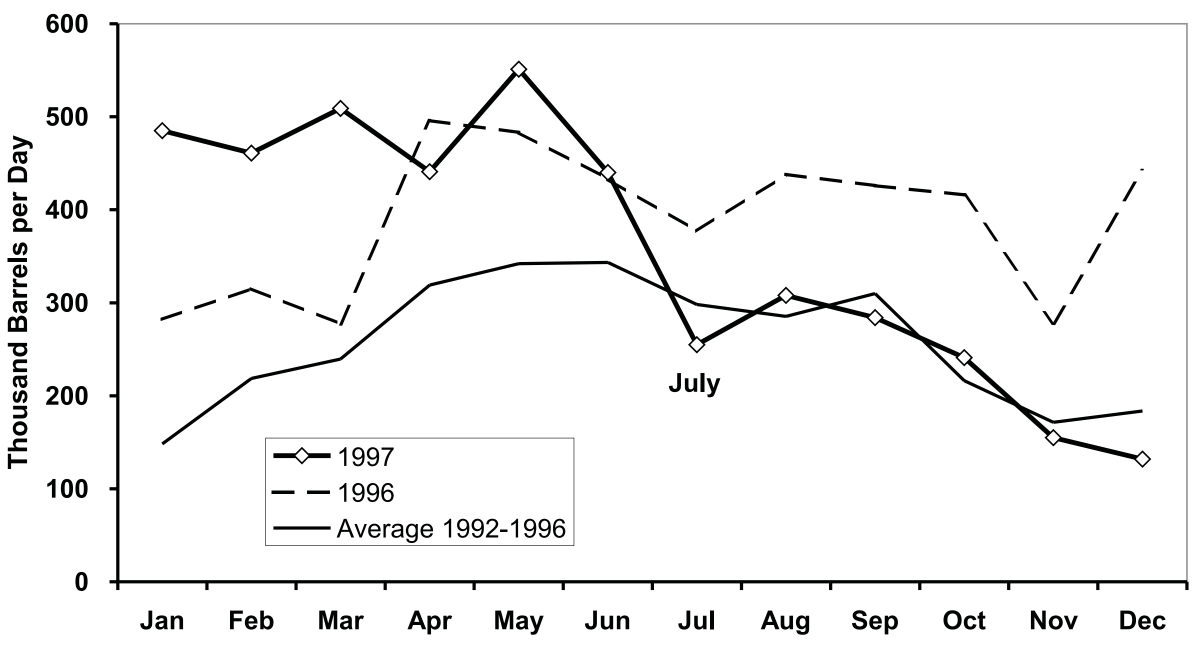
Refinery turnarounds during the first quarter helped encourage imports. But imports stayed high as refineries resumed strong production in April and May, running at high utilizations and having additional volumes from the return of the Trainer refinery in PADD 1. Imports began to fall after peaking in May 1997 at 664 thousand barrels per day, tumbling 109 thousand barrels per day in June and another 125 thousand barrels per day in July. July imports averaged 430 thousand barrels per day, 77 thousand barrels per day less than the previous year.

Most of the decline in June and July stemmed from a drop in European imports, which were discouraged by U.S. East Coast market prices declining relative to European prices. The high U.S. imports and production in May and June weakened the market, causing prices and margins in the U.S. to decline. Although European prices also fell in June, U.S. prices fell faster, thus decreasing the incentive for Europeans to ship gasoline to the United States (Chapter 5).

U.S. gasoline exports, which are much smaller than imports, increased in July about 60 thousand barrels per day over June to average 175 thousand barrels per day, but most of the increase was from the West Coast (Chapter 3). Exports had little effect on eastern U.S. markets. Because of the relative size of imports to exports, U.S. net imports followed the pattern of imports over the summer 1997; however, the falloff in July is slightly exaggerated by the increase in exports (Figure 2.7).

In conclusion, declining imports were another important contribution to the market reversing from weak in June to tight by the end of July. With August being near the end of the gasoline season, and uncertainty over how long prices would remain elevated, buyers and sellers were reluctant to commit to additional imports. August net imports only rose 53 thousand barrels per day over July.

Figure 2.7 U.S. Net Imports of Finished Gasoline and Blending Components



Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual,* DOE/EIA-0340(92-96)/2, Table 3. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 4.

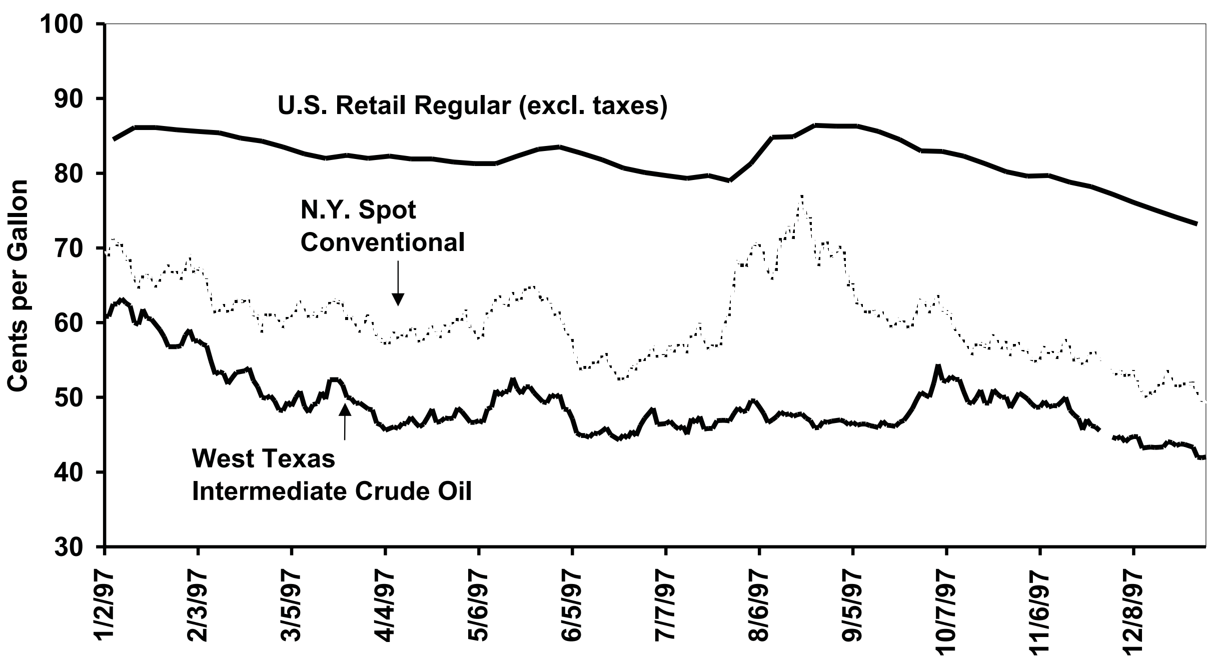
Thus, not only did falling imports in June and July play a role in adding to the market tightening in late July, they also played little role in resolving the tightness in August.

Gasoline Prices Responded to Change in Market Balance

Despite relatively flat crude oil prices during summer 1997, spot gasoline prices responded to the dramatic increase in July gasoline demand and drop in inventories by turning up sharply at the end of summer (Figure 2.8). Spot gasoline prices had been climbing slowly since late June as markets began to tighten. Towards the end of July, gasoline spot market prices began to rise sharply, as buyers were confronted with rapidly expanding consumption and declining stocks. With little discretionary inventory left, and facing the prospect of even higher demand in August, prices rose rapidly as market fundamentals tightened and precautionary buying added upward pressure. During one week, from July 24 to July 31, New York Harbor spot conventional gasoline prices rose over 10 cents per gallon.

In late July and early August, numerous refinery problems were reported. Uncertainties in the timing and duration of a maintenance shutdown of the Tosco Bayway refinery's large fluid catalytic cracking unit, a key East Coast supply source, added buying pressure, as did a fire at Exxon's Baytown refinery, problems at two of PDVSA's (Venezuela's) export refineries, and a subsequent

Figure 2.8 Gasoline and Crude Oil Prices



Source: Spot Prices: Reuters Daily Spot Prices; **Retail Prices:** Energy Information Administration, Weekly Retail Outlet, Regular Grade, All Formulations (Conventional, Oxygenated, Reformulated), Form EIA-878 "Motor Gasoline Price Survey," less estimated taxes of 38 cents per gallon.

declaration by Venezuela of *force majeure* on up to nine cargoes of gasoline scheduled for August delivery to the United States. In addition, three major refineries in Europe experienced catalytic cracking unit problems during this same time, signaling that little supply relief would come from that important source of gasoline imports.

Although demand dipped somewhat in August, supply increases from production and imports were insufficient to cover continuing relatively high domestic demand and export requirements. As a result, inventories continued to decline, albeit at a slower rate than in July. Prices continued to rise through the first part of August. New York Harbor spot prices increased about another 10 cents per gallon from July 31 to August 20, when they peaked at almost 77 cents per gallon, or about 20 cents higher than in late July.

On top of the gasoline supply/demand fundamentals, oxygenates also added to gasoline price pressure. Methyl tertiary butyl ether (MTBE) supply problems pushed MTBE prices up, which, in turn, elevated RFG prices faster than those for conventional gasoline (See Sidebar - 1997 Oxygenate Markets). MTBE spot prices averaged 4 cents per gallon higher in June than in May due to supply problems, and rose further in July to average 11 cents per gallon higher than June. These increases could add about 2 cents per gallon to the price of RFG versus conventional, all other factors being equal. However, RFG prices increased more than would be expected from the rising cost implications of MTBE. RFG spot prices in New York held at about 2.5 cents per gallon over conventional in June, but spiked briefly in the later part of July to about 6 cents per gallon over conventional. In August, MTBE prices began to fall, and RFG prices quickly receded to a 2.5-3.0 cent differential over conventional.

Along with rising MTBE values, the strong New York Harbor spot RFG price response relative to conventional gasoline during this period was affected by the strong dependence of East Coast RFG supply on distant sources like imports, which cannot quickly fill unexpected needs. Imports, the most distant supply source, supplied about 31 percent of East Coast RFG demand in 1997, and other U.S. regions (mainly PADD 3) supplied another 30 percent of East Coast RFG demand. With rising MTBE prices, dwindling stocks, and little production close at hand, RFG buyers on the East Coast bid prices up in an effort to assure their needs would be met.

The impact of increases in spot and wholesale prices in late July and the first three weeks of August showed up at the retail level in August and the first part of September (Figure 2.10). While retail prices nationwide rose less than spot prices, as is typically the case, they nevertheless rose to an unusual degree during this period (Chapter 6). With demand receding from high summer driving levels after Labor Day, prices softened and continued to fall through year end.

In summary, 1996 and 1997 exhibited crude-driven and gasoline market-driven price changes. The two crude-driven situations (spring 1996 and spring 1997) were described in earlier reports. Table 2.1 summarizes the similarities and differences between the two spring markets and the gasoline-driven August 1997 market.

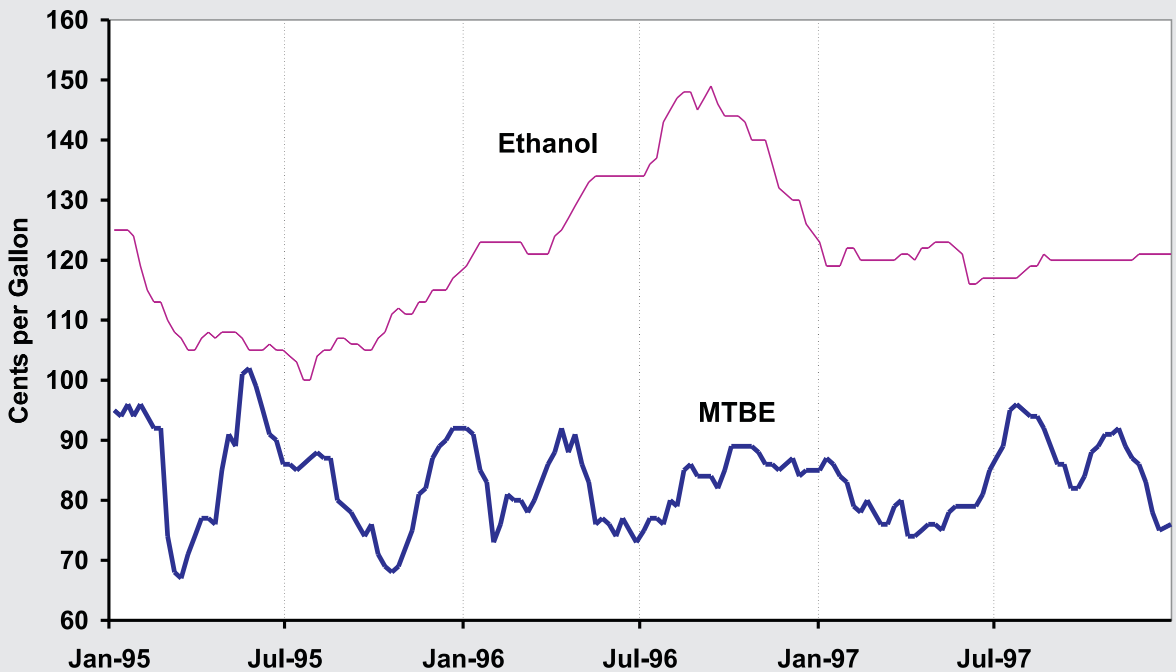
The nature of the summer 1997 price increase raised questions regarding production and imports, requiring an EIA examination of the factors contributing to the relatively weak supply response. In addition, the price increase that occurred on the West Coast in late summer 1997 exhibited different

1997 Oxygenate Markets: Ethanol Quiet, MTBE Volatile

Ethanol prices were fairly stable during August, as they were through most of 1997, fluctuating in a narrow band around $1.20 per gallon (Figure 2.9). In the United States, corn is the primary source for fuel ethanol, and for most of the year corn prices traded in a range between $2.50 and $3.00 per bushel. In contrast, spot corn prices in 1996 had varied between $2.50 and $5.25 per bushel, and ethanol prices were correspondingly much more volatile than MTBE prices.

In July 1997, it was MTBE that had a sharp price runup, peaking at 96 cents per gallon, 22 cents per gallon higher than its low point in April. Methanol is an important feedstock for making MTBE, and it rose in price in July to 66 cents per gallon, 8 cents higher than in June. In addition, plant outages in August decreased the supply of MTBE, keeping prices elevated over 90 cents per gallon through much of August. The price spike in MTBE added to the overall cost of gasoline in August.

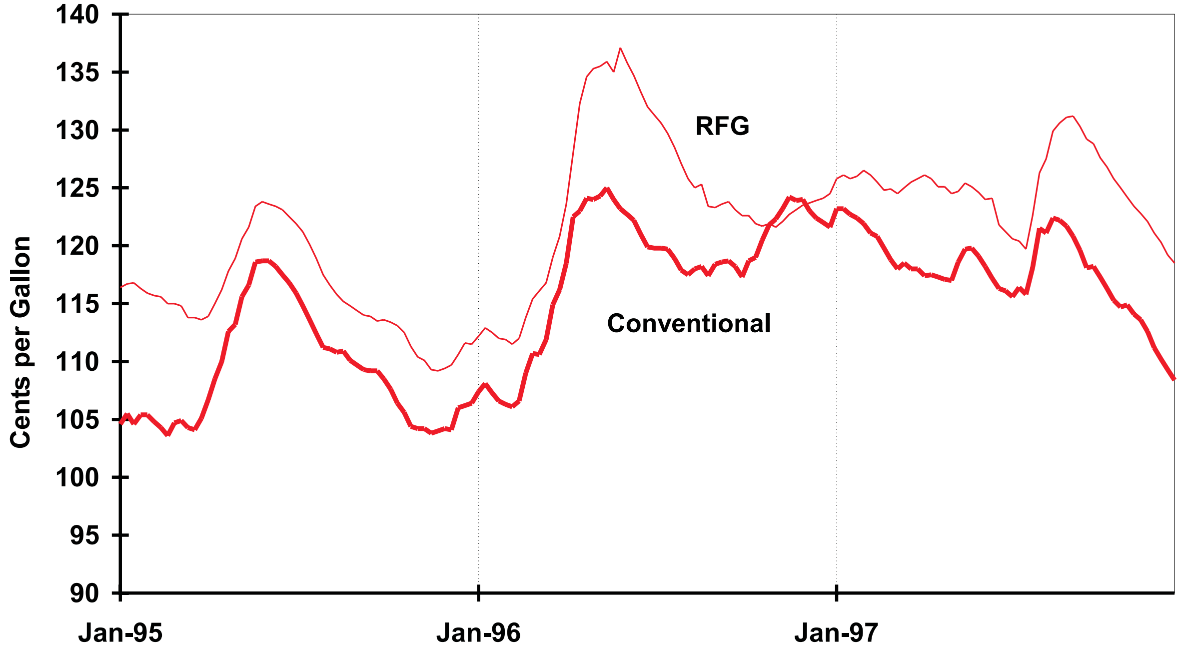
Figure 2.9 Oxygenate Prices



Source: "Octane Week Price Report," *Octane Week*, Hart Publications, Arlington, VA, Various Issues.

behavior than seen in the rest of the country. The remaining chapters of the report provide the results of the EIA work in these areas.

Figure 2.10 U.S. Weekly Retail Regular Gasoline Prices



Source: Energy Information Administration, Retail Outlet, Regular Grade, Form EIA-878, "Motor Gasoline Price Survey."

Table 2.1 July-August 1997, Spring 1997, and Spring 1996 Summary Market Comparison

Markets	January-April 1996	January-April 1997	July-August 1997
Crude Oil Markets	Began 1996 under $20/barrel.	Began 1997 about $26/barrel after high-demand fourth quarter.	Began July just over $20/barrel after a slight increase at the end of June.
	Tight: Prices rose February thru April with cold weather and lack of expected supplies.	Weakening: Prices fell January through April with strong supplies relative to demand.	Flat: Market stayed relatively constant. West Texas Intermediate (WTI) fell back in July, averaging $19.66. August WTI averaged $19.95.
	Backwardation was steep (decreasing term structure of crude oil futures contracts).	Term structure of crude oil futures was flattening.	Futures market was in contango (increasing term structure) during July and August.
U.S. Gasoline Supply/Demand Balance	Demand growth was modest (1.1 percent).	Demand growth was low to modest (0.8 percent).	Demand growth was modest through June (1.1%), but shot up in July (3.7% over July 1996). Third quarter demand in 1997 averaged 2.1% higher than in 1996.
	Demand level was seasonally high (7,601 thousand barrels per day).	Demand level was seasonally high (7,658 thousand barrels per day).	Demand level was record high in July (8,471 thousand barrels per day); fell back slightly in August (8,195 thousand barrels per day).
	Production growth was modest.	Production growth was modest.	Production in July was higher than previous July, but 233 thousand barrels per day less than record-high June production.
	Imports were high through the market event (met 6.0 percent of national demand).	Imports were very high through the entire event (met 7.7 percent of demand).	Imports began very high, but fell rapidly in June and July. Met 8.2 percent of demand in May, 6.7 percent in June, and 5.1 percent in July.
	Stocks were low.	Stocks were very low.	Stocks recovered to normal levels in June, but dropped well below the normal range in July and reached record lows in August.
Gasoline Price Components	Increasing crude oil prices pushed gasoline prices up.	Falling crude oil prices brought gasoline prices down.	Flat crude oil prices did not affect gasoline prices.
	Spot spreads were mainly at or below seasonal norms.	Spot spreads were slightly above seasonal norms.	Spot spreads moved from below seasonal norms in June to slightly above in July, and well above seasonal norms in August.

Source: Energy Information Administration

3. PADD 5 August Gasoline Markets

PADD 5 covers the western region of the United States and represents about 17 percent of the nation's gasoline demand (Table 3.1). It is relatively isolated from other PADD's in terms of petroleum supply. Pipeline connections from other PADD's reach only a very limited area in the region, and tankers from the Gulf Coast must transit the Panama Canal. In addition, major product import sources, such as Europe, are a long distance from the West Coast. As such, refineries within PADD 5 supply almost all of the region's needs. Isolated markets even exist within the PADD, such as Alaska and Hawaii. California is also somewhat isolated because of its use of a unique clean-burning fuel -- California reformulated gasoline (CaRFG). This single state consumes over 10 percent of the gasoline sold in the United States, and produces most of PADD 5's gasoline.

Table 3.1 1997 Gasoline Supply and Demand Summaries by PADD
(Thousand Barrels per Day)

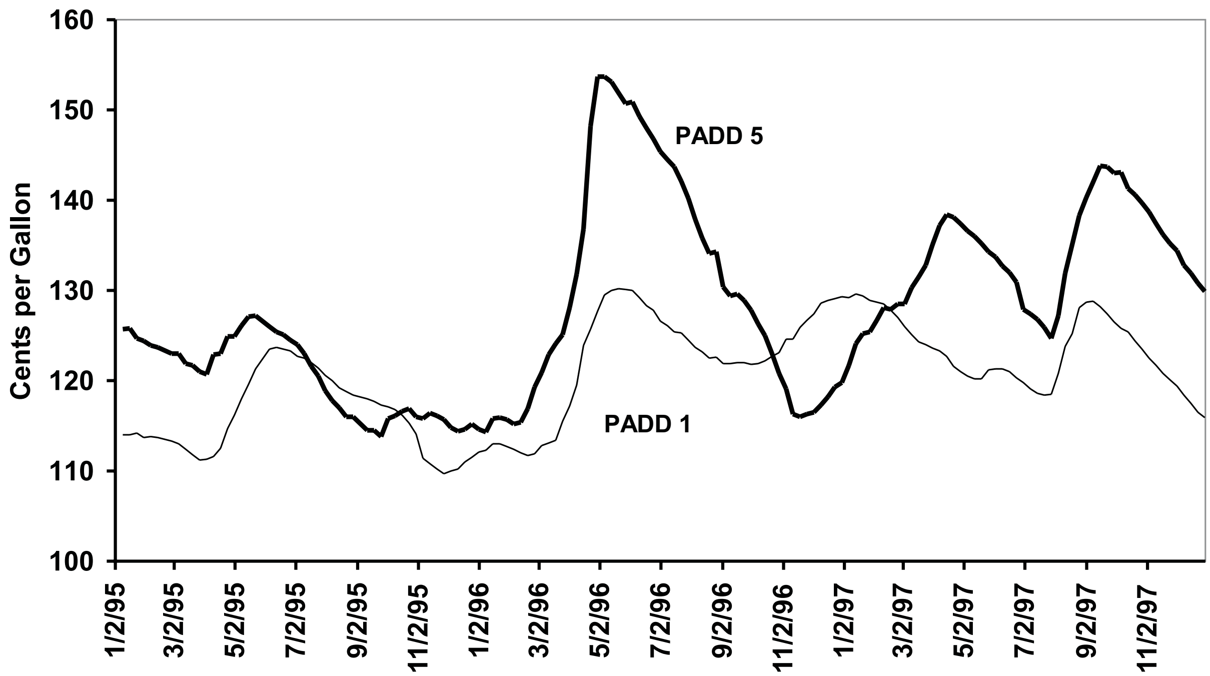
PADD	Demand	Total Production	Total Imports	Total Exports	Tot Net Receipts
1	2,830	992	481	4	1,581
2	2,411	1,928	3	1	541
3	1,131	3,371	11	124	(2,208)
4	258	249	1	-	10
5	1,377	1,323	9	21	77
Total	8,007	7,863	505	150	
		PADD Shares (Percent)			
1	35.3%	12.6%	95.2%	2.7%	
2	30.1%	24.5%	0.6%	0.7%	
3	14.1%	42.9%	2.2%	82.7%	
4	3.2%	3.2%	0.2%	0.0%	
5	17.2%	16.8%	1.8%	14.0%	
Total	100.0%	100.0%	100.0%	100.0%	

Source: Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340(96)/1, Tables 5, 7, 9, 11, and 13.
Notes: Total production is refinery plus field production. Total imports, total exports, and total net receipts are finished gasoline plus blending components.

Since the inception of the CaRFG program, PADD 5 prices often rise higher and fall farther than average U.S. prices (Appendix B). They also sometimes move at different times and for different reasons than prices in markets east of the Rocky Mountains (Figure 3.1). In late summer 1997, the West Coast experienced a price increase about the same time as the rest of the country. CaRFG spot prices rose almost 29 cents per gallon from late July to peak just after Labor Day. The increase lasted longer and was over 9 cents more than for New York Harbor spot RFG. After peaking at 89 cents in early September 1997, CaRFG spot prices fell by about 35 cents in about 5 months. Retail prices lagged behind the changes in spot prices, beginning their rise and peaking later. Because retail prices pick up prior spot price changes over a longer period of time, retail prices don't normally rise as much as spot prices (Chapter 6). PADD 5 conventional prices only rose about 11 cents per gallon, while CaRFG rose about 19 cents.

Although the West Coast increase occurred about the same time as the increase in the rest of the country, the causes were not entirely the same. The remainder of this chapter explains the factors behind the PADD 5 gasoline markets in August 1997.

Figure 3.1 PADD 1 and PADD 5 Weekly Retail RFG Prices



Source: Energy Information Administration, Weekly Retail Outlet, Regular Grade, Form EIA-878, "Motor Gasoline Survey."

PADD 5 Supply and Demand Fundamentals

As discussed in Chapter 2, prices respond to changes in demand and supply. At a PADD level, gasoline demand is met by the supply components of production within the PADD, net imports into the PADD, net flow of production from other PADD's, and changes in PADD inventory levels absorbing the imbalances. The next part of this chapter examines each of these supply and demand elements individually to help explain the roles they played in the August price runup.

Stocks: The Measure of Supply/Demand Balance

Gasoline stock levels and changes in stock levels reflect the relative tightness of the gasoline market. If inventories are falling, demand is exceeding production, net imports, and net receipts from other PADD's, and stocks are being drawn to meet demand. When stocks have fallen to a low level, especially in a high demand season, the market is considered tight, and buyers bid prices up to assure supply. These increasing prices provide additional stimulus for new supply —whether from imports or higher production.

West Coast stock levels were an exaggeration of national inventory behavior during summer 1997 (Figure 3.2). Inventories in March were below normal levels, but rose to end May well above normal. During June, stocks fell back to within the normal band, still comfortably high. As in the rest of the country, the market turned around in July. Inventories plunged 2.8 million barrels, which is 11 times the average drop for the month. Stocks ended July well below normal, leaving little stock cushion for August, typically the peak-demand month in PADD 5. The next sections discuss the role of each of the demand and supply components in producing the large stock draw and subsequent price increases.

Demand Kept Pressure on the Market, But Added No Surprises

Through April of 1997, demand in PADD 5 had been at or below the prior year's levels, but the situation reversed during the summer (Figure 3.2). Demand picked up after April, averaging 2.2 percent higher in May through September than in 1996. Compared to 1996, 1997 PADD 5 demand followed a more typical seasonal pattern, building from a low point in January to peak in August.

Strong summer demand after a weak spring can surprise refiners. In PADD's 1, 2, and 3, demand stayed weak through June, but surged unexpectedly in July. In contrast, summer demand in PADD 5 was generally strong, with no specific month standing out. Demand alone cannot explain the sharp drop in July inventories and market tightening.

Production Limits Reached in Major Refining Centers

PADD 5 gasoline production in February and March 1997 was much lower than in 1996 due to refinery operating problems, including a large explosion and fire at Tosco's Avon, California refinery. With stocks ending March below normal, refiners pushed production hard to meet rising summer demand. However, strong PADD 5 production exceeded weak demand during April and May, resulting in a large stock build and declining prices. With excess stocks at the end of May and weak prices, refiners cut back on production in June, and stocks fell back into the normal range. In July, stocks continued to fall, even though refiners increased production substantially in anticipation of export needs and growing demand. While some refinery problems were reported in late July, they were not large enough to prevent refinery production in July from hitting the highest monthly gasoline production recorded since January 1981.[1] Refinery production stayed high in August, before falling off as summer driving demand receded.

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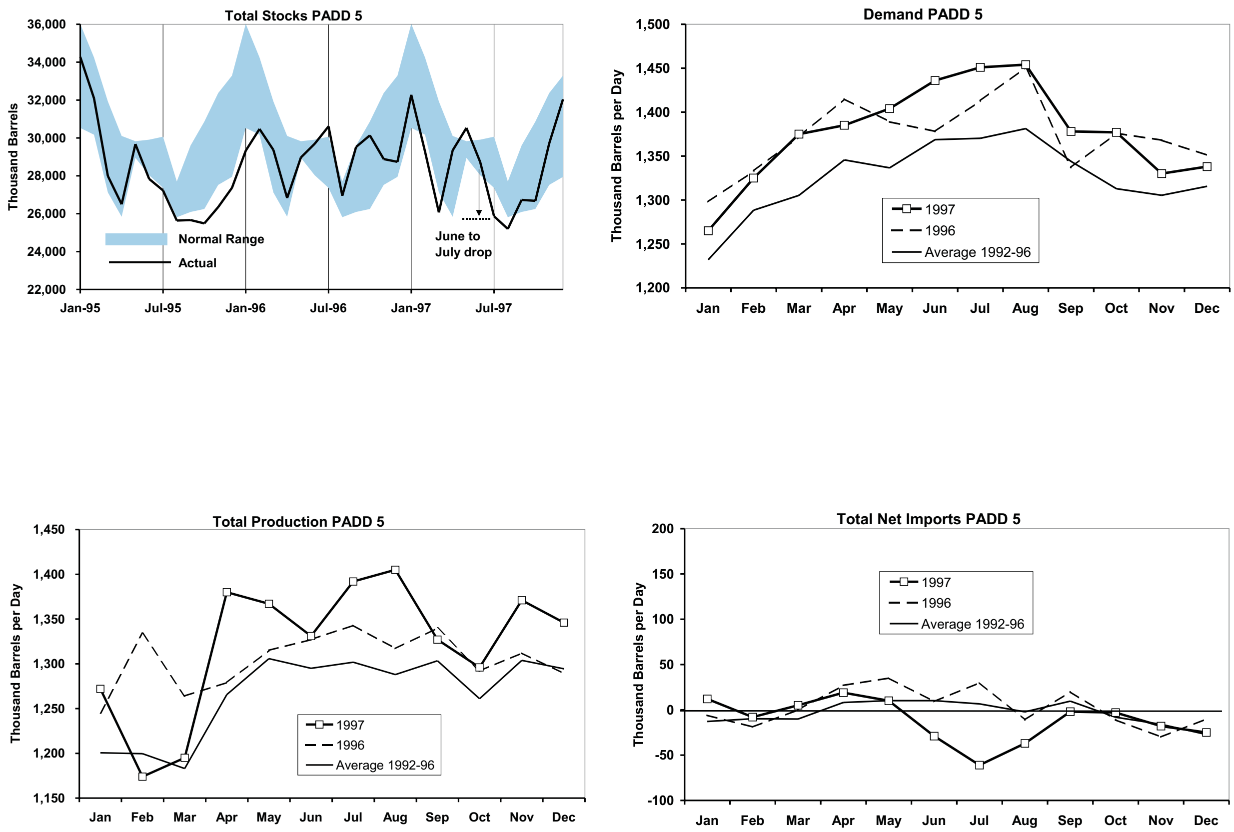
1 Note that Figure 3.2 shows field production plus refinery production. While total production was higher in August than in July, refinery production peaked in July.

Figure 3.2 PADD 5 Gasoline Supply/Demand Balance



Source: Energy Information Administration, **1992-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(92-96)/2, Tables 12, 13. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 22, 24.
Notes: Normal range is the 1992-1996 average value for a given month plus or minus one standard deviation of that month's values. Total stocks and total net imports include finished gasoline and blending components. Total production is field production plus refinery production.

With the exception of June, refineries in the major refining areas of Los Angeles, San Francisco, and Puget Sound produced gasoline at or near their maximum capability (Chapter 4). The only way they could have produced more would have been to cut back on distillate production, but refiners were balancing growing jet fuel and diesel needs with gasoline over the summer.

Net Receipts Explained Little of the Late Summer Tightening

PADD 5 receives some product from PADD's 3 and 4, mainly by pipeline, but these pipelines do not feed the major consuming area of California. In 1996, pipelines from PADD's 3 and 4 delivered 46 and 22 thousand barrels per day, respectively, of gasoline into PADD 5. Tankers from PADD 3 delivered another 13 thousand barrels per day to the West Coast. As is usually the case, very little gasoline (4 thousand barrels per day) moved from PADD 5 to other PADD's in 1996.

In 1997, net receipts into PADD 5 ran similarly to net receipts in 1996 through June. July 1997 net receipts ran 30 thousand barrels per day lower than in July 1996 as gasoline demand soared in areas east of the Rocky Mountains, but, in August, net receipts quickly moved back in line, averaging only 7 thousand barrels per day above average August volumes, and over 10 thousand barrels per day below the August 1996 volumes. Large gasoline volumes from other PADD's have not historically materialized when unexpected problems arise in PADD 5, in spite of attractive short-term prices, as is discussed below. Thus, net receipts contributed very little to the market tightening in July or the subsequent relief.

Imports Offered Little Relief

Due to the long distance from major gasoline export areas like Europe and the limited number of export refineries that can produce CaRFG, imports are not a major supply source for PADD 5. For example, in 1996, PADD 5 gasoline imports only averaged 15 thousand barrels per day.

When supply problems occur in PADD 5, product cannot arrive quickly from other PADD's or from other countries. Even if only conventional gasoline is needed, shipping time is about 14 days from the Gulf Coast, and can be as much as 30 days from foreign sources. If CaRFG is needed, an additional 7 to 10 days is required for refineries to produce the unique fuel.[2] The lack of immediately available outside supply is a factor in the market psychology driving PADD 5 prices up during a tight market. Buyers are willing to pay more in the short term to assure supply, and prices tend to be bid up for longer periods of time than would be the case if new supply were near at hand.

For a seller outside of the region to break even financially on a delivery to PADD 5, the gasoline price in PADD 5 must rise high enough over the seller's regional price to cover the additional transportation cost to get the product to the West Coast, and, in the case of CaRFG, the additional production cost. Transportation cost alone from the Gulf Coast/Caribbean areas to California is 5-10 cents per gallon. Transportation from other countries can run even higher. When a supply/demand balance problem drives prices up, either the buyer or the seller must take the risk that prices will stay up long enough for the cargo of distant gasoline to arrive before prices fall back. Shipping and production time require gasoline prices to stay up 2 to 3 weeks, which is a risk many buyers and sellers are not willing to make.

Although PADD 5 prices surged in August 1997, no imports were attracted to the area for the reasons stated above, and because prices in other parts of the United States had also surged, competing for the same import barrels. However, PADD 5 August imports are normally very low, averaging 6 thousand barrels per day in 1992-1996. In conclusion, imports neither hurt nor helped the California markets in July and August 1997.

2 California Energy Commission, California Air Resources Board, *Motor Vehicle Fuel Price Increases,* January 1997, p. 13.

Exports Provided a Piece of the Puzzle

Over the course of a year, gasoline exports from PADD 5 average about the same as imports. Mexico and Canada are usually the two biggest destinations for these exports, accounting for 56 percent of the total in 1996. Japan received an additional 13 percent.

Exports in 1997 showed a deviation from the normal pattern. Exports increased in June and peaked in July before falling back to more typical levels in October (Table 3.2). The increase in exports above average in July alone was 52 thousand barrels per day, which if supplied from stocks alone, would require a 1.7-million-barrel stock draw. Exports played a much larger role in contributing to the August market tightness in PADD 5 than they played in areas east of the Rocky Mountains.

Table 3.2 1997 Export Destinations from PADD 5
(Thousand Barrels per Day)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Canada	2.5	6.8	6.5	2.9	3.5	4.8	17.8	17.8	2.3	2.6	2.6	2.6	6.1
Mexico	0.8	0.6	7.5	1.2	1.1	1.1	8.8	11.9	6.3	11.6	12.3	22.6	7.2
Japan	0.0	0.0	2.4	0.0	2.5	14.7	2.2	2.8	0.0	0.0	0.0	0.0	2.1
Taiwan	0.0	0.0	0.0	0.0	0.0	0.0	25.3	0.0	0.0	0.0	0.0	0.0	2.1
Ecuador	0.0	0.0	0.0	0.0	0.0	7.3	7.1	0.0	7.2	0.0	0.0	0.0	1.8
Other	0.0	1.8	3.5	0.0	0.0	1.4	0.0	4.7	0.0	2.8	3.0	0.0	1.4
Total	3.4	9.1	20.1	4.1	7.1	29.4	61.2	37.2	15.9	17.1	17.9	25.2	20.8
Average 1992-96	18.4	15.8	16.2	9.8	7.2	3.2	9.4	8.6	4.4	14.0	21.0	30.0	13.2

Source: U.S. Bureau of the Census.

The reason for the increased exports during summer 1997 was the weak early summer market, as production and net receipts outstripped demand. Markets were weaker on the West Coast in May and June than on the East Coast. Spot prices for CaRFG on the West Coast dropped below RFG prices on the East Coast, despite the higher production costs for CaRFG.

CaRFG spot prices remained depressed from May until the last week in July (Figure 3.3). Furthermore, spot conventional prices in California dropped uncharacteristically below those in Singapore through June and into July. Not surprisingly, with building inventories and attractive prices abroad, several companies contracted to export gasoline. Most exports are contracted for well in advance of when shipments leave the country. Thus, the weak prices in May encouraged exports during June, and continued weak prices in June encouraged even more exports in July.[3]

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3 Gasoline exports to Japan and Ecuador in June accounted for much of the U.S. export increase over May. In July, Canada, Mexico, Taiwan and Ecuador stand out. In August, Canada and Mexico continued to attract U.S. exports. Mexican import volumes from the United States were not unusually high, but Canadian volumes were much higher than normal in both July and August. Reports of refinery problems in Ecuador and Canada in July and August were probably the major factors setting attractive prices in these areas.

The unusual export volumes that occurred during summer 1997 point out a peculiarity of the West Coast market: industry has readily available consuming markets to take excess supply, but few readily available producing sources to supply PADD 5 gasoline consumption. Apart from distance, product specifications also work to make it easier to export than import. PADD 5 product specifications can meet other countries' needs, but most other countries can only meet PADD 5 conventional requirements. Export shipments in June through August were all reported as conventional or blending components. No product requiring RFG specifications was exported. However, if the price is right, even CaRFG can be used to supply conventional gasoline export markets.

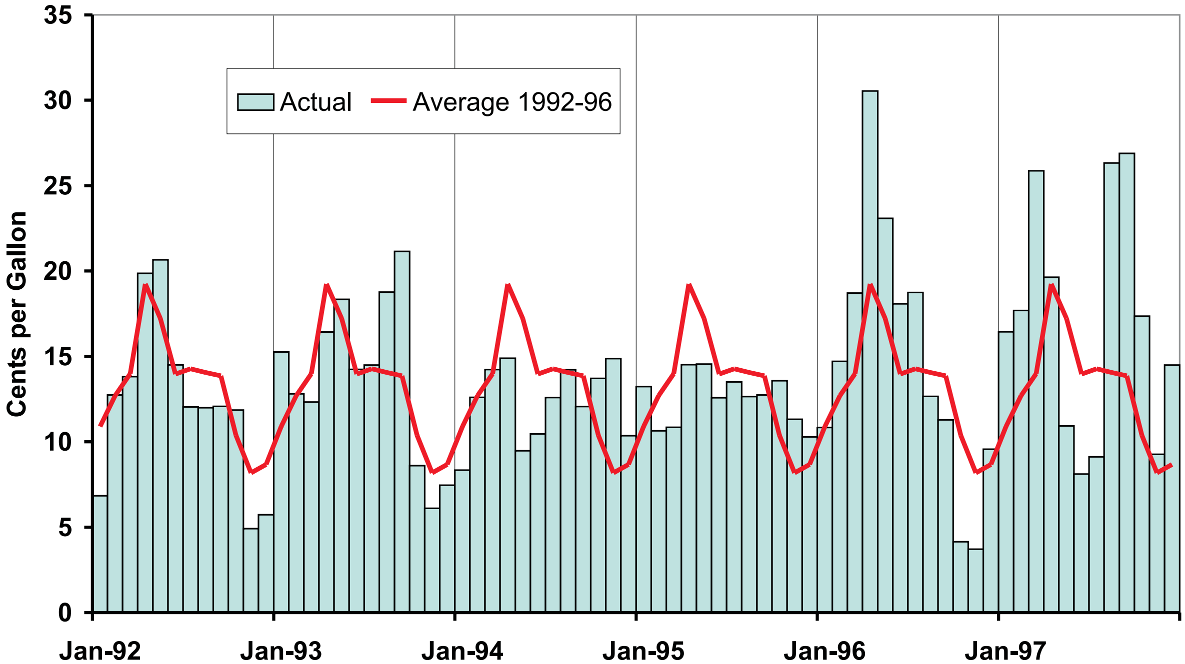
Figure 3.3 California RFG Minus Gulf Coast RFG Spot Prices

Source: Reuters RFG Regular Grade Daily Spot Prices.

Prices Responded to the Change in Supply/Demand Balance

In PADD 5, the origin of the tight market that occurred in late summer was the well-supplied market earlier in the year. After spring refinery turnarounds, with some accompanying operational problems, production rebounded in April and May to very high seasonal levels. Supplies quickly caught up with the lackluster demand growth that characterized the first part of 1997. Stocks shifted from seasonally low levels in March to high levels in April and May. Spot prices and spreads (spot gasoline minus spot crude oil price) correspondingly plummeted with the excess gasoline supply (Figure 3.4). Prices on the West Coast during May, June and July were much weaker than in areas east of the Rocky Mountains. Exports were being considered, as prices in other markets became more attractive than in California. In June, refiners began cutting back on production and continued to look for export opportunities. The slowing in production and increasing exports brought stocks back down toward the normal range, but price spreads continued

Figure 3.4 Average Monthly Los Angeles Spot Price Minus Crude Oil Price



Source: DRI Platt's Spot Prices for Los Angeles Regular Conventional Gasoline and West Texas Intermediate Crude Oil.

to remain low. By the end of June, stocks were solidly in the middle of the normal historical range; however, prices had not improved for refiners.

In July, refiners increased production to record levels, both to meet the export obligations to which they were already committed and to meet continuing strong demand. For the first part of the month, weekly reports showed little change in stock levels. One mid-month report cited a refiner as saying that the very high production was essentially negating any impact the exports might have on the market.[4] However, the market shifted during the second half of July. Stock levels began dropping rapidly, and ended July 2.8 million barrels lower than June ending stocks, which is about 11 times the average drop during July. Prices began to increase, but were only recovering to normal levels by the end of the month.

In concert with the rest of the United States, the markets in the West faced the largest gasoline demand month, August, with low and rapidly dropping stocks, in spite of high refinery production. Stocks continued to decline during the first two weeks of August and spot prices rose rapidly. Through the month, refiners were able to keep production at high levels. Exports were not as high in August as in July, but remaining export commitments kept export volumes in August higher than

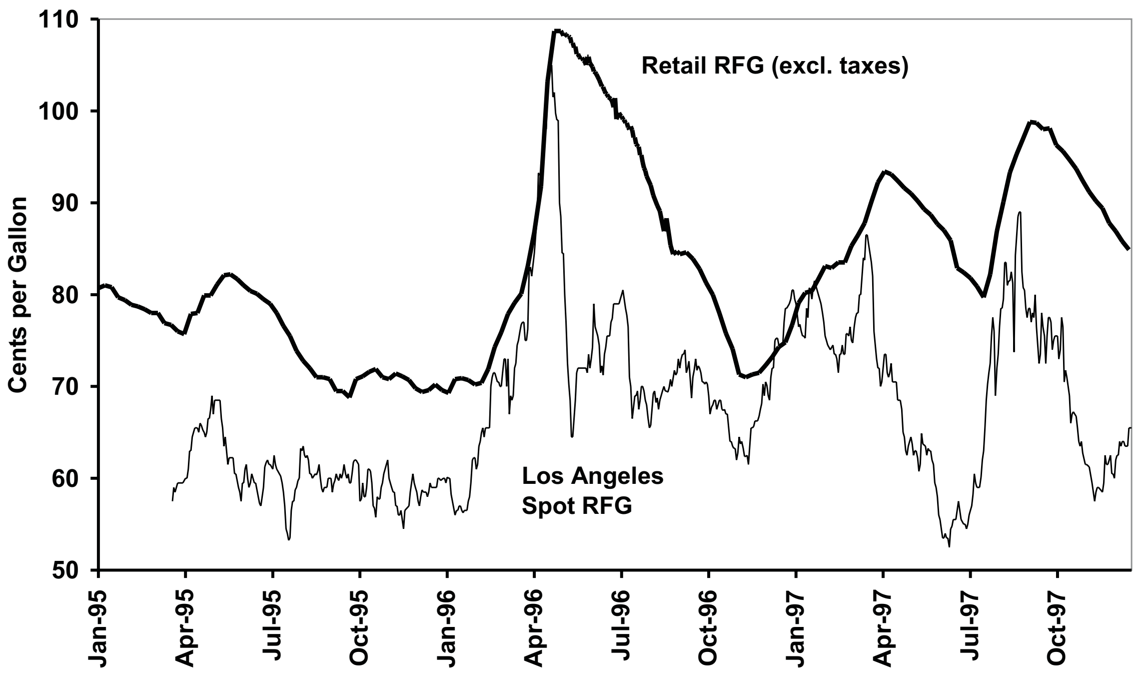
4 Oil Price Information Service, PAD 4/5 Overview, (Rockville, MD: July 14, 1997), p 9.

average. Stocks ended August lower than in July, but the strong production push and receding export volumes kept stocks from dropping as much as they normally would have during that month. In September, the supply/demand balance had recovered, stocks began rebuilding, and spot prices finally fell back.

Spot prices in California reflected conditions throughout West Coast markets in summer 1997 (Figure 3.5). Spot CaRFG prices rose over 29 cents per gallon from the end of July to peak at 89 cents around Labor Day. They then declined as driving demand fell in September faster than production and net imports declined.

Retail prices in California, as in other parts of the country, exhibited a consistent lag relationship with spot prices (Chapter 6). The change in one week's retail price reflects spot price changes over the prior two months. This lag relationship has the effect of keeping retail prices from rising or falling as much as spot prices. It also sometimes causes a visual distortion that makes it appear as though the retail price is staying up longer than it should. EIA calculations showed that in the last summer price runup in PADD 5, the California RFG retail price relationship to spot price was consistent with historical behavior. That is, the lag relationship held when spot prices rose as well as when they declined, giving rise to the asymmetric pattern seen in Figure 3.5.

Figure 3.5 California Retail and Spot Prices



Source: **Retail Regular RFG Prices:** Energy Information Administration, Form EIA-878, "Motor Gasoline Survey," less estimated taxes of 45 cents per gallon. **Spot Prices:** Reuters Los Angeles Regular RFG daily prices.

4. Focus on Refinery Production

Through much of the 1990's, petroleum product demand has grown year to year, and refinery utilization has been high during the summer months. The sharp price increase in August 1997 raised the question of whether gasoline production limits were being reached, and if so, were part of the reason for the price increase. This chapter looks into summer 1997 production in depth to better understand what occurred operationally in this supply sector.

In analyzing refinery gasoline production over the summer of 1997, the objectives were to determine:

- How close gasoline production was to maximum production capability;
- Whether gasoline and other light-product yields were decreasing due to running at high utilizations (Appendix C).

EIA data aggregated to a PADD level and individual refinery data were both analyzed to explore these issues.[1]

To estimate how close production was to maximum capability, refinery utilization of both distillation and downstream units (fluid catalytic cracking units, hydrocrackers, and cokers) were analyzed. The refinery capacity utilization most commonly listed is based on use of atmospheric distillation capacity, but the availability of downstream conversion capacity is even more important in assessing how close light product production is to maximum capability. EIA monthly data on the feed rate to fluid catalytic cracking units (FCC's), hydrocrackers, and cokers were analyzed as a percent of refinery feed of crude and unfinished oils to determine if capacity of these downstream units may be limiting light product production.

Declines in light-product yields can be an indication of encountering downstream capacity limits. If crude oil input to refineries rises and capacity utilization increases, then some refineries may have insufficient capacity in key downstream conversion units to handle larger intermediate stream volumes. These refineries with insufficient downstream capacity would suffer yield declines of high-valued, light products. Yield trends for all light products (gasoline, jet fuel, diesel, and other middle distillates) were analyzed to find any evidence of yield declines and potential association with unit capacity limitations. Changing to a heavier crude oil (lower API gravity) can also produce yield declines, but if capacity is available to meet the need for increased throughput to such units as FCC's and cokers, the yield decline could be very minor.

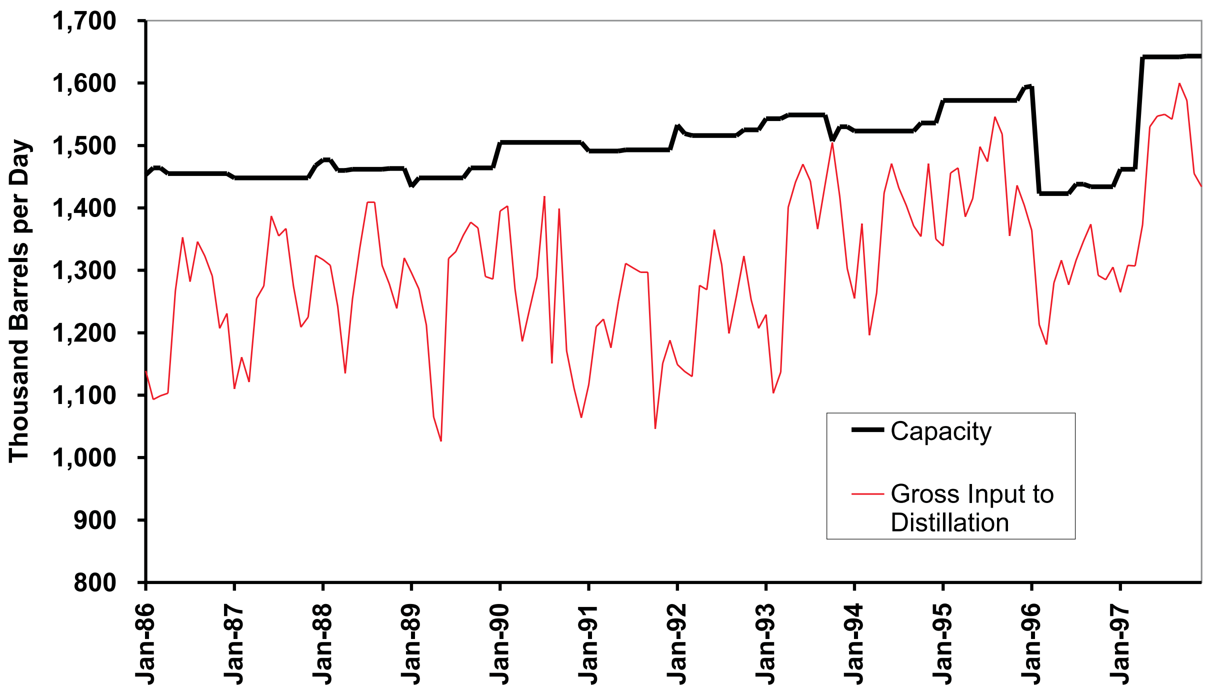
1 Refinery data in PADD's 1,2,3, and 5 were reviewed. PADD 4, which contains about 3 percent of total U.S. refinery production, was not covered in this study.

Gasoline Production in PADD 1 Could Have Been Higher

Over 90 percent of the PADD 1 refinery capacity is concentrated in New Jersey and the Delaware River Basin. The production from these refineries is consumed in the Middle Atlantic and New England states.

In 1997, PADD 1 refinery capacity reached its highest level since 1986 with the return to operation of the Tosco Trainer refinery (formerly the BP Marcus Hook refinery) in Pennsylvania in May, and the increase in distillation capacity at Bayway by Tosco. Operable capacity utilization rates, based on inputs to atmospheric distillation, reached 97.4 percent in September, and averaged 94.6 percent during May through September (Figure 4.1). Although crude oil inputs were high, they could have been higher for the months June through August 1997. Refinery input levels in these months may have been set based on early summer estimates of regional summer gasoline demand, which were lower than what actually occurred. Also, refinery operating problems restricted inputs in some refineries during July and August.

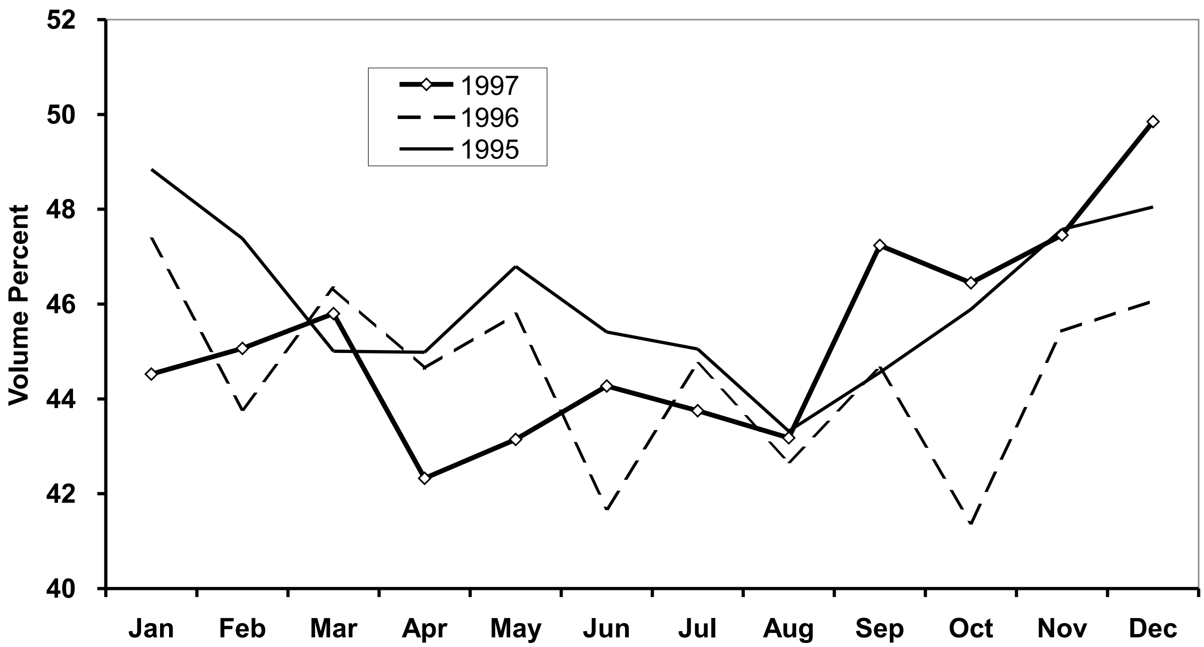
Figure 4.1 Monthly PADD 1 Operable Refining Capacity and Gross Inputs



Source: Energy Information Administration, **1986-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(86-88)/2, Table 11, DOE/EIA-0340(89-96)/2, Table 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 28.

PADD 1 refinery gasoline production in May through September 1997 was up compared to 1996 and 1995 as a result of increased refinery inputs. The average May through September gasoline yield[2] was also higher than in 1996, primarily because of a very high level of production in September 1997 (Figure 4.2). In the earlier part of the summer of 1997, refiners were running at lower gasoline yields and higher jet fuel and distillate yields than for the prior two summers. Thus, PADD 1's stronger emphasis on distillate production in early and mid-summer appears to have been more based on a perception of market needs than on any limitations of refinery capability.

Figure 4.2 PADD 1 Adjusted Gasoline Yield



Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 5 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 8 and 28.
Note: Adjusted Yield is derived from Adjusted Production which equals refinery gasoline production minus inputs of butane, oxygenates, and net inputs of gasoline blending components divided by crude oil plus net inputs of unfinished oils.

Gasoline production could have been higher in mid-summer 1992 in PADD 1, if not for two factors:

- PADD 1 refiners seem to have been focused on higher summer distillate production to meet higher jet fuel demand and to avoid the low distillate stock situation at the end of summer such as occurred in 1996;

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2 The yields used in this study are derived from "adjusted production" which equals refinery gasoline production minus inputs of butane, oxygenates, and net inputs of gasoline blending components. The purpose of the adjustment is to separate the gasoline produced from crude oil and net unfinished oil inputs from that produced from materials brought into the refinery exclusively for additions to the gasoline pool. The volume of the gasoline components removed from refinery production varies seasonally, and gasoline blending components may be added at a terminal, never entering the refinery.

- High availability of gasoline imports and only moderate gasoline demand growth were assumed for the remainder of the summer. (As discussed in Chapter 2, that assumption turned out to be incorrect.)

There was no indication from the analysis of PADD-level or refinery-specific data that downstream capacity limitations negatively impacted gasoline yield in the summer of 1997 in PADD 1. After taking into consideration changes in crude oil gravity, unfinished oil inputs, gasoline/distillate ratios, and the Tosco Trainer refinery coming back on stream, FCC throughput as a percentage of crude and unfinished oils indicated an ability to handle the volume of FCC feed that refiners wished to charge (Table 4.1). Total light-product yield (gasoline, kerosene, jet fuel, and distillate) in summer 1997 exceeded 1996 levels. This is in keeping with FCC capacity availability and the use of a higher gravity crude charge in 1997 versus 1996.

Table 4.1 PADD 1 Summer Refinery Inputs and Gasoline Production

	May-Sept 1995	May-Sept 1996	May-Sept 1997
Operable Capacity (MB/D)	1572	1431	1642
Crude Input (MB/D)	1542	1366	1582
Crude Gravity (°API)	31.2	31.4	32.6
Net Unfinished Oil Inputs (MB/D)	106	101	108
Gross Inputs to Distillation (MB/D)	1490	1326	1554
Operable Utilization Rate (%)	94.8%	92.6%	94.6%
N-Butane + Oxygenate + Net Blending Stock Inputs (MB/D)	90	195	275
FCC Feed Percent (1)	36.3%	38.1%	37.2%
Hydrocracker Feed Percent (1)	4.5%	4.1%	3.0%
Coker Feed Percent (1)	4.7%	5.6%	5.1%
Adjusted Gasoline Production (MB/D) (2)	741	644	750
Adjusted Gasoline Yield (1)	45.0%	43.9%	44.3%
Jet, Kerosene & Distillate Yield (1)	30.1%	31.1%	32.7%
Total Light-Product Yield (1) (3)	75.1%	75.0%	77.0%

Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 5 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 8 and 28.
Notes: (1) Yields and percents are calculated on the basis of percent of crude oil plus net unfinished oil inputs. (2) Adjusted production equals refinery gasoline production minus inputs of butane, oxygenates and net inputs of gasoline blending components. (3) Light products are gasoline, jet fuel, kerosene, and distillate.

While PADD 1 FCC capacity was not viewed as a constraint to light product production in summer 1997, estimated summertime FCC capacity utilization appeared to be approaching the maximum level. However, it is difficult to know the precise maximum input capacity for FCC's in PADD 1. Downstream unit capacity data is only collected every two years, and there has been some understatement of capacity.[3] As a result, the aggregate PADD data sometimes shows feed rates higher than reported stream-day capacity on a monthly basis.[4] In spite of the impression given by the magnitude of aggregate PADD-level data, analysis of the data for specific refineries indicated that some operated below both primary distillation and downstream unit capacity levels.

PADD 1 gasoline production levels and capacity utilization rates are affected both by demand levels and by availability and flow of gasoline imports. Of the last three years, capacity utilization for the months of May through September was highest in 1995. RFG was introduced in 1995, and gasoline imports to PADD 1 fell off as importers adjusted to the new product requirements. In 1996, demand rose, while refining capacity dropped 9 percent with the shutdown of the BP Marcus Hook refinery. An increase in capacity utilization might have been expected, but utilization actually fell from 94.8 percent to 92.6 percent as gasoline imports increased robustly. In summer 1997, demand again rose, but far less than refinery capacity as the Tosco Trainer refinery came back into service. This might lead one to expect a decline in utilization in 1997 over 1996, but capacity utilization rose as imports during the summer again dropped.

Despite the difficulties of analyzing constraints limiting gasoline production, it is possible to get a range for the maximum potential summer production for the PADD in summer 1997. In September 1997, PADD 1 adjusted gasoline production was 828 thousand barrels per day, excluding net input of gasoline blending components, which are reported as part of refinery inputs, but which go mainly to the blenders rather than refiners. September 1997 gasoline production set a new high for summer monthly refinery gasoline production volumes since 1986. The September production was achieved with:

- A record high crude input, and capacity utilization of 97.4 percent;
- A record FCC feed rate of 654 MB/CD;
- Lower jet and distillate yields than for prior summer months.

Average adjusted production in PADD 1 during May through September was 750 thousand barrels per day (excluding blend stock inputs). Given PADD 1 capacity during summer 1997, which did not include the Trainer refinery at the beginning of the season, and relative product demand patterns, it appeared that total summer production for PADD 1 could have been 20-60 thousand barrels per day above the actual summer 1997 production.

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3 Summertime 1997 FCC utilization estimates are based on January 1, 1997 capacity reported to EIA in 1996. Actual capacity in 1997 may be higher. Also, based on comparing prior capacity and input data, there has been some capacity understatement.

4 Stream-day capacity for PADD 1 FCC units was estimated at 575 thousand barrels per stream day as of January 1, 1997 (Energy Information Administration, *Petroleum Supply Annual 1996*, DOE/EIA-340 (96)/2). That figure does not include the 50 thousand-barrels-per-stream-day FCC unit of Tosco's Trainer, PA plant, which returned to full operation in May 1997. In May and June 1997, the PADD 1 FCC feed rate was 646 thousand barrels per calendar day, exceeding the estimated barrel per stream-day capacity of 625 thousand barrels per stream day, and in September it was 654 thousand barrels per stream day.

Gasoline Production in PADD 2 Was At Maximum

PADD 2 covers the mid-continent portion of the United States, bounded on the east with the states from Michigan to Tennessee, and on the west by the states from North Dakota south to Oklahoma. This region produces about three quarters of its own gasoline, with most of the rest coming from the Gulf Coast refineries of PADD 3.

During the summers of 1995 through 1997, refinery capacity utilization in PADD 2 was very high and increasing. In summer 1997, capacity utilization was 102.2 percent of calendar-day operable distillation capacity (Appendix D). The downstream conversion units were operated at high levels for all of the months from May through September (Table 4.2).

Table 4.2 PADD 2 Summer Refinery Inputs and Gasoline Production

	May-Sept 1995	May-Sept 1996	May-Sept 1997
Operable Capacity (MB/D)	3448	3405	3447
Crude Input (MB/D)	3274	3349	3474
Crude Gravity (°API)	33.7	33.4	33.0
Net Unfinished Oil Inputs (MB/D)	34	41	33
Gross Inputs to Distillation (MB/D)	3353	3406	3524
Operable Utilization Rate (%)	97.2%	100.0%	102.2%
N-Butane + Oxygenate + Net Blending Stock Inputs (MB/D)	16	50	17
FCC Feed Percent (1)	35.1%	33.8%	33.6%
Hydrocracker Feed Percent (1)	4.1%	4.4%	4.2%
Coker Feed Percent (1)	8.6%	8.5%	9.3%
Adjusted Gasoline Production (MB/D) (2)	1775	1783	1818
Adjusted Gasoline Yield (1)	53.7%	52.6%	51.9%
Jet, Kerosene & Distillate Yield (1)	29.4%	30.7%	31.2%
Total Light-Product Yield (1) (3)	83.1%	83.3%	83.0%

Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 7 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 12 and 28.
Notes: (1) Yields and percents are calculated on the basis of percent of crude oil plus net unfinished oil inputs.
(2) Adjusted production equals refinery gasoline production minus inputs of butane, oxygenates and net inputs of gasoline blending components. (3) Light products are gasoline, jet fuel, kerosene, and distillate.

Throughputs to primary distillation fell back slightly in July, with corresponding changes in downstream units. There were no indications that refinery operating problems affected light product production during the summer.

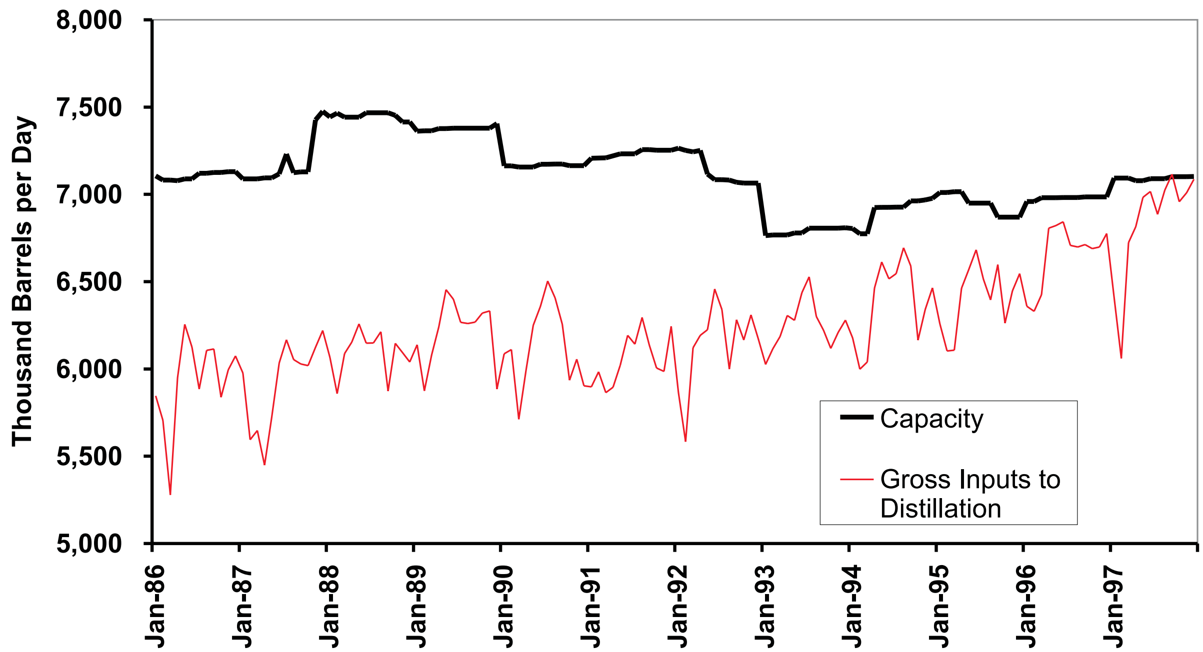
Light-product yields were about the same for each of the three summers. Gasoline yield declined in 1997 from 1996 and 1995, while distillate yield (kerosene jet fuel, kerosene and distillate) rose. This yield shift reflects a shift in the mix of the light product demand. The drop in API gravity of crude oil inputs from 33.4 in 1996 to 33.0 in 1997 indicates use of a heavier crude charge for refineries in the PADD, but a significant increase in the volume charged to coking units compensated somewhat for the decline in gravity.

Given the data presented in Table 4.2 and analyzing individual refinery monthly data, it is very difficult to see how additional gasoline could have been produced in PADD 2 during summer 1997. PADD 2 may even have difficulty repeating those levels of production in the future without capacity increases.

PADD 3 Gasoline Production Was Close to Maximum

PADD 3 covers the Middle South from New Mexico to Alabama, with most of the refining along the Gulf Coast states of Texas, Louisiana and Mississippi. PADD 3 production far exceeds demand within the PADD, but is used to help meet the needs of other regions, primarily PADD's 1 and 2. As in other refining regions, PADD 3 capacity utilization increased substantially during the 1990's, both due to refinery capacity reduction and to demand growth (Figure 4.3).

Figure 4.3 Monthly PADD 3 Operable Refinery Capacity and Gross Inputs



Source: Energy Information Administration, **1986-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(86-88)/2, Table 11, DOE/EIA-0340(89-96)/2, Table 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 28.

In summer 1997, refinery inputs in PADD 3 were high in June, but slightly lower in July and August. In September, inputs increased again, and utilization of operable capacity reached 100.2 percent (Appendix D).

The analysis of PADD 3 production indicated this region was also operating close to its maximum capability. PADD 3 refinery inputs increased in summer 1997 over prior years, but the input increase was not matched by a proportionate increase in gasoline production (Table 4.3). Only in September was refinery gasoline production significantly higher in 1997 than in 1996.

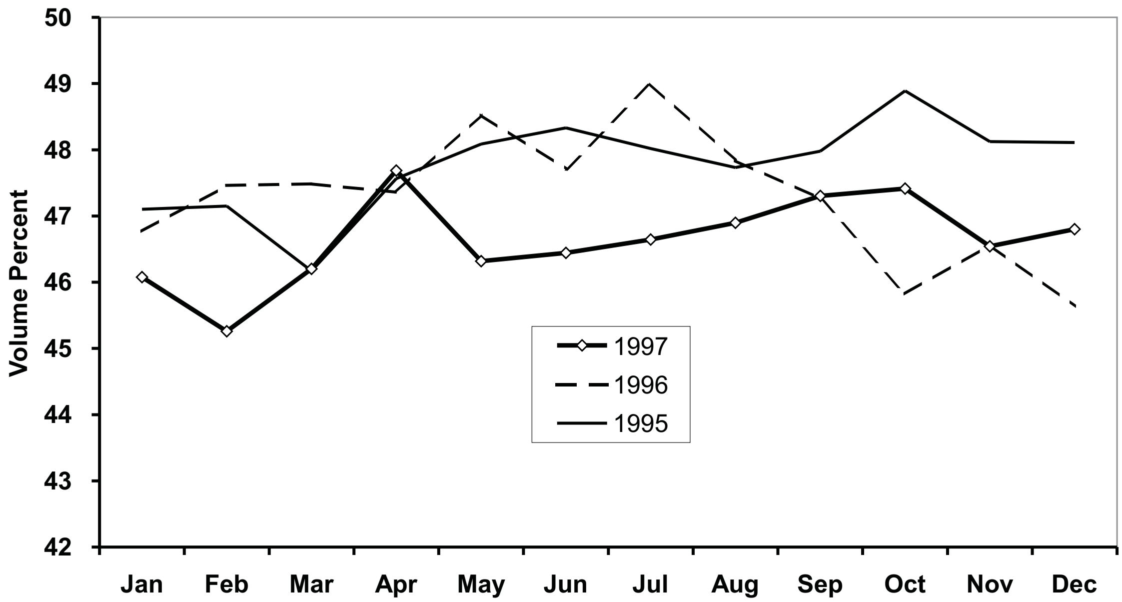
Table 4.3 PADD 3 Summer Refinery Inputs and Gasoline Production

	May-Sept 1995	May-Sept 1996	May-Sept 1997
Operable Capacity (MB/D)	6934	6983	7090
Crude Input (MB/D)	6512	6737	7003
Crude Gravity (°API)	31.9	31.7	31.2
Net Unfinished Oil Inputs (MB/D)	392	346	289
Gross Inputs to Distillation (MB/D)	6552	6757	7005
Operable Utilization Rate (%)	94.5%	96.8%	98.8%
N-Butane + Oxygenate + Net Blending Stock Inputs (MB/D)	82	80	56
FCC Feed Percent (1)	34.9%	35.7%	35.5%
Hydrocracker Feed Percent (1)	7.2%	7.5%	7.2%
Coker Feed Percent (1)	10.7%	11.1%	10.7%
Adjusted Gasoline Production (MB/D) (2)	3316	3404	3407
Adjusted Gasoline Yield (1)	48.0%	48.1%	46.7%
Jet, Kerosene & Distillate Yield (1)	30.2%	32.0%	32.3%
Total Light-Product Yield (1) (3)	78.3%	80.1%	79.0%

Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 9 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 16 and 28.
Notes: (1) Yields and percents are calculated on the basis of percent of crude oil plus net unfinished oil inputs.
(2) Adjusted production equals refinery gasoline production minus inputs of butane, oxygenates and net inputs of gasoline blending components. (3) Light products are gasoline, jet fuel, kerosene, and distillate.

With gasoline production in summer 1997 about the same as that in summer 1996, despite higher refinery inputs, gasoline yield declined from 48.1 percent to 46.7 percent (Figure 4.4). The yield decline did not appear to be the result of refiners running crude oil in excess of the capability of their downstream processing facilities. Most of the yield decline over the two summers can be explained by refiners shifting to produce higher yields of distillate products and running heavier crude oils.

Figure 4.4 PADD 3 Adjusted Gasoline Yield



Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 9 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 16 and 28.
Note: Adjusted Yield is derived from Adjusted Production which equals refinery gasoline production minus inputs of butane, oxygenates, and net inputs of gasoline blending components divided by crude oil plus net inputs of unfinished oils.

From the PADD-level data, FCC feed rates as a percent of crude oil and unfinished feed charge did not decline in the summer of 1997, compared to prior summers (Table 4.3). This indicated that processing limits on this unit played no role in the lower yields.

The increase in distillate yield during the summer of 1997 stemmed from increased jet fuel production at the expense of gasoline. This is part of an increasing trend in jet production. Over the past decade (1987-1997), PADD 3 refiners have increased kerosene jet fuel production from 10.0 to 11.4 percent of crude and unfinished feed charge.

In PADD 3, average crude gravity dropped from 31.7 in summer 1996 to 31.2 in summer 1997, while the feed rate to cokers declined 0.4 percentage points to average 10.7 percent of crude oil and unfinished oil inputs. These changes could have accounted for an estimated drop of 0.5 to 0.7 percent in gasoline yield. Coking capacity has been steadily rising in PADD 3, and volume inputs were up in April and May, but then fell off considerably in June. Unscheduled shutdowns may explain the decline in coker input levels and associated impact on light-product yields in summer 1997, but that has not been quantified.

Operating data from a selected set of eleven PADD 3 refiners[5] were monitored to better detect changes of unit throughput limits and potential gasoline yield impacts. The eleven refineries did

5 These eleven refineries represented 2,286,000 barrels per calendar day of atmospheric crude oil distillation capacity. This is almost one-third of operable capacity in PADD 3 in 1997.

not exhibit a common pattern. Two refineries showed gasoline yield increases in summer 1997 versus 1996. Four refineries showed similar yield patterns for the summers of 1996 and 1997, while five refineries showed decreased gasoline yields in 1997. Of these last five, two showed declining yields as a result of increased kerosene jet fuel yields; two ran lower gravity crude oils, which accounted for some of the yield loss; and the last showed a yield decline that could not be explained. Overall downstream unit limitations did not appear to be a factor causing light-product yield declines for the 11 refineries. In some cases, downstream capacity appeared to be the primary factor in determining overall refinery throughput. (Crude input was less than distillation capacity, and appeared to be limited by maximum inputs of downstream units.)

PADD 3 refineries were operating at high throughput levels in summer 1997. The relative production levels of gasoline versus distillate light products were based on refiners' anticipation of demand levels. Gasoline yield in July and August could have been a bit higher, had the high gasoline demand that occurred been anticipated. In September, refinery capacity utilization was 100.2 percent, downstream units were operating at high input rates, and the adjusted gasoline production was 73 thousand barrels per day more than the May-through-September average.

Providing an estimate of maximum gasoline production capability requires solving the problem of imprecision of capacity figures, estimating normal unit shutdown levels, and taking into consideration the competition of distillate co-production from the product barrel. Recognizing these limitations, it appears that in the summer of 1997, PADD 3 refiners were operating near the limits of gasoline production capability, and that production for the summer was less than 100 thousand barrels per day below the maximum achievable production level under the assumed conditions.

PADD 5 Major Refining Centers Approached Production Limits

Production from refineries within PADD 5 supplies almost all of the region's product needs. Most of the capacity is located in three areas: Los Angeles, San Francisco, and the Puget Sound area in Washington State (Table 4.4). Capacity utilization has grown in PADD 5 at a similar rate as in PADD's 1 and 3, but the operable utilization rate on a total PADD-level basis is lower than for those in other PADD's (Figure 4.5).

PADD 5 has the set of most complex refineries in the United States, with the greatest upgrading capabilities of any U.S. refining region. As Table 4.5 shows, coking capability is very high, and the combination of hydrocracking and FCC capabilities provide a high level of flexibility to change the mix of light products.

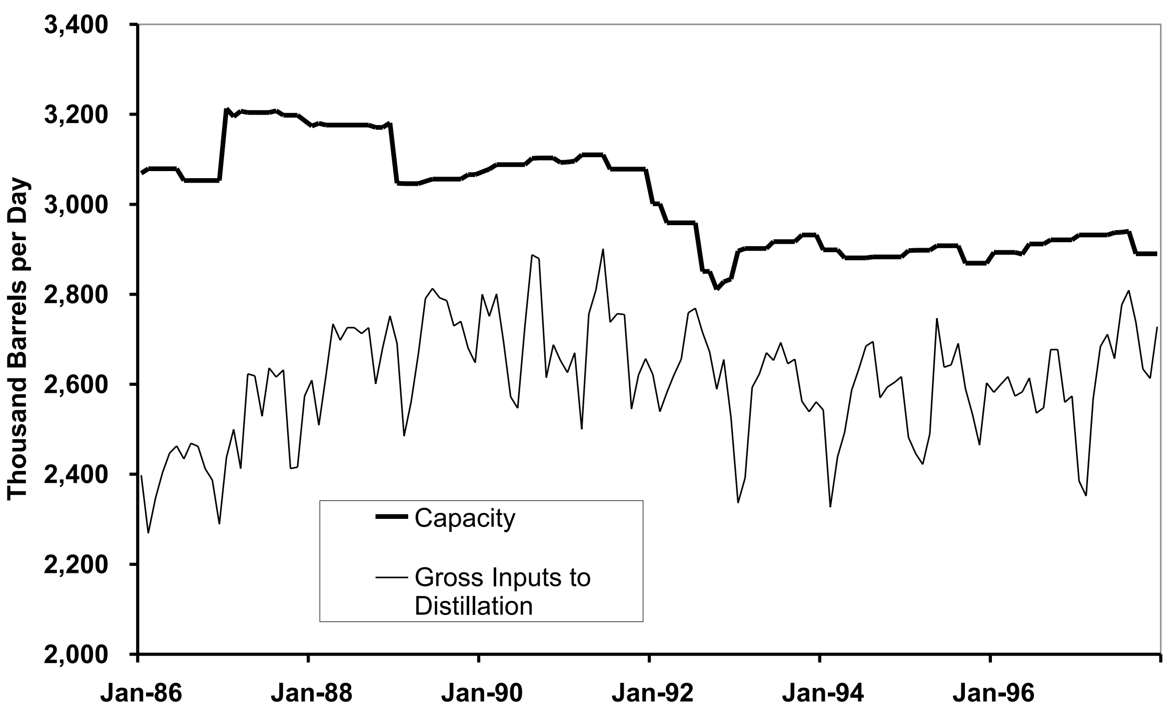
Light-product yield in PADD 5 refineries has been increasing over the last decade as a consequence of increasing downstream upgrading facilities (Figure 4.6). Today, light-product yield from PADD 5 refineries is higher than that of refineries in PADD's 1 and 3, despite PADD 5 refiners using the heaviest crude oil (lowest API gravity) of any of the PADD's.

Table 4.4 PADD 5 Refining Capacity Locations

	Number of Refineries	Operable Capacity (MB/CD)	Percent of Total PADD 5 Capacity
Alaska	6	283.3	9.7%
California	24	1,911.3	65.2%
Hawaii	2	147.5	5.0%
Nevada	1	7.0	0.0%
Oregon	1	0.0	0.0%
Washington	7	582.6	19.9%
Total PADD 5	41	2,931.7	100.0%

Source: Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340(96)/1, Table 39.
Note: MB/CD is thousand barrels per calendar day.

Figure 4.5 Monthly PADD 5 Operable Refinery Capacity and Gross Inputs



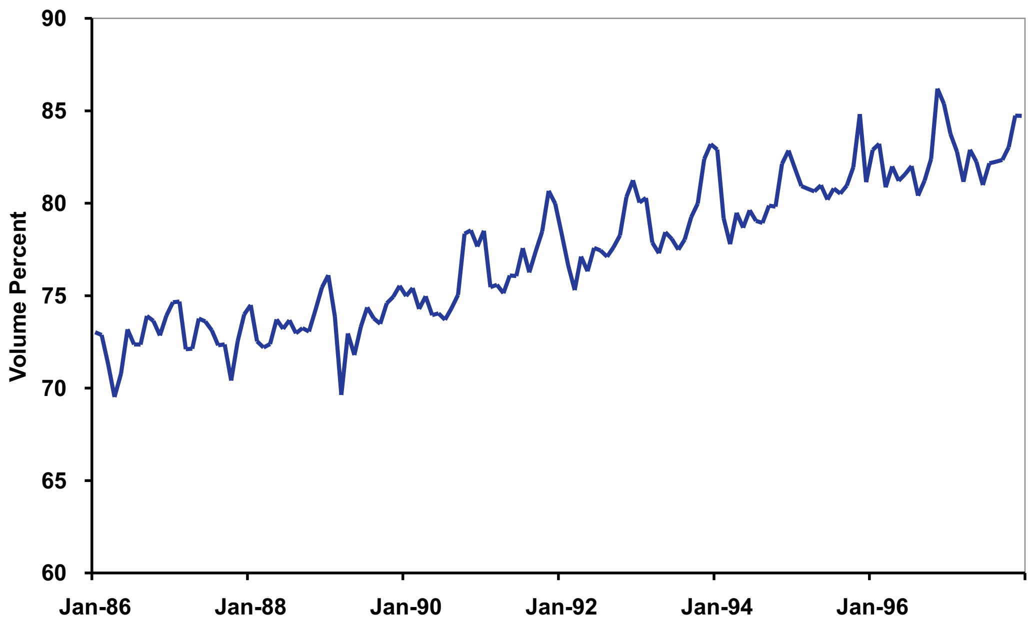
Source: Energy Information Administration, **1986-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(86-88)/2, Table 11, DOE/EIA-0340(89-96)/2, Table 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 28.

Table 4.6 contains an overview of PADD 5 refining operations for the summers of 1995 through 1997. Gasoline yields were about the same for all three summers. Total light-product yields, however, were increasing, mainly as a result of increasing jet fuel yield. As in other parts of the country, jet fuel is one of the fastest growing petroleum products. Capacity utilization was higher in summer 1997 than for the prior two summers, but the 93.5 percent utilization figure may give the

Table 4.5 Operable Refinery Upgrading Capacity in Summer 1997				
	Coking	Hydrocracking	Fluid Catalytic Cracking	Distillation
Region	Percent Distillation Capacity			Barrels/Stream Day
PADD 1	5.2	3.6	39.0	1727
PADD 2	9.8	4.2	34.7	3625
PADD 3	11.2	9.0	36.6	7484
PADD 5	18.8	16.6	25.7	3099

Source: Energy Information Administration, *Petroleum Supply Annual, DOE/EIA-0340(96)/1, Table 38, Petroleum Supply Monthly* DOE/EIA-0109 (97/09), Table 28.
Note: Tosco's Trainer refinery is included in PADD 1, but is not listed in *Petroleum Supply Annual* 1996 data.

Figure 4.6 Monthy PADD 5 Light-Product Yield



Source: Energy Information Administration, **1986-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(86-88)/2, Tables 8 and 11, DOE/EIA-0340(89-96)/2, Tables 13 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 24 and 28.
Note: Light-product yield is light product refinery production (gasoline, jet fuel, kerosene, and distillate) as a percent of crude oil plus unfinished oil inputs.

impression that capacity was pushed less strongly on the West Coast than in refining centers on the East and Gulf Coasts and in the Midwest. However, when capacity utilization in PADD 5 is viewed on the basis of the major refining centers within the PADD, a very different picture emerges.

The capacity utilizations for the larger refineries in the Los Angeles and San Francisco Bay areas were quite high in the summer of 1995, dipped slightly in summer 1996, but rose above the 1995 utilizations in summer 1997. During the May to September period of 1997, utilizations for the Los Angeles and San Francisco refineries were uniformly high, except for the month of June, when

Table 4.6 PADD 5 Summer Refinery Inputs and Gasoline Production

	May-Sept 1995	May-Sept 1996	May-Sept 1997
Operable Capacity (MB/D)	2900	2909	2927
Crude Input (MB/D)	2581	2512	2580
Crude Gravity (°API)	25.5	25.8	26.0
Net Unfinished Oil Inputs (MB/D)	35	27	4
Gross Input (MB/D)	2662	2592	2738
Operable Utilization Rate (%)	91.8%	89.1%	93.5%
N-Butane + Oxygenate + Net Blending Stock Inputs (MB/D)	95	134	164
FCC Feed Percent (1)	28.1%	28.0%	28.9%
Hydrocracker Feed Percent (1)	17.4%	17.0%	16.5%
Coker Feed Percent (1)	18.5%	17.7%	20.0%
Adjusted Gasoline Production (MB/D) (2)	1233	1177	1209
Gasoline Yield (1)	47.1%	46.4%	46.8%
Jet, Kerosene & Distillate Yield (1)	33.5%	34.9%	35.2%
Total Light-Product Yield (1) (3)	80.7%	81.3%	82.0%

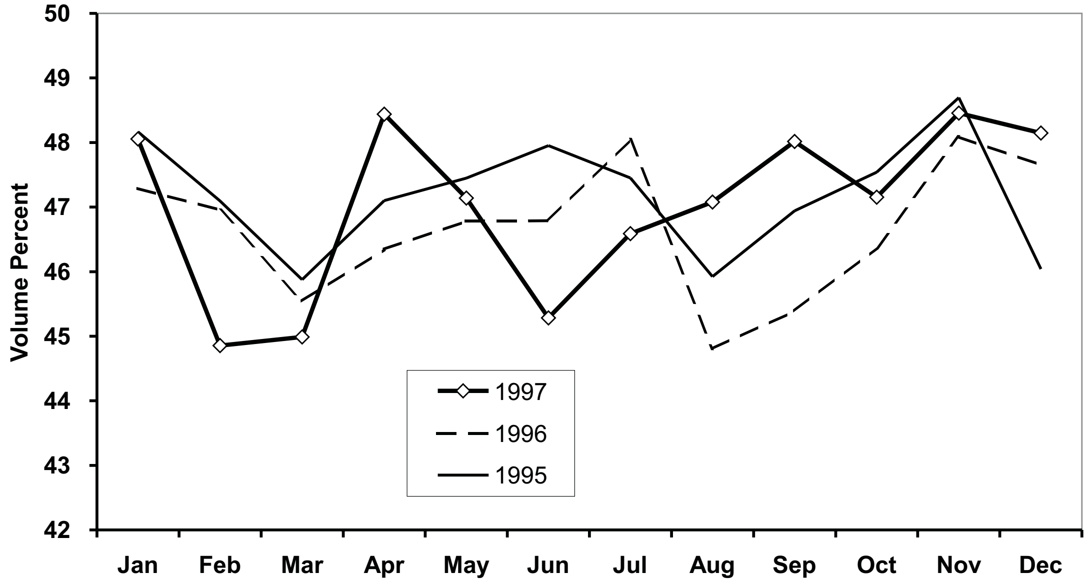
Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 13 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 24 and 28.
Notes: (1) Yields and percents are calculated on the basis of percent of crude oil plus net unfinished oil inputs.
(2) Adjusted production equals refinery gasoline production minus inputs of butane, oxygenates and net inputs of gasoline blending components. (3) Light products are gasoline, jet fuel, kerosene, and distillate.

refinery inputs dropped by about 50 thousand barrels per day. Refinery utilizations were also very high for the Puget Sound refineries, which primarily provide product to the Pacific Northwest, but are also capable of providing some gasoline blending components to California for producing CaRFG.

The low overall operable utilization rate stemmed from several sources. California contains several small refineries that have experienced deactivation and reactivation in recent years, and other small refineries that are capable of producing very small volumes of gasoline for the state. Alaska has a reported refinery capacity level of nearly 300 thousand barrels per day, but the utilization rate for the state is quite low. Regardless, the gasoline produced in Alaska could not be expected to contribute significantly to the West Coast market for logistical reasons.

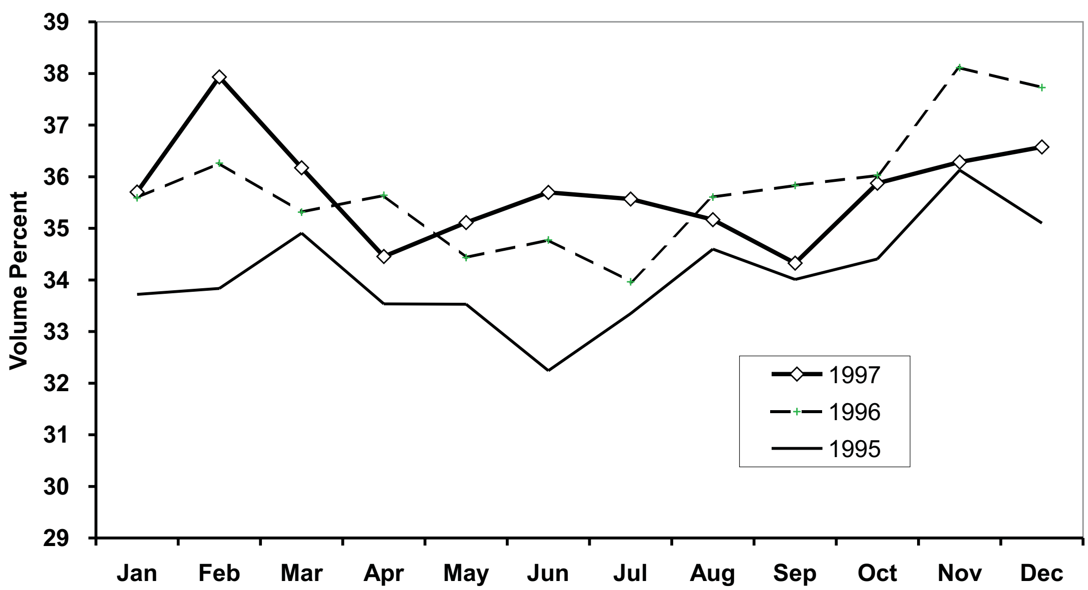
The monthly light-product yields from 1995 through 1997 in PADD 5 are shown in Figures 4.7 and 4.8. PADD 5 gasoline yields tend to fall off in February and March, as distillate production is favored and because many refineries plan unit shutdowns for maintenance during this period. Gasoline yields usually increase in the April to July period, and distillate yields decrease. In June 1997, because of surplus gasoline supply and weak prices, West Coast refiners reduced refinery inputs about 50 thousand barrels per day, and also reduced gasoline yield, while slightly increasing

Figure 4.7 PADD 5 Adjusted Gasoline Yield



Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Tables 13 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 24 and 28.
Note: Adjusted Yield is derived from Adjusted Production which equals refinery gasoline production minus inputs of butane, oxygenates, and net inputs of gasoline blending components divided by crude oil plus net inputs of unfinished oils.

Figure 4.8 PADD 5 Distillate, Kerosene, and Jet Kerosene Yields



Source: Energy Information Administration, **1995-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(95-96)/2, Table 13. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 24.
Note: Yield is calculated as a percent of crude oil and unfinished oil inputs.

that for distillate. PADD 5 gasoline production in June was 40-50 thousand barrels per day lower than it might have been had these changes not been made. In July, August, and September, gasoline yields were pushed up and distillate yields decreased. While gasoline production could have been increased in June, the potential for any added production in July and August is difficult to estimate precisely, but is judged to be fairly small. It might have been possible from a process equipment standpoint to increase gasoline production at the expense of jet fuel and other distillate in the summer months, but market requirements might have precluded this option.

When data for specific California refineries were reviewed, no light-product yield degradation was evident with increasing utilization. For the PADD as a whole and for the specific refineries analyzed, as utilization has increased over time, light product yields have grown. This has occurred because availability and throughput levels for one or more of the major conversion units have also risen over the period. Generally for PADD 5, the availability of downstream conversion capacity has increased relative to distillation capacity, providing the yield improvement.

The analysis of refinery data also showed the impact of unit outages on refinery yields. Since 1995, a number of significant outages of major downstream units have occurred, and the review showed the negative impact on gasoline and other light-product yields during these outage periods. In short, refinery operation usually continues during a unit outage, but the yields of light products are reduced. In the summer of 1997, the impact of outages on gasoline production for the specific refineries that were reviewed was only minor.

In conclusion, the larger refineries in California producing RFG and the refiners in the Puget Sound area ran at high utilizations in the summer of 1997. Refinery unit outages for these refineries resulted in only minor impacts on production of light products. Average monthly gasoline production was high for the summer period, while gasoline yields were about the same. However, early in the summer, gasoline yields were lower than in 1996, due to a shift in product mix to more jet fuel and less gasoline. The total light-product yield did not deteriorate. Thus, the lower gasoline yield early in the summer was not the result of refiners operating at high refinery utilization rates. It is estimated that the major California refinery group could only have produced 30-40 thousand barrels per day more of gasoline during summer 1997, assuming no major unit outages during the period.

Conclusions from Production Analysis

The analysis provided clear indications that in summer 1997, gasoline production from U.S. refineries was approaching the upper limit (See Sidebar - Production of Incremental Gasoline Barrels at High Capacity Utilization).

- Refinery utilization was high in the major refining areas within the continental United States.
- As capacity utilization increased, gasoline yields declined, but total light product yields were stable, as jet and other distillate yields increased at the expense of gasoline.
- Despite uncertainty caused by the lack of precision of reported unit capacity data, maximum U.S. summer gasoline capability is estimated to be at most 200 thousand barrels per day more than the

Production of Incremental Gasoline Barrels at High Capacity Utilization

A generally held hypothesis about the economics of refining is that, as refinery operations approach high utilization rates, the incremental or marginal product barrel would contain a lower yield of high-value, light products (gasoline and distillate fuels). This would occur for two possible reasons:

- Inputs to primary distillation units would rise to a level exceeding the capacity of downstream units to handle the full volume of the intermediate streams to be processed, and the last (or incremental) barrels would be processed without the benefits of all downstream conversion units; or
- The last barrel to be produced would be produced by less well-equipped refineries that had either operated at lower throughput levels, or had been reactivated because the production (albeit high cost) of these marginal refineries was needed to meet demand.

Based on the analysis of this study, despite reaching quite high utilization rates, there is no evidence to indicate the hypothesis has been fulfilled by either of the two possible routes. As U.S. capacity utilization has increased, many refiners have invested in debottlenecking and added capacity to downstream units to achieve balanced operations for the refinery. Consequently, most refineries have little or no distillation capacity in excess of downstream capacity. Changing the mix of crude oils charged has also been used to achieve balanced utilization of units as capacity utilization increases.

From detailed analyses of individual refineries, as capacity utilization has risen, yield of high-quality, light products has almost always been maintained. In the few cases when yields have dropped, it is usually traceable to clear causes such as use of heavier, poorer quality crude oils. Yields have also been observed to drop temporarily because of outages of important units. Refiners in some areas have improved yields through downstream unit capacity additions and improved process technology.

In those cases where primary distillation capacity exceeds the capacity of the more expensive downstream conversion units (such as FCC and coking), refiners appear to limit refinery input based on the downstream unit capacity, and will not operate at higher distillation utilizations where yield levels would decline.

Finally, reactivations that occurred during recent years have not been short-term to take advantage of short-term strong markets.

Does this mean that, since light-product yields have not fallen off at high capacity utilization, there is no market impact when operating at high levels? No, the impact is that the market can expect less contribution from refinery production in a high demand period, and imports and inventory reduction will have to fill the market need. Imports can be a source of higher prices in that this alternative can potentially be high cost, depending on availability and the market situation in the region from which they come. Imports also can have long lead times that add to market worries and upward price pressure during times of market stress.

summer 1997 production level, assuming similar distillate production levels and no unusual summer outages.

- At the high utilization rates experienced during the summer 1997, U.S. refiners had limited ability to increase gasoline production to meet any surges in demand. When the market tightened, added production was relatively small and slow to arrive, and the tight gasoline market was only resolved over time by a combination of falling demand, increased production, and imports.

5. Focus on Imports

Gasoline and gasoline blending component imports into the United States in 1997 began the year very high, but fell off sharply in June and July. The drop from June to July alone was 125 thousand barrels per day. While normally such a drop might not have drawn much attention, demand surged in July 1997, growing 211 thousand barrels per day over June. The drop in imports was one of the supply factors that contributed to the tightening markets in July.

Background on U.S. Imports

PADD 1 Accounts for Most U.S. Imports

Most gasoline imports are used to help meet East Coast (PADD 1) demand, with PADD 1 receiving over 95 percent of total U.S. gasoline imports the since the beginning of 1995. In 1996 and 1997 imports supplied 17 percent of total East Coast gasoline demand, making them an important source of supply to this region.

PADD 1 is a major RFG consuming area, with RFG representing over 38 percent of the region's 1997 gasoline demand. Imports supplied a large share, about 31 percent, of this RFG. Production and stocks from inside the PADD filled another 39 percent of RFG demand, and the remaining 30 percent was met by refinery production from other regions, particularly the Gulf Coast (PADD 3). Conventional gasoline demand in PADD 1, occurring mostly in the southeast, was met primarily from production in PADD 3, with only about 8 percent coming from imports.

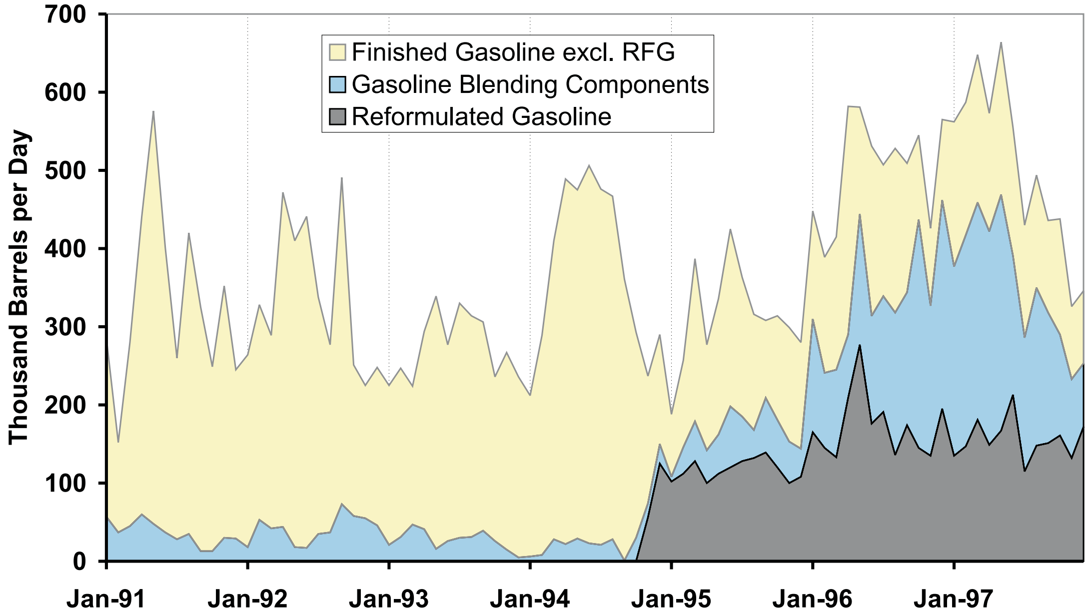
Since PADD 1 is a major RFG-consuming area and the largest user of imports, it is not surprising that a large share of U.S. imports are RFG and blending components, which are largely used to make RFG. RFG and blending components comprised 53 percent of U.S. total gasoline imports in 1995, but increased to 68 and 71 percent in 1996 and 1997 respectively (Figure 5.1).

Europe Is a Major Swing Source of Imports

Canada, the Virgin Islands (considered a source of U.S. imports in EIA data) and Venezuela are three of the largest countries and territories supplying gasoline imports to the continental United States, and thus to PADD 1 (Table 5.1). These areas find it economic to export large quantities of product to the United States regularly, forming a base level of imports that ranged annually from 162 to 212 thousand barrels per day between 1990 and 1995. Generally these three sources supply over 50 percent of U.S. gasoline imports. In 1996 and 1997, they increased their gasoline exports to the United States to 278 and 288 thousand barrels per day respectively, and accounted for 35 percent of the import volume growth in 1996. Of the these three supply sources, Venezuela has contributed the most to growth in imports since 1995.

Europe, the single most important regional source of gasoline imports, tends to be a swing exporting area, providing very high flows of product from time to time. In 1995, Europe only

Figure 5.1 Composition of Total Gasoline Imports



Source: Energy Information Administration, **1991-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(91-96)/2, Table 3. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 4.

Table 5.1 U.S. Total Motor Gasoline Imports
(Thousand Barrels per Day)

	1990	1991	1992	1993	1994	1995	1996	1997
Canada	55.8	70.1	64.5	55.6	49.3	66.4	93.1	82.6
Virgin Islands	52.8	48.2	50.0	56.3	117.7	107.4	104.9	112.6
Venezuela	78.1	53.0	65.3	50.1	33.4	37.7	80.1	92.4
Europe	130.2	93.3	90.2	48.9	128.5	67.6	151.0	140.7
Middle East & Africa	38.5	33.8	28.6	15.8	4.8	11.3	27.4	32.9
South & Central America	45.4	29.9	30.2	40.6	32.4	14.5	21.6	22.7
Other	2.9	4.7	6.5	7.3	9.9	7.7	24.8	20.7
Total	**403.7**	**333.0**	**335.3**	**274.6**	**375.9**	**312.7**	**502.8**	**504.6**

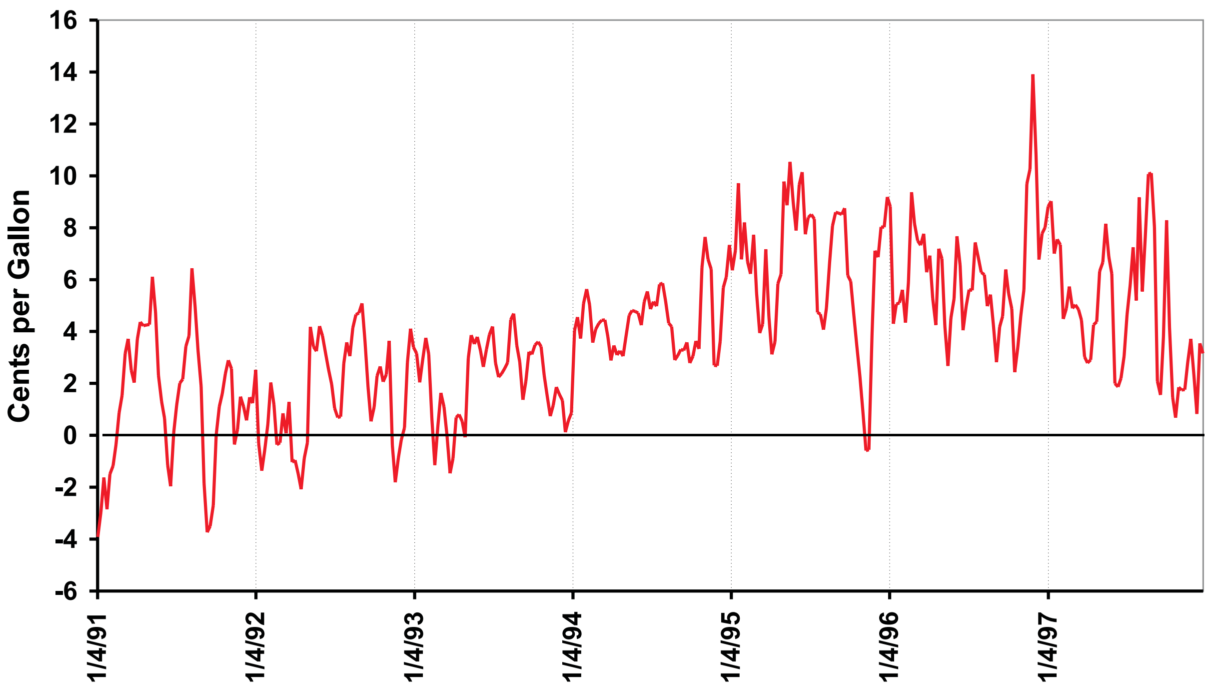
Source: Energy Information Administration, **1990-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(90-96)/1, Table 21. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 35.
Notes: South & Central American values exclude Venezuela.

provided 68 thousand barrels per day of imports (22 percent share). However, since 1996, Europe has increased substantially its export volumes to the United States, providing 151 thousand barrels per day (30 percent share) in 1996 and 141 thousand barrels per day (28 percent share) in 1997. Of the190 MB/D increase in imports in 1996 over 1995, Europe accounted for 44 percent of the addition.

One of the reasons Europe has been a major source of imports to the United States is that Europe has an excess supply of gasoline. This excess stems from a mismatch between European refinery configurations and the current product demand mix. Many of the conversion facilities installed (i.e., fluid catalytic cracking units and cokers) in European refineries produce more gasoline than diesel, whereas diesel demand has been growing faster than gasoline demand.

Prices in Europe relative to the United States were not always conducive to large flows of product to this country. Figure 5.2 shows the spot price differences between Rotterdam (the spot market price reflecting trade in oil products in northern and western Europe) and New York Harbor. From 1992 through 1993, the price fluctuated between 0-4 cents per gallon. In order to cover transportation costs, U.S. prices generally would have to exceed European prices by about 4-5 cents per gallon. Such price differences only occurred for short time periods prior to 1994. U.S. prices began to strengthen relative to Europe in 1994, helping explain the strong imports in that year. Although the price differences continued to grow in 1995, imports from Europe fell back. It is thought that the uncertainties surrounding the beginning of the RFG program hindered more flow from Europe that year. As the RFG program stabilized, imports from Europe increased considerably in 1996.

Figure 5.2 Weekly Average Spot Gasoline Price Difference Between NY Harbor and Rotterdam



Source: DRI Platts Regular, Conventional Spot Gasoline Prices.

The Role of Imports in Summer 1997

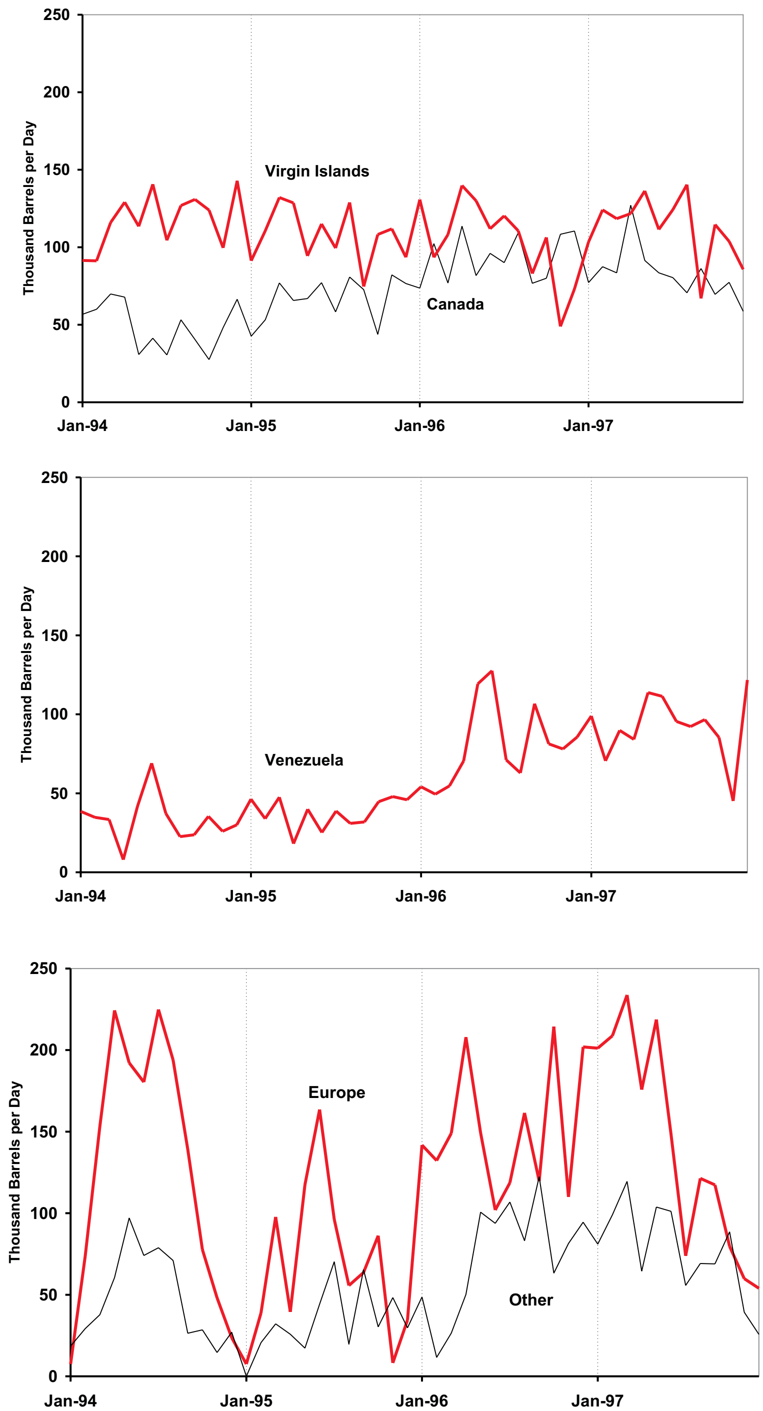
In July 1997, U.S. demand surged 211 thousand barrels per day over June. At the same time, imports fell back by 125 thousand barrels per day, putting even more pressure on domestic supply. Much of the decline can be traced to falling import volumes from Europe, one of the largest U.S. sources of swing supply.

While in recent years, Europe has accounted for a large part of the growth in gasoline imports to the United States, in June and July 1997, it accounted for most of the decline. Market conditions changed between Europe and the United States during 1997, as reflected by the difference in price between the two regions. The U.S.-European price differential remained at elevated levels (6 cents per gallon) through early 1997, but dropped later in the year. During the first half of the year, European imports reached record levels, averaging 215 thousand barrels per day in the first quarter and 181 thousand barrels per day in the second. However, during the second quarter, imports were beginning to fall off (Figure 5.3).

Both European and U.S. prices were falling in early summer, but U.S. prices fell faster than in Europe, causing the price difference between the areas to narrow. U.S. gasoline prices weakened mainly as a result of gasoline margins declining. Gasoline price spreads on the East Coast softened in May and June of 1997 as production and imports exceeded demand, and stocks built from the low levels at the beginning of the year to end June at more normal levels (Chapter 2). New York Harbor gasoline spot price spreads (gasoline minus crude oil price) fell from about 3.6 cents per gallon above five-year-average levels in March to 2.0 cents below average levels in June as supply grew (Figure 5.4). European prices were also dropping in June, but not as fast as in New York. The New York Harbor minus Rotterdam price difference averaged just over 2 cents for the month, well under what is needed to cover transportation costs. European imports dropped from 219 thousand barrels per day in May to 149 thousand barrels per day in June and 74 thousand barrels per day in July. Although U.S. gasoline prices strengthened again in July and August relative to Europe, imports did not recover to the levels seen earlier in the year. With the gasoline season nearing its end, buyers and sellers were not expecting high prices to continue, and were reluctant to commit to any additional imports that late in the season.

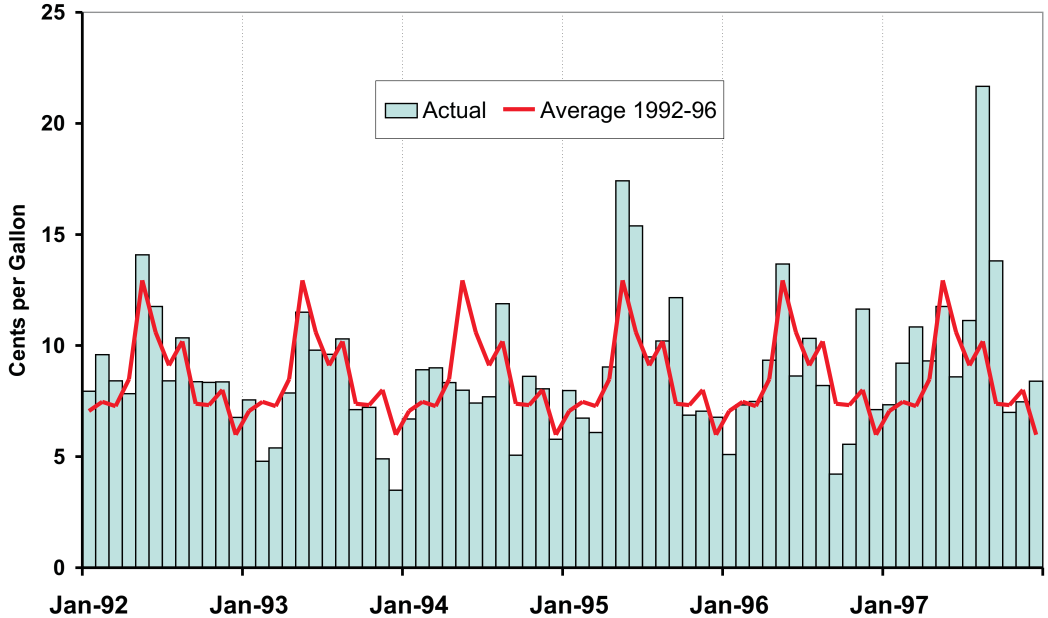
Refinery problems were reported in both Europe and Venezuela in late July and August, which added to concerns over supply. Price, however, produces some strong incentives to overcome such problems quickly. For example, when August ended, Venezuelan imports had only dropped 3 thousand barrels per day from July, and European imports had increased almost 48 thousand barrels per day, in spite of the reported refinery problems. In order to take advantage of the attractive U.S. prices in August, Venezuela seemed to get around its refinery problems by exporting more blending components in place of finished gasoline. The mix of gasoline imports from Venezuela moved from 47 percent blend stocks in July, to 88 percent blend stocks in August. Venezuela returned to a more normal mix in September when its refinery problems were resolved.

Figure 5.3 Monthly Total Gasoline Imports By Geographic Source



Source: Energy Information Administration, **1994-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(94-96)/2, Table 21. **1997:** *Petroleum Supply Monthly,* DOE/EIA-0109 (97)/various issues, Table 35.

Figure 5.4 Monthly Average Spot Gasoline Price Minus Crude Oil Price



Source: DRI Platts Spot Prices for New York Harbor Regular Conventional Gasoline and West Texas Intermediate Crude Oil.

The Role of Exports in Summer 1997

This chapter focused on imports because gasoline exports played very little role in adding to gasoline market tightness in July and August in most of the United States. The exception was the West Coast, which experienced an increase in gasoline exports that contributed to the markets tightening in that part of the country. The role of West Coast exports is covered in Chapter 3.

Most exports from the area east of the Rocky Mountains leave from PADD 3 and travel to Mexico and Central and South America. July exports from the Gulf Coast region increased 27 thousand barrels per day over June, and in August they increased another 35 thousand barrels per day, partially offsetting the 65 thousand barrels per day increase in imports during August. The biggest export increases from July to August went to Mexico, Colombia, and the Netherlands Antilles.

6. Focus on Gasoline Prices

While spot, rack, DTW and retail prices showed movements during the late summer 1997 price runup typical of past price runups, the futures market displayed more speculative interest than usual. The noncommercial traders did not start the price changes, but followed the movements by participating in a larger percentage of the trades than occurred in prior runups, such as that in spring 1996.

The movements of gasoline prices through the distribution system from spot to retail during the summer 1997 price runup followed patterns previously observed, with retail prices picking up about 50 percent of their movement from spot price changes over the prior month. Class of trade prices indicated that throughout much of 1997, margins were better for the downstream business than in 1996, but most of the gains accrued to refiners rather than retailers, who generally experienced margins only slightly better than in 1996.

Noncommercial Traders Were Active During The August Price Rise

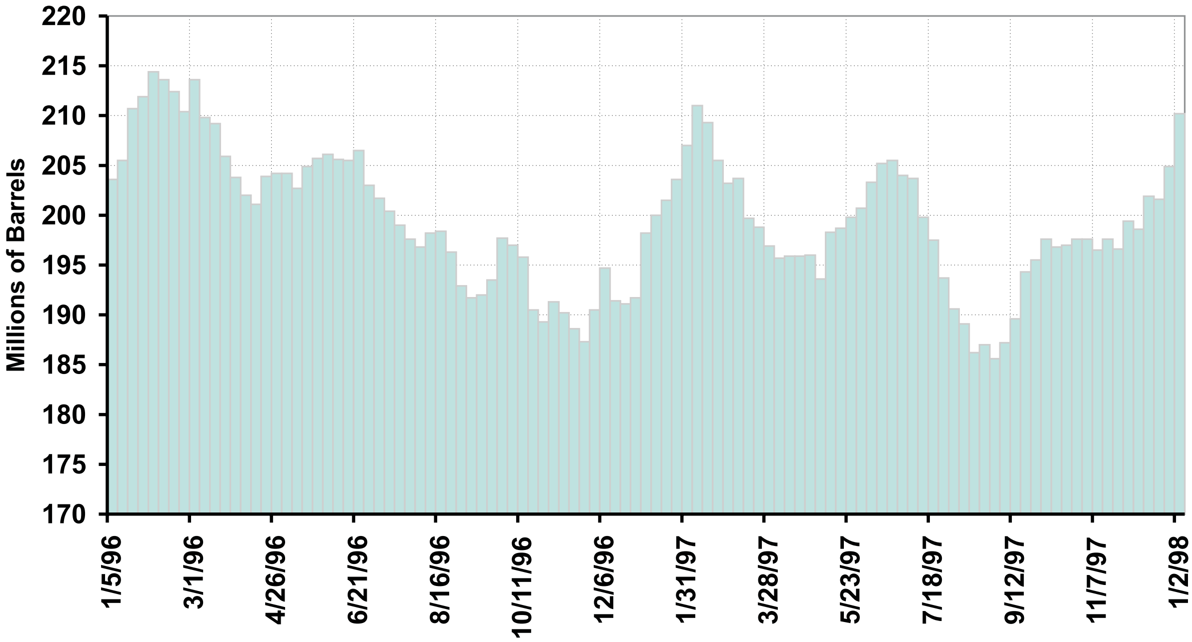
In contrast to earlier gasoline price rises, the August 1997 rise attracted a great deal of speculative interest in energy futures markets. There are many large speculative funds that follow price trends in commodity futures markets, and in August 1997 they were attracted to the petroleum futures markets. Questions naturally arise about how speculators affect prices. In particular, this chapter shows that speculators definitely did not start the upward trend in gasoline prices in August 1997, but that they helped sustain the upward price trend once it started.

One of the most important determinants of futures market prices is the relative levels of stocks available for delivery against the expiring contracts.[1] Stocks are an important barometer of the tightness of the gasoline markets and potential for price increases. When demand is high and outpacing supply, stocks will fall. If stock levels are low during high demand seasons, there is little cushion to absorb supply/demand imbalances. Under these conditions, buyers tend to bid up prices to assure supply. Figure 6.1 shows that stocks in August 1997 were much lower than in August 1996. Gasoline stocks were very low for reasons already discussed: strong demand straining supply, which was affected by refinery problems in the U.S. and in major import source regions (Europe and Venezuela).

The upward price pressure from tight market conditions can manifest itself in the futures markets in a situation called "backwardation," in which prices for nearby contract deliveries are higher than for more distant deliveries. In August, backwardation in the gasoline futures market was especially steep, i.e., contracts for gasoline to be delivered in September were 6 cents higher than contracts for

1 Only reformulated gasoline is deliverable against futures contracts.

Figure 6.1 1997 Weekly U.S. Blending Component & Finished Gasoline Stocks



Source: Energy Information Administration, *Weekly Petroleum Status Report*, DOE/EIA-0208(96-98)/various issues, Table 10.

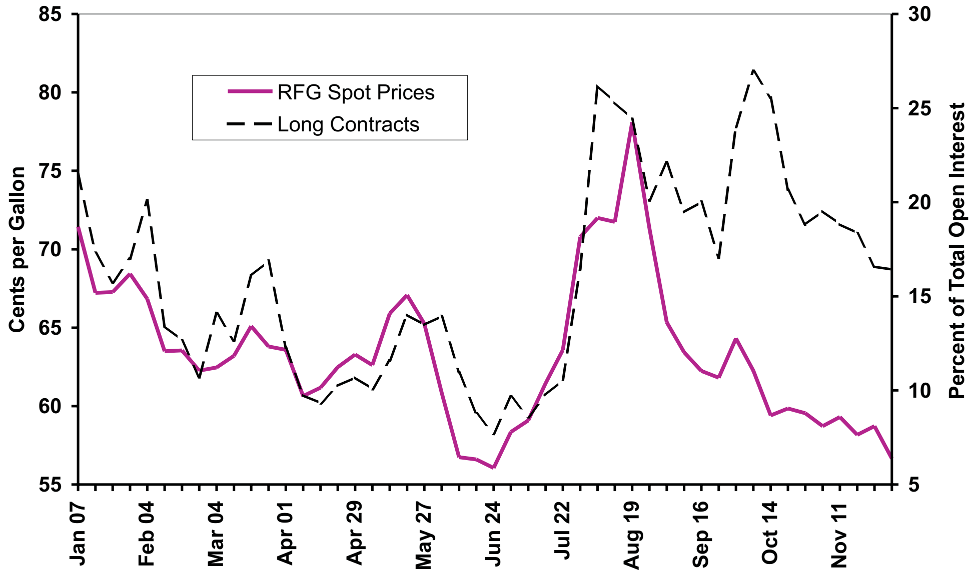
delivery in October. Tight market conditions frequently also cause abnormal relative prices. For example, close to Labor Day, spot prices of conventional gasoline nationally rose above those of reformulated gasoline. Conventional prices had not been this strong relative to RFG since the Colonial Pipeline break in Texas in October 1994 temporarily drove up the price of conventional gasoline. Exceptional tight market situations like this, i.e., strong demand, low stocks, and steep backwardation, frequently lead to a sharp upward price trend in the spot market.

Once a price trend is established, speculative money funds tend to follow it.[2] Figures 6.2 and 6.3 show that this trend-following occurred during the gasoline price runup.[3] Figure 6.2 shows that the spot price of reformulated gasoline was 56 cents per gallon at the end of June. As it rose sharply toward 78 cents per gallon on August 19, noncommercials followed the price trend by increasing their percentage holdings of the total open interest, or number of contracts outstanding. In early August, large noncommercials with contracts to buy gasoline held over one-fourth of all

2 Dale, C. and Zyren, J., "Noncommercial Trading in the Energy Futures Market," *Petroleum Marketing Monthly*, DOE/EIA-0380(96/05)(Washington, DC, May 1996), pp. xiii-xxiv., and "Petroleum Futures Markets: Volatile Prices, Controversial Functions, Stagnant Volumes," Chapter 6 of Energy Information Administration, *Petroleum 1996: Issues and Trends*, DOE/EIA-0615(Washington, DC, September 1997), pp. 101-119.

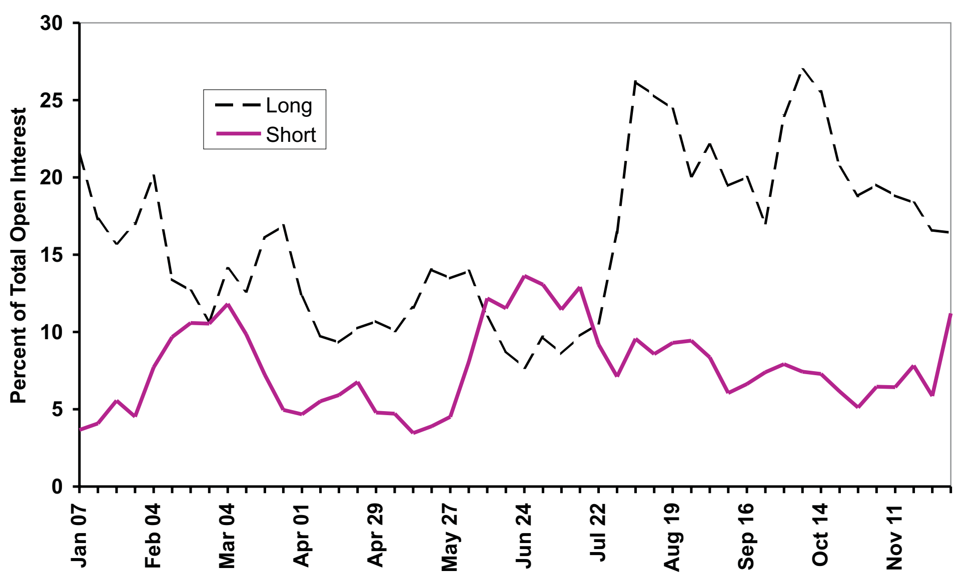
3 Holders of large numbers of commodity futures contracts must have their brokers report their holdings to the Commodity Futures Trading Commission (CFTC). The CFTC, in turn, publishes this data weekly, where it is examined carefully by futures market traders. "Noncommercials" are traders who do not have an interest in making or taking delivery of the physical commodity, i.e., they are speculators.

Figure 6.2 1997 Noncommercial Holdings of Gasoline Futures Contracts & RFG Spot Prices



Source: **Spot Prices:** Reuters RFG regular grade weekly averages. **Long Contract Volumes:** Commodity Futures Trading Commission.

Figure 6.3 1997 Noncommercial Holdings of Gasoline Futures Contracts



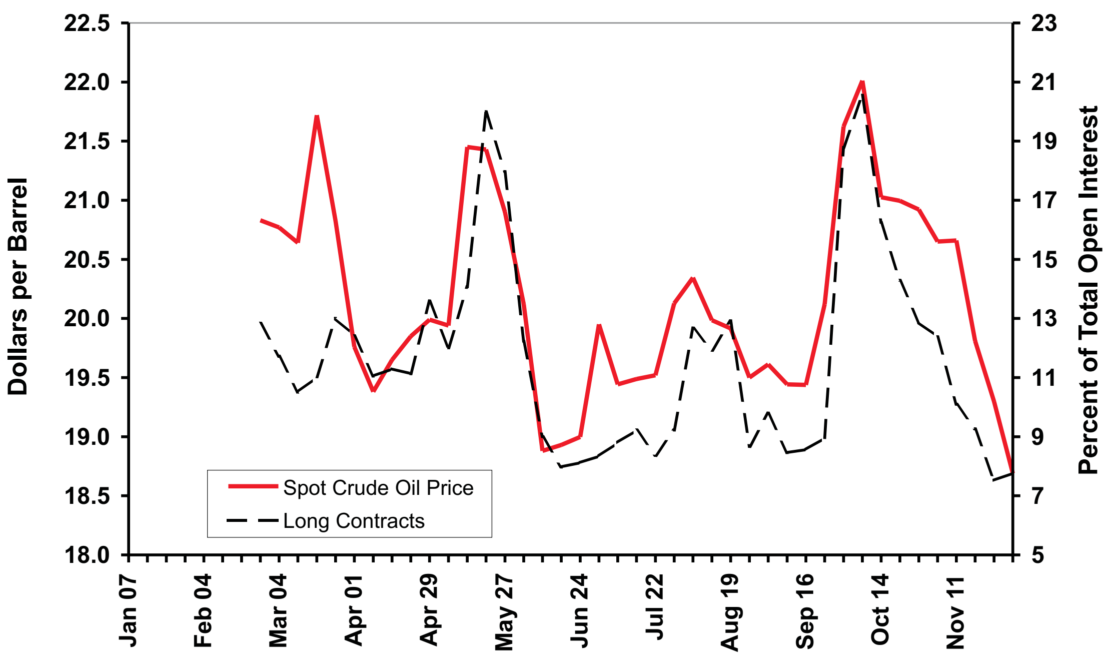
Source: Commodity Futures Trading Commission.

outstanding contracts, a much higher percentage than normal and one which did not occur at any time earlier in the year. Noncommercials began to liquidate their positions after prices started to fall in late August, again trying to follow a trend.

While some noncommercials bought futures contracts, others were selling them, so the question naturally arises as to what was the net position of noncommercials during the price runup. Figure 6.3 shows that while long, or buying, positions of noncommercials followed the price trend, the short, or selling, positions were relatively stable. Thus, Figure 6.2 shows an accurate picture of how rapidly noncommercials followed the price trend. They weren't, for example, pursuing a complex trading strategy such as building large long and short positions simultaneously, which would have left their net positions relatively small.

Finally, noncommercials are frequently attracted to similar markets that they believe may move together. But, Figure 6.4 shows that noncommercials were relatively inactive in the crude oil futures market in August during the large increase in gasoline prices. They did follow crude oil price movements in late September and early October, but much of the activity in the crude oil market then was due to external factors such as the Iraq situation rather from internal pressure from improving gasoline prices.

Figure 6.4 1997 Noncommercial Holdings of Sweet Crude Oil Futures Contracts and Crude Oil Spot Prices



Source: **Spot Prices:** Reuters West Texas Intermediate Crude Oil weekly averages. **Long Contract Volumes:** Commodity Futures Trading Commission.

In summary, noncommercials, or speculators, did not play a large role during the spring 1996 or fall 1996 gasoline price rises, so their increased activity was new to the August 1997 price runup. But there is no evidence from the graphs that noncommercials had any role in starting the price rise, although their net purchases of gasoline futures contracts helped sustain the upward price movement after it started. Large noncommercial money funds can be expected to be attracted as trend-followers to such situations as they arise again in the future.

Increased Margins in 1997 Benefitted Refiners

Class of trade prices (spot, rack, dealer tank wagon or DTW, and retail) provide information on where in the distribution chain prices increased, and who benefitted from the increase (See Sidebar - Class of Trade Prices). Rack prices are prices paid for product sold from within the refinery or terminal loading racks. Only limited distribution and storage costs are included in this price. DTW price represents the prices paid by retailers for gasoline. Thus the difference between retail price (excluding taxes) and DTW price is the money retailers have available to cover the cost of their operations and return on investment. The difference between rack price and crude oil costs represents the dollars refiners have to cover production costs and some storage and distribution costs. DTW price includes additional marketing, distribution and storage costs beyond those covered in the rack price.

Class of Trade Prices

Spot Price — Represents a price agreed to by a wholesale buyer (e.g., distributor) and seller (e.g., refiner) for a single cargo of product. It can vary significantly day to day.

Rack Price — Refers to the wholesale price charged by wholesalers at their refineries or company terminals to open dealers or distributors. Rack prices are usually determined on a daily basis and are influenced by competitors' prices as well as by spot and futures market prices. Rack prices cover refining costs, including the cost of feedstocks and some storage costs.

DTW (Dealer Tank Wagon) Price — Is that charged by distributors and refiners to their retailers. These prices include transportation costs to the dealers' stations and other business costs (promotions, dealer incentives, etc.) beyond the basic rack price. DTW prices are established by considering competitors' prices and spot, futures, and rack prices.

EIA DTW and Rack Prices — Include both branded and unbranded prices. Branded prices generally carry an arrangement for security of supply, trademark, credit cards, and advertising, thereby carrying a premium over unbranded prices. However, when markets are tight, volumes available to unbranded dealers may diminish and unbranded prices then can exceed branded prices.

Retail Price — Is the price paid by the consumer at the gasoline station. It includes the DTW price paid by the retail station for fuel, additional station operation costs, dealer margins and taxes.

During 1996, consumers saw large increases in gasoline prices, both in the spring and in the fall. Most of these increases were used to pay for higher feedstock cost because the price of crude oil, from which gasoline is produced, was rising. Thus, the refiners and retailers benefitted little from the price rises. Table 6.1 shows that, with the exception of PADD 5, on an annual basis, the 1996 rack spreads (rack price minus crude oil price) and DTW spread (DTW price minus crude oil price) did not vary much from previous years. Retail margins (retail price minus DTW price) also did not show any large changes in 1996, again with the exception of PADD 5. The increases in PADD 5 during 1996 can be traced back to California's introduction of its new CaRFG. Not only is this fuel more expensive to produce, but the region experienced supply problems that drove regional gasoline prices up relative to crude oil.

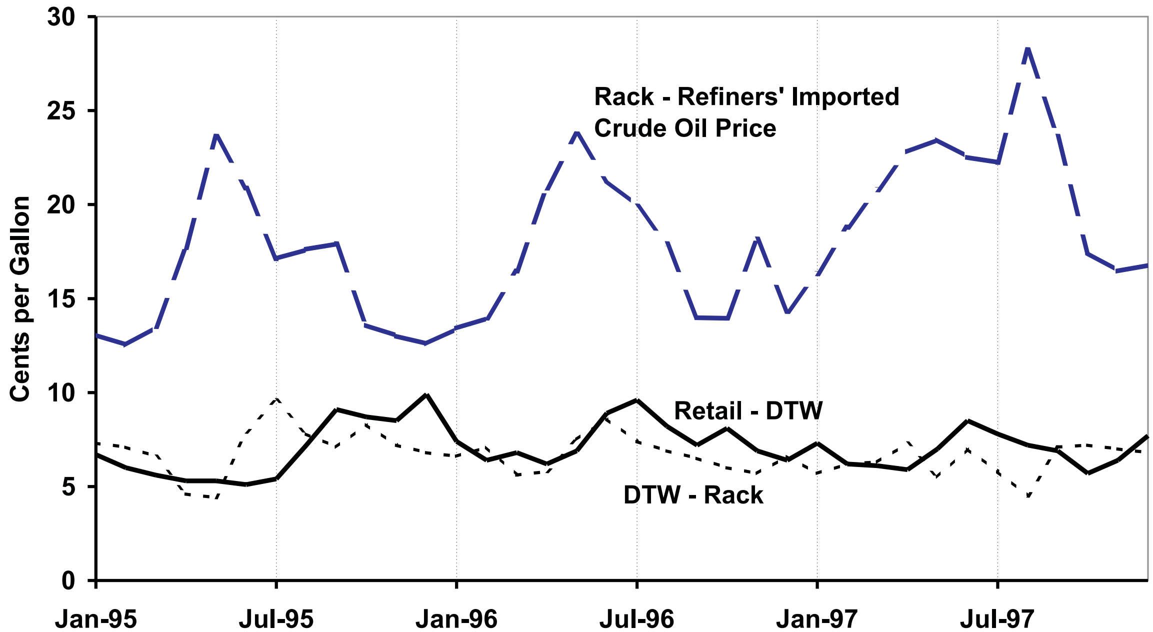
Table 6.1 Class of Trade Margins for Conventional Gasoline (Cents per Gallon)

	Rack - Refiners' Imported Crude Oil Price	DTW - Refiners' Imported Crude Oil Price	Retail - DTW
PADD 1 (East Coast)			
1994	19.3	29.4	6.5
1995	18.1	27.0	8.0
1996	18.0	25.6	7.4
1997	20.8	28.7	7.8
PADD 2 (Midwest)			
1994	19.6	26.9	7.4
1995	17.7	24.2	8.3
1996	19.3	25.3	7.4
1997	21.7	27.2	8.1
PADD 3 (Gulf Coast)			
1994	18.1	25.5	9.7
1995	17.0	26.2	9.0
1996	17.5	25.5	8.2
1997	20.4	28.1	8.3
PADD 4 (Rocky Mountains)			
1994	27.1	32.1	10.4
1995	24.1	29.0	10.7
1996	25.9	31.2	9.9
1997	30.1	35.4	10.6
PADD 5 (West Coast)			
1994	23.7	33.9	9.3
1995	23.6	32.6	10.3
1996	29.6	38.4	13.5
1997	28.7	37.9	13.5

Source: Energy Information Administration, **1994-1996:** *Petroleum Marketing Annual*, DOE/EIA-0487(94-96), DTW, Retail Prices — Table 32, All Grades; Refiners Acquisition Price of Crude — Table 1. **1997:** *Petroleum Marketing Monthly*, DOE/EIA-0380(97)/various issues, Rack, DTW, Retail Prices — Table 32, All Grades; Refiners Acquisition Price of Imported Crude Oil — Table 1.
Note: Retail prices are sales to end users through retail outlets, excluding taxes.

Crude prices were relatively flat during the rise in gasoline prices in late summer 1997. As a result, refiners and/or retailers benefitted from the gasoline price increase. Figure 6.5 shows the monthly margin contribution to refiners (rack minus crude oil price) and to retailers (retail minus DTW price). The rack spread (rack price minus crude oil cost) shows the typical seasonal gasoline market behavior in 1995 and 1996. In the spring, as refiners finish their maintenance and turnarounds, gasoline production begins to increase along with summer driving demand. The seasonally low stock cushion coupled with the uncertainty of being able to bring production back on line quickly enough to meet demand causes the market to tighten during this period. This spring period usually determines how much return (if any) refiners will earn for the year.

Figure 6.5 U.S. Conventional Gasoline Class of Trade Margins



Source: Energy Information Administration, **1995-1996:** *Petroleum Marketing Annual*, DOE/EIA-0487(95-96), Table 32. **1997:** *Petroleum Marketing Monthly*, DOE/EIA-0380 (97)/various issues, Table 32.
Note: Retail prices are sales to end users through retail outlets, excluding taxes.

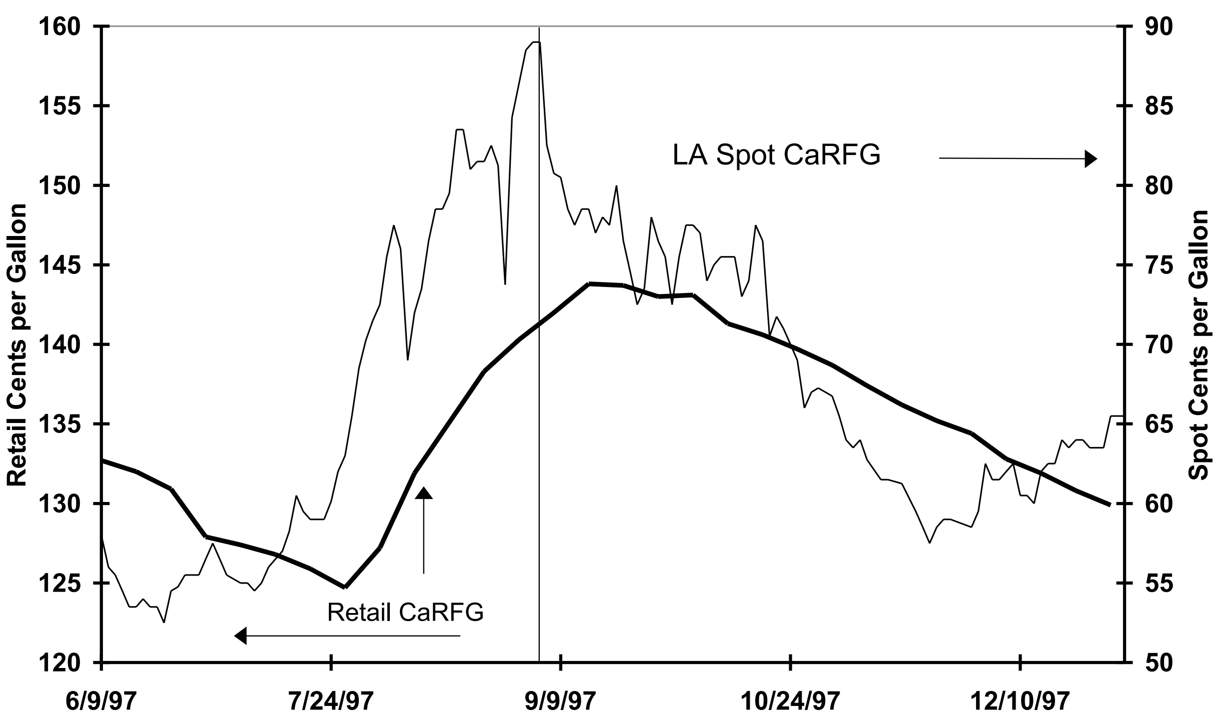
In 1997, the spring rack spread peaked and began its normal fall in June. The late summer price increase, however, produced a very different picture than in the prior two years. Refiners received an additional contribution to cover their costs and return on investment. Figure 6.5 also shows that the retail margin (retail price minus DTW) did not vary much. Thus retailers received little, if any, of the late-summer price increase, which is consistent with the market event. Rack prices went up because wholesale buyers were looking for more supply. That is, the price incentive was acting at the appropriate location in the supply chain.

Price Movement from Spot to Retail Was Typical

As spot prices change at major buying centers on the U.S. Gulf Coast (USG) and New York Harbor (NYH), prices further along the distribution chain begin to reflect those changes. Motor gasoline prices travel relatively quickly through the system to the retail level. In a prior study, EIA explored how retail prices at the end of the distribution chain reflect spot price changes at the major buying centers on the USG and NYH.[4] That analysis investigated changes in weekly retail gasoline prices as a function of changes in spot prices. In general, the results showed that about 50 percent of a spot price change was passed through to retail within 4 weeks, with an additional 30 percent pass-through occurring in the next 4 weeks. That is, if spot price rose 10 cents from one week to the next, retail customers would only have seen about 5 cents of the increase 4 weeks later, and about 8 cents of the increase 8 weeks later.

The time lag of the retail price response behind spot price movements is easily visible on graphs such as Figure 6.6 that show retail prices rising slower and peaking later than spot prices. This lag effect, which means that the current retail price change is a moving average of prior spot price

Figure 6.6 Lag Between Retail and Spot Prices



Source: Retail Prices: Energy Information Administration, Retail Outlet, Regular, Reformulated Gasoline Prices, Form EIA-878, "Motor Gasoline Price Survey." **Spot Prices:** Reuters daily prices.

4 Energy Information Administration, *Motor Gasoline Assessment Spring 1997*, DOE/EIA-0613, (Washington DC: July 1997), pp. 42-45.

changes, creates a distortion that makes it seem as though the retail price is staying up longer than it should.

The speed of price pass-through results reported in the previous study were updated for this study. Table 6.2 summarizes the updated speed of price pass-through results. The results are very similar to the previous study for PADD's 1A, 1B, 1C, 2, and 3. Additionally, this study also investigated the behavior of RFG spot and retail prices in PADD 5. Spot Los Angeles RFG prices were used to explain PADD 5 retail RFG prices. The price pass-through results are very much in line with those of the other PADD's (except for PADD 2). There was a 56 percent price pass-through to retail of spot price changes after 4 weeks, increasing to 85 percent after 8 weeks.

Table 6.2 Cumulative Pass-Through to Retail for a 10-Cent Change in Spot Price (Cents per Gallon)

Time	PADD 1A	PADD 1B	PADD 1C	PADD 2	PADD 3	PADD 5
4 weeks	4.95	4.78	5.34	7.90	5.00	5.56
8 weeks	7.85	8.01	8.49	10.02	7.94	8.48

Source: Energy Information Administration calculations.

The August price increase provides another opportunity to study price pass-through movements. An important question addressed in the current study is whether or not regular conventional retail gasoline prices exhibited normal historical behavior during the August price runup. The results showed that the answer was yes in most cases (see Appendix E for a detailed discussion of the methodology and results). The statistical results showed that for all areas except PADD 1A, there is no difference in pass-through behavior for the period before the August runup and the period during and after the August runup; the different PADD 1A result could be due to the low percentage of conventional gasoline relative to total gasoline sales in this area (around 13.4 percent from August through October 1997[5]).

5 Form EIA-782C, "Monthly Report of Prime Supplier Sales of Petroleum Products Sold for Local Consumption," survey results.

Appendix A
Petroleum Administration For Defense Districts (PADD) Definitions

PADD 1

Subdistrict 1A: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.

Subdistrict 1B: Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania.

Subdistrict 1C: Florida, Georgia, North Carolina, South Carolina, Virginia, West Virginia.

PADD 2

Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Wisconsin.

PADD 3

Alabama, Arkansas, Louisiana, Mississippi, New Mexico, Texas.

PADD 4

Colorado, Idaho, Montana, Utah, Wyoming.

PADD 5

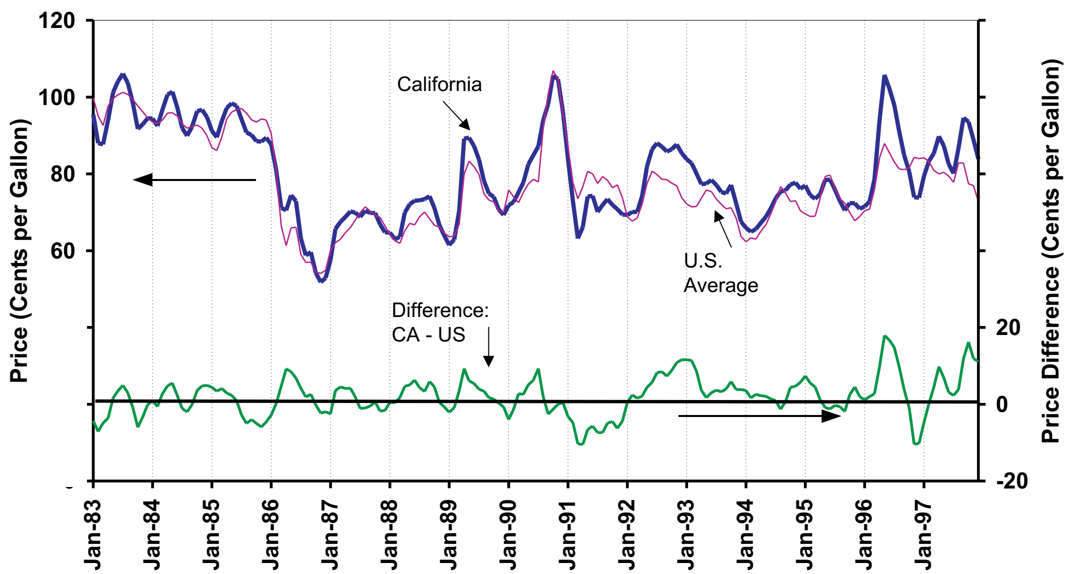
Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington.

Appendix B
Why Do Prices Vary Regionally?
California Case Study

In recent years, retail gasoline prices in California have tended to be higher than average U.S. retail prices. What might be the cause of this difference? Four factors that affect price can be explored to provide some insights into the answer: state and local taxes, costs of feedstocks used to produce gasoline, costs of operations excluding feedstock costs, and profitability.

State and local taxes have been higher in California than in many other states. For example, in 1996 California state and local taxes (including sales tax) ran about 5-6 cents per gallon higher than the U.S. average state and local tax. However, after taxes are removed, California gasoline prices are still higher than in other parts of the country. Annual average California prices, excluding taxes, ran about 1.3 cents per gallon higher than U.S. average prices (all formulations) prior to the Gulf War (1983-1990). From 1992 through 1995, the period between the Gulf War and when the CaRFG program began, California prices averaged 3.9 cents higher than U.S. average. Since the CaRFG program began in 1996, they have averaged 5.6 cents higher than average U.S. prices (Figure B.1). In this period, California prices have been more volatile — moving up and down more than average U.S. prices.

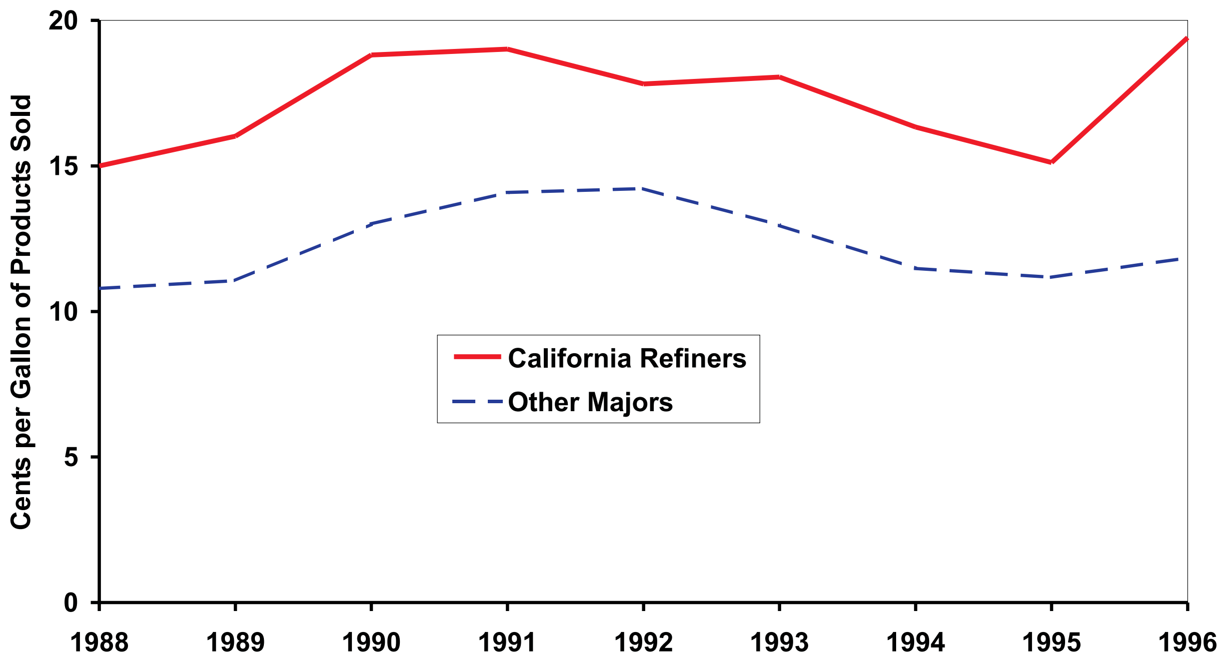
Figure B.1 California and U.S. Retail Regular Gasoline Prices



Source: Energy Information Administration, **1983-1996:** *Petroleum Marketing Annual*, DOE/EIA-0487(83-96), Table 31. **1997:** *Petroleum Marketing Monthly*, DOE/EIA-0380(97)/various issues, Table 31.

A factor often cited in discussions of California gasoline prices is higher operating costs, excluding feedstock (e.g., crude oil) costs. Companies operating in the West experience higher refining and marketing costs. Figure B.2 shows refining and operating costs of major oil companies having 70 percent or more of their refining capacity on the West Coast. These companies represent 52 percent of PADD 5 capacity, and 58 percent of California's capacity. Only 7 percent of the "Other Majors" capacity shown in the figure is located in PADD 5. This figure shows that from 1990 through 1995, it cost companies $1.50 to $2.00 per barrel (3.5-5.8 cents per gallon) more to operate[1] in the West than elsewhere. In 1996, it cost them $3.20 per barrel (7.6 cents per gallon) more.

Figure B.2 Annual Refining and Marketing Operating Cost Comparison



Source: Energy Information Administration, Financial Reporting System, Form EIA-28.

Costs can be higher in the West for a number of reasons. For example, CaRFG is more expensive to produce than other gasolines. The California Energy Commission has reported that CaRFG costs between 5 and 8 cents more per gallon to produce than Federal RFG. The refineries in the West are the most complex in the country (Chapter 4), which by itself, would indicate higher operating costs, since complexity increases both investment and operating cost.

Crude oil costs counter the operating cost differences to some extent. The refineries in the West were designed to process heavier crude oils, which are less expensive on a per barrel basis than

1 These costs reflect unit operating costs to produce all products. Operating costs do not include depreciation or purchase costs of crude oil or other feedstocks, or costs of products purchased and not produced. Most of the cost difference between the Western companies and those operating elsewhere stems from refining and distribution costs. Marketing cost differences were small.

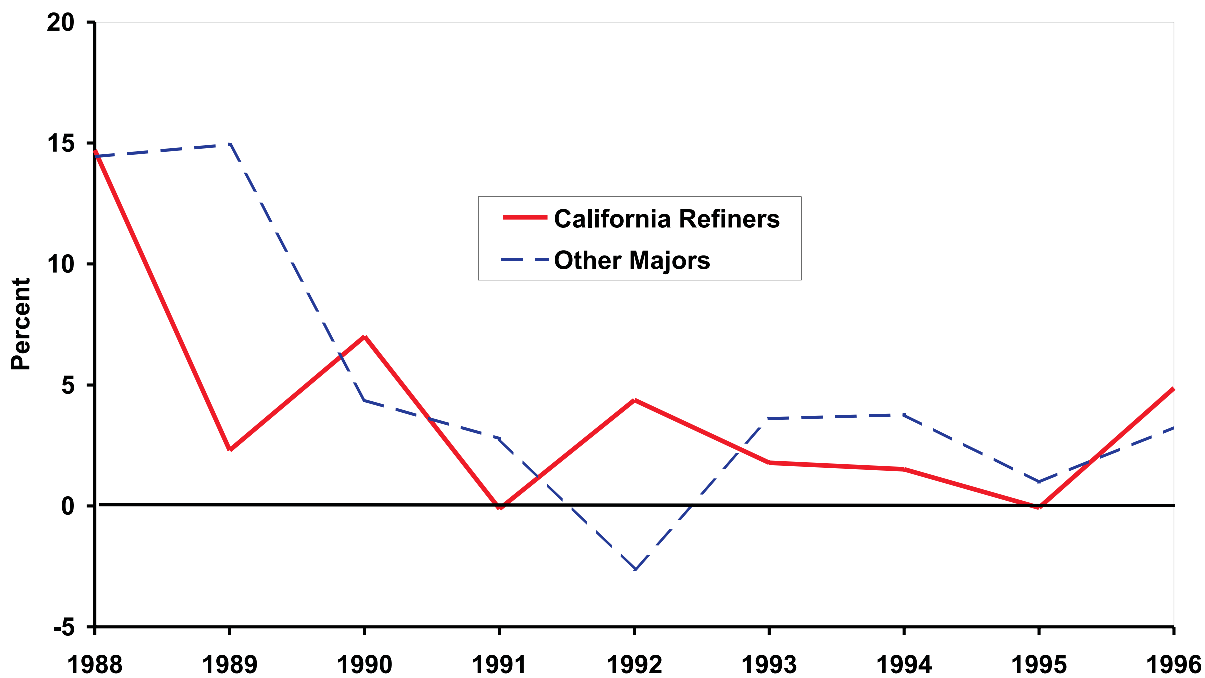
lighter crude oils. For example, Line 63[2] crude oil spot prices averaged over 2 cents per gallon lower than refiners' average imported cost of crude oil in 1996, and California refinery crude inputs average even lower gravity (25-26 degrees API) than Line 63, which runs 28-30 degrees API.

Another important feedstock, MTBE, costs more in the West since much of this oxygenate must be shipped from other locations. Los Angeles spot MTBE prices averaged almost 8 cents higher than those on the Gulf Coast during 1997. This difference could add about 1 cent per gallon to the price of reformulated gasoline on the West Coast versus that on the Gulf Coast.

Based on feedstock costs reported to EIA through the Financial Reporting System, and on crude oil and MTBE price comparisons, the net effect of higher increased operating costs with lower feedstock costs is higher costs to produce gasoline in California.

The final factor considered is that of profits. Figure B.3 shows that the companies operating in California have not been able to earn higher profitability than companies operating outside of the area. Profitability is about the same for both groups of companies shown. Apparently, despite the higher market concentration on the West Coast, there is still adequate competition, and refiner/marketers cannot extract higher profits from consumers (Side Bar - Market Concentration

Figure B.3 Annual Return on Investment Comparison



Source: Energy Information Administration, Financial Reporting System, Form EIA-28.

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2 Line 63 prices represent a price assessment for a blend of crude oils in a range of 28-30 degrees API gravity and sulfur content 1.02 percent that is delivered at Hynes station on Four Corners' pipeline line 63.

in California). The data indicate that in the West, prices are higher, production costs are higher, and refinery investment per barrel is higher, but return on investment is about the same.

Market Concentration In California

Gasoline markets are generally more concentrated in the West than on the East Coast. Table B.1 shows two measures of concentration for California and PADD 1. The first is the aggregate market share of reformulated gasoline sales for the top five market share holders. The second is the Herfindahl-Hirschman Index (HHI) for all gasoline sales. This index gives higher weighting to large-share companies. It is used by the Antitrust Division of the Department of Justice (DOJ) and Federal Trade Commission (FTC) as a guide when considering proposals for horizontal mergers. It can go from near zero, in perfect competition, to 10,000, which is a monopoly. According the DOJ/FTC guidelines, an HHI index below 1,000 indicates the market is unconcentrated. An index of from 1,000 to 1,800 indicates moderate concentration. Above 1,800 indicates high concentration. This table shows that California is not highly concentrated.

Table B.1 Market Concentration Comparison (Preliminary 1997 Estimates)

	California	PADD 1 (East Coast)
Top 5 Share Percent (RFG Only)	73.5%	53.2%
HHI Index (All Gasoline)	1290	640

Source: Energy Information Administration, EIA Form-782.
Notes: HHI - Herfindahl-Hirschman Index.

The operating costs discussed above reflect very little of the costs incurred to operate retail establishments in California. Retailers pay a “dealer tank wagon (DTW) price” for gasoline. The DTW price represents the costs and profits to produce and get the gasoline to the retail establishment. Retailers sell the product to consumers at a price higher than DTW to cover their costs and profits. Table B.2 shows the retail markup (retail price excluding taxes minus DTW price) for California versus the United States for the last several years. The comparison is for all grades, all formulations. Individual years can vary, as in 1996 when the CaRFG transition was occurring, but California is generally in line with the rest of the United States As is discussed in Chapter 6, PADD 5 retail minus DTW prices average well above the other PADD’s, but California is not the source of the PADD 5 aggregate difference. Retail margins in areas like Alaska, Hawaii, and rural areas run higher than the U.S. Average.

In conclusion, both taxes and the higher cost of refining on the West Coast seem to explain much of California’s higher prices for gasoline.

Table B.2 Retail Minus DTW Price Comparison
(Cents per Gallon)

	1994	1995	1996	1997
U.S.	6.8	6.4	6.4	6.3
California	6.4	6.6	8.5	6.3

Source: Energy Information Administration, **1994-1996:** *Petroleum Marketing Annual*, DOE/EIA-0487(94-96), Table 31.
1997: *Petroleum Marketing Monthly,* DOE/EIA-0380(97)/various issues, Table 31.
Note: Retail price is sales to end users through retail outlets, excluding taxes.

Appendix C
Analyzing Refinery Data

Chapter 4 is an analysis of how the yield or percentage of gasoline that is being produced by U.S. refineries may be affected by the capacity of the process units within the refinery. For those with limited technical understanding of refining, this appendix provides background information on the fundamentals of how crude oil is transformed into refined products. The discussion includes several demonstrations of how those fundamentals are applied in developing the results of Chapter 4.

A Simple Description of Crude Oil Refining

Crude oil is a mixture of thousands of individual hydrocarbon compounds, ranging from very simple low molecular weight compounds such as propane (C_3H_8), which is a gas at room temperature, to heavy complex compounds with 400 or more carbon atoms and a boiling range of 1,000°F to 1,500°F. Each compound in crude oil has its own boiling temperature, and a crude oil is often characterized by a distillation curve as illustrated in Figure C.1. There are many different types of crude oils. The figure shows a light crude oil that has more compounds that boil at lower temperatures and a relatively small fraction that boil above 1,000°F. The heavy crude oil, by contrast, has more compounds that are in the high boiling range. This high boiling material poses a problem for the refiner because it requires expensive processing facilities for producing the high valued transportation and heating fuels the market desires. The compounds in the high boiling material must be broken into lower molecular weight compounds, and the high boiling material often also contains impurities, such as sulfur and heavy metals, that must be removed. Another attribute of the heavy versus light crude oil is specific gravity (or density stated as pounds per gallon). Crude oil gravity is measured by API gravity[1], which is inversely related to density; thus, high API values indicate light crude oils, and low API values indicate heavy crude oils.

Distillation is the first step in refining. Distillation separates crude oil into a set of distillation cuts as shown in Figure C.2, based on the boiling temperature of the components in the crude oil. For example, the kerosene cut is a material consisting of components with boiling points between 350°F and 450°F. The cut range for specific distillation products is not a fixed temperature range. Product specifications give refiners some latitude in varying the "cut" temperature, and allows them to change the mix of products they produce to meet their product demand. The extent to which cut ranges overlap is shown in Table C.1. An example will demonstrate how this aspect of refining can be observed in the refinery data EIA collects.

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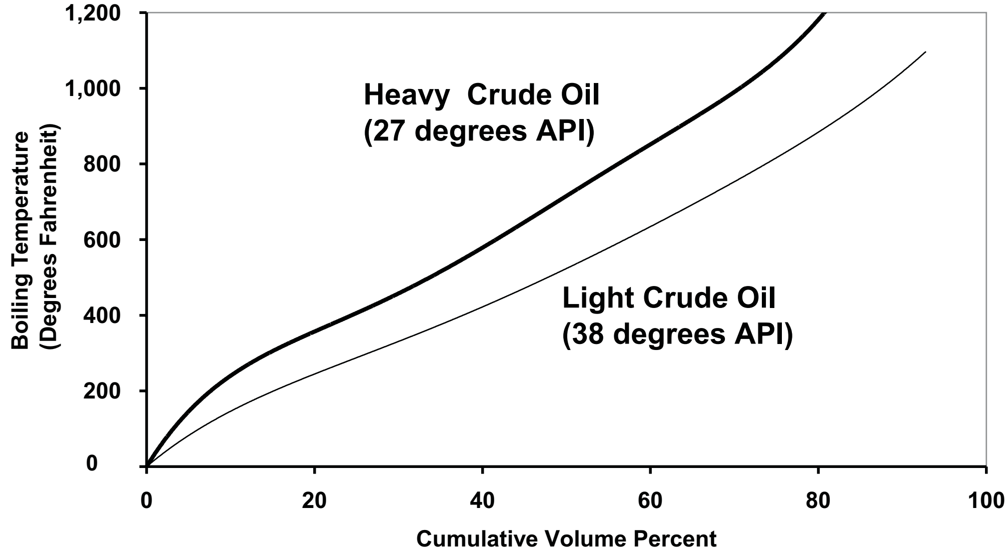
1 API gravity is an arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API; it may be calculated in terms of the following formula:

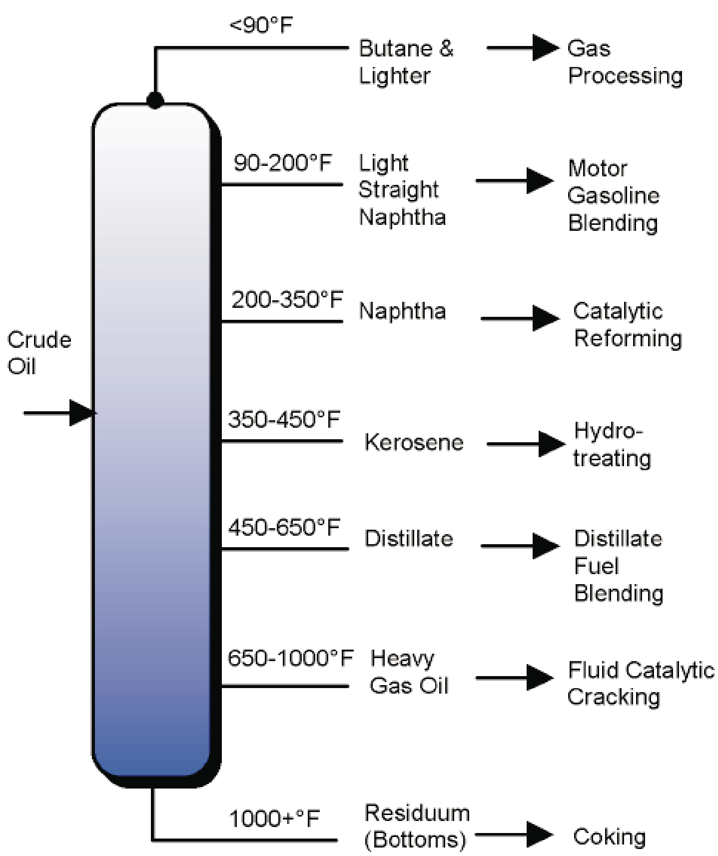
$$\text{Degrees API} = (141.5/\text{specific gravity})-131.5$$

Figure C.1 Distillation Curves for Two Crude Oils



Source: Energy Information Administration.

Figure C.2 Crude Oil Distillation and Refinery Stream Flow



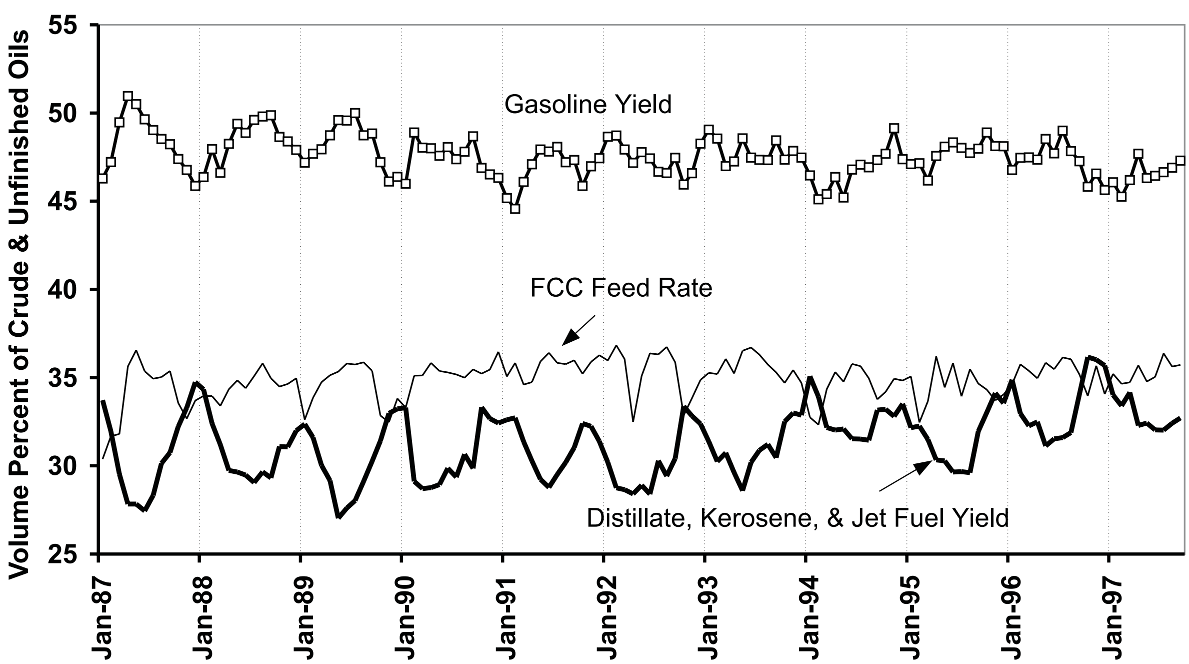
Source: Energy Information Administration.

Table C.1 Overlapping Temperature Ranges for Distillation Products	
Product	**Temperature Range °F**
Gases (Butanes & Lighter)	<90
Light Straight Run Naphtha	90-200
Naphtha	160-360
Kerosene	330-520
Distillate	420-650
Heavy Gas Oil	610-1050

Source: Energy Information Administration

In many refineries, the heavy gas oil (or vacuum gas oil) cut which goes to the fluid catalytic cracking unit (FCC) has a different cut temperature range in the winter than the summer. In the fall and winter when heating oil demand is high, refiners may wish to make more heating oil and less gasoline. This can be done by setting the cut temperature for distillate at 450-650°F, and then in summer changing it to 450-610°F. During the summer, the heavy gas oil volume increases as the cut temperature range is expanded from 650-1050°F to 610-1050°F. This diverts more volume to the FCC unit, where it will be converted into gasoline. Figure C.3, shows that as the FCC feed rate increases seasonally, gasoline yield increases and distillate yield declines. This figure includes data aggregated over many refineries, and while the correlation is not perfect, the underlying relationship is evident.

Figure C.3 PADD 3 FCC Feed Rate and Light-Product Yields



Source: Energy Information Administration, **1987-1996:** *Petroleum Supply Annual*, DOE/EIA-0340(87-88)/2, Tables 6 and 11, DOE/EIA-0340(89-96)/2, Tables 9 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 16 and 28.

Kerosene jet fuel yield, which as been rising in the United States, can be increased by expanding its boiling range in both directions, taking from the gasoline cut and/or the distillate oil cut at the upper end of the kerosene boiling range. Chapter 4 discusses this occurrence at the PADD level and at individual refineries.

Using crude oils with different API gravities can affect light-product yields and the requirement for downstream conversion units. Looking back at Figure C.1, the difference between the light crude oil and the heavy crude oil is that the heavy crude contains more material boiling above 1,000°F (heavy residuum cut), and correspondingly less in the naphtha and distillate boiling range. The heavy gas oil (650-1,000°F), which is the primary feed to the FCC unit, is quite often about 25-30 percent of the crude oil, whether it is a heavy or light crude oil (at least for crude oils in the 20-40°API gravity range).

To illustrate analyzing the impact of a shift to heavier crude, consider the PADD 3 data for the past decade, which is shown in Table C.2. From 1987 to 1997, the average gravity of the crude oils used in PADD 3 refineries has dropped by 2.1 degrees. Based on typical relationships for residual cut volumes and API gravity, for each degree change in gravity, the residual content will change by about 1.4 volume percent. This indicates that between 1987 and 1997, residual content rose about 2.9 percent. The primary destination of residual oil is a coking unit (coker). Coker feed rate between 1987 and 1997 increased 2.6 percentage points. Thus, increases in coking capacity would have been available to accommodate most of the additional material to be processed. (Chapter 4 described the impact on light-product yields when coking feed rate decreased and gravity declined from summer 1996 to summer 1997.)

Table C.2 PADD 3 Annual Average Refinery Data

	Average Crude Gravity (°API)	FCC Feed Rate	Hydro-cracker Feed Rate	Coker Feed Rate	Light-Product Yield
1987	33.5	33.9	6.3	8.3	82.7
1988	33.2	34.6	5.7	8.8	82.8
1989	33.4	34.5	5.9	8.8	82.0
1990	33.1	35.2	5.9	8.6	83.1
1991	32.9	35.6	6.3	9.3	82.5
1992	32.4	35.3	6.2	9.7	82.1
1993	32.3	35.6	6.5	9.8	85.0
1994	32.2	34.5	5.9	10.2	83.7
1995	31.9	34.5	7.0	10.7	83.5
1996	31.7	35.3	7.0	11.2	84.2
1997	31.4	35.3	6.5	10.9	82.4

Sources: Energy Information Administration, **1987-1996:** *Petroleum Supply Annual,* DOE/EIA-0340(87-89)/2, Tables 6 and 11, DOE/EIA-0340(90-96)/2, Tables 9 and 16. **1997:** *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Tables 16 and 28.
Note: Feed rates and yields are in units of percent of crude oil and unfinished oils.

When refineries use a heavier crude oil, even when there is adequate coking or other bottoms conversion capacity to handle the increases in residual material, some decline in light-product yield can be expected. The impact on light-product yield of the shift from light to heavy crude oil can be illustrated by considering what happens when exchanging 1 percent of the barrel that would be in the light product range with 1 percent in the residuum range. Originally, the 1 percent in the light range will contribute virtually its full 1 percent to light-product yield. After the switch, the 1 percent heavy material goes to the coker, where a significant fraction of this heavy material ends up as coke and light gases. Thus, the light-product yield from the heavy feed to the coker will contribute less than 1 percent to the light-product yield. Table C.2 shows light-product yields in PADD 3 staying about the same for the past decade. This constancy may be an indication that some other process changes have occurred in PADD 3 refineries that would improve light-product yields and offset the impacts of declining crude oil gravity. In fact, all units and all yields were analyzed, but that is beyond the scope of this overview discussion.

In Chapter 4 and in this Appendix, the discussion of yields is restricted to only those factors that have large impacts on light-product yields at the PADD level. There are other factors that affect yields such as turnarounds, operational factors, technology changes, and changes in product specifications. In some years, the number of turnarounds and length of outages for key units are greater and affect yields more adversely than in other years. Yields are also affected by changes in opeational variables, unit improvement at turnarounds, improvements in catalysts and use of new catalyst additives. All of these and other factors can cause variation in yields when comparing individual refinery data or aggregate PADD-level data year to year. Product specifications changes can have a large impact on yields; however, with the exception of California, no signficant product changes occurred in the 1995-1997 period analyzed in the report.

Examples from Chapter 4 of Using Refinery Data

The discussion to this point has dealt with changes in product mix and crude oil gravity, but much of the focus of Chapter 4 was on determining if capacity limits of conversion units, such as FCC's, hydrocrackers, and cokers were reached, and if light-product yields declined as refinery utilization rates increased. To detect if any capacity limits were reached, causing light yields to decline, trends for light yields were observed, along with feed rate to conversion units. If the feed rates to FCC units, hydrocrackers, or cokers stayed the same or rose (after adjusting for crude gravity charge), then it is likely that no yield impacts from capacity limitations occurred. The yields themselves, for both light and other refined products, were analyzed to see if reported results were consistent with expectations.

All the yields and throughput rates used in this report are stated as percent of crude and unfinished oils. The meaning of unfinished oils and how they fit into refinery operations merit commentary. Unfinished oils can be any of the intermediate streams shown in Figure C.2, such as naphtha, heavy gas oil, or residual oil. The precise breakdown of the material is not available in the EIA refinery input data. There is a clue that the material is mostly FCC feedstock (heavy gas oil) and coker feed (residual oil), which are purchased by a few refineries with FCC's, coking units, or other residual processing capacity beyond their primary distillation units. Most of the unfinished oil used by

PADD 3 refineries is imported, and imported unfinished oil is broken down by components. Table C.3 shows that, in 1996, imports of heavy gas oil and residual oil (residuum) were 131 and 105 thousand barrels per day respectively, totaling 236 thousand barrels per day. Net refinery inputs of unfinished oils were 293 thousand barrels per day. Thus, the conclusion is that unfinished oils input to refineries are mostly FCC and coking feedstocks, and should be part of the yield and unit throughput calculations.

Table C.3 PADD 3 Unfinished Oil in 1996

	Unfinished Oil Inputs	Imports of Unfinished Oils		
		Naphtha & Light Oils	Heavy Gas Oil	Residual Oil
Thousand Barrels per Day	293	47	131	105
Percent of Imports		16.6%	46.3%	37.1%

Source: Energy Information Administration, *Petroleum Supply Annual*, DOE/EIA-0340(96)/1, Tables 9 and 20.

Appendix D
EIA Capacity Utilization Data

EIA collects refinery capacity data monthly for atmospheric crude oil distillation units (barrels per calendar day), and on a biannual basis, for both atmospheric and vacuum distillation and downstream refinery units (barrels per stream day). Monthly data is also collected on inputs to fluid catalytic cracking (FCC), hydrocracking, and coking units.

When EIA reports refinery capacity utilization, it is based on gross input to atmospheric crude oil distillation units divided by refinery operable distillation capacity. The operable capacity is defined as the sum of the operating and idle capacity. The operating capacity is that which is operating at the beginning of the period. The idle capacity is that which is not operating and not under active repairs, but which is capable of being placed in operation within 30 days, or capacity which is under repairs that can be completed within 90 days. The idle capacity component can be important in interpreting maximum production capability. Table D.1 is a summary of data used in Chapter 4.

Table D.1 Comparison of Summer 1997 Average Operable and Operating Capacity Utilization

	PADD 1	PADD 2	PADD 5
Operable Capacity (MB/CD)	1642	3447	2927
Idle Capacity (MB/CD)	80	0	50
Operating Capacity (MB/CD)	1562	3447	2877
Gross Inputs to Distillation (MB/CD)	1554	3524	2738
Capacity Utilization Percent Operable	94.6%	102.2%	93.5%
Capacity Utilization Percent Operating	99.5%	102.2%	95.2%

Source: Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA-0109(97)/various issues, Table 28.
Notes: Summer is defined as May through September; MB/CD - Thousand barrels per calendar day.

For PADD's 1 and 5, the utilization as a percent of operable capacity is lower than utilization as a percent of operating capacity because of the idle capacity. For PADD's 1 and 5, the same idle capacity was reported every month, but it never came on stream. From analyzing past data, when a short-term market stress event occurs, this idle capacity may be unlikely to come into production, and hence, the capacity utilization based on operable capacity may provide an unrealistic perspective of what production response might be.

Historically, only the capacity data for atmospheric distillation units is collected on a barrels per calendar day basis. Capacity data for other units is collected on a barrels per stream day basis.

Stream day capacity is an engineering design throughput rate that represents operational capability, while calendar day capacity represents an annual average capacity that accounts for expected and unexpected unit outages. A stream day factor is an estimate of the fraction of time that a production unit is available for service. A unit is not in service 100 percent of the time because of planned and unplanned outages; hence, the calendar day capacity is equal to the stream day capacity times the stream day factor.

The stream day factor is an estimate, based on experience with various types of process units. Typical estimates used for refinery process units are 0.95 for distillation and FCC, and 0.92-0.93 for cokers. There is sometimes a bit of confusion when unit utilization data are used. When utilization is reported on the basis of calendar day capacity, a reported capacity utilization of 102 percent for several months is not an unreasonable number. Part of the unit downtime assumed in the stream day factor is scheduled outage when planned maintenance occurs. Refiners will arrange to do the planned maintenance at times of the year when product demands are low, such as February and March. Thus, for individual refiners, throughput could be 104-105 percent of calendar-day capacity if they have no unplanned unit outages; however, utilization on a stream day basis should never exceed 100 percent.

When a refinery unit is built, it may have a design maximum unit throughput rate (capacity) of 100 thousand barrels per stream day. But in practice, the actual maximum capacity is only determined by pushing the unit to maximum in daily operation. The refinery may find that the unit can be run at 105 thousand barrels per stream day. The refiner may also find that throughput can be increased to 110 thousand barrels per stream day by making small changes to the unit (e.g., different tower packing, larger pumps, changes to heaters). These types of changes are called debottlenecking, because they involve making a change in some component section of the overall unit that has been limiting unit throughput. In recent years, as average refinery utilization has risen, refiners have been testing the actual limits of unit capacity, and have done many debottlenecking projects. However, refiners have not been uniform in reporting changes in stream-day capacity to EIA; thus, the data is not precise. This situation can be illustrated by the following example of FCC capacity utilization for 11 specific PADD 3 refineries whose performance was reviewed for this report.

FCC capacity utilization data must be interpreted with some care, as demonstrated by the results of the 11 individual PADD 3 refineries summarized in Table D.2. One group of the PADD 3 refineries operated FCC units above 100 percent of the stream day capacity for the 5 month summer period in 1997, which may indicate an understatement of reported capacity.[1] A second group of refineries in the set of 11 that experienced no shutdowns operated at 94.7 percent of capacity, and the third group of refineries with shutdowns during the summer 1997 operated at 89.1 percent of capacity for the period.

Thus, the FCC input capacity limits in PADD 3 are not precisely known, but by examining data for individual refineries, it was possible to develop reasonable maximum production limits for the

1 FCC capacity is only collected by EIA every two years. Summertime 1997 FCC utilization estimates are based on January 1, 1997 capacity reported to EIA in 1996. Actual capacity in 1997 may be higher. Also, based on comparing prior capacity and input data, there has been some capacity understatement.

Table D.2 FCC Operations for Eleven PADD 3 Refineries in Summer 1997

Description of Operating Status in Summer	Group	Capacity Description	Average Input MB/D	FCC Capacity MB/SD	Capacity Utilization Percent Stream Day Capacity
Units with No Shutdowns	Group 1	> 100% Stream Day Capacity	353.8	339.0	104.4
	Group 2	< 100% Stream Day capacity	350.5	370.0	94.7
Units with Shutdowns	Group 3		244.5	274.5	89.1
Total			**949.8**	**983.5**	**96.5**

Source: Energy Information Administration, **Inputs:** Form EIA-810. **Capacity:** *Petroleum Supply Annual*, DOE/EIA-0340(96)/1, Table 38.
Notes: Summer is defined as May through September; MB/D - Thousand barrels per day; MB/SD -Thousand barrels per stream day.

PADD's. Such analysis was used in the study summarized in Chapter 4. EIA will continue to work with respondents to improve capacity data quality so that aggregate values can be as useful as possible to analysts.

Appendix E
Quantitative Explanation Of Motor Gasoline Price Pass-Through

By using industry and EIA data, an analysis was undertaken to explore the speed of price change pass-through from the spot market to the retail market for individual PADD and subPADD districts. The results reported below update the preliminary results published in the *Motor Gasoline Assessment, Spring 1997* (DOE/EIA-0613, July 1997), and include an analysis of PADD 5, which was not examined in the prior work. These results will be used to form the basis for further research on pricing mechanisms in petroleum product markets.

Estimates showed that the price pass-through from spot market to the retail level is complete by three months, with about 50 percent of the change occurring within 4 weeks and 80 percent within 8 weeks. The price pass-through speed for PADD 5 was found to be similar to most of the other areas studied.

The speed of adjustment of motor gasoline retail prices as a function of spot prices was estimated using weekly EIA data from the Form EIA-878, "Motor Gasoline Price Survey." The gasoline prices used were those of PADD 1A, 1B, and 1C, PADD 2 and PADD 3 conventional regular gasoline and PADD 5 reformulated regular gasoline. The U.S. Gulf Coast (USG) conventional regular, New York Harbor (NYH) conventional regular and Los Angeles reformulated regular (LARFG) spot prices were weekly averages, calculated from daily prices obtained from Platt's. Investigation of the time series properties of the price data was performed in order to assist in specifying the appropriate form of the model; for example, data with unit root properties are best analyzed using first differences, whereas stationary series can be estimated in level form. Augmented Dickey-Fuller test could not reject the hypothesis that the retail gasoline data had a unit root, whereas the averaged spot data rejected the unit root hypothesis at the 5-percent level but not at the 1-percent level. Since all series had a strong autoregressive component, first differences were used for the regression analysis. The retail prices and the weekly averages of the spot prices were defined to correspond to the same week, so that the retail prices were estimated as a function of lagged spot prices.

The interpretation of the regression model depends on the form of the lag parameters in the model. For example, the estimated model has the form:

$$\Delta y_t = b_1 \Delta x_{t-1} + b_2 \Delta x_{t-2} + \cdots + b_k \Delta x_{t-k} + c_0 z_t + e_t$$

or more succinctly

Equation E1:

$$\Delta y_t = \sum_{i=1}^{k} b_i \Delta x_{t-i} + c_0 z_t + e_t$$

This model can be interpreted as follows. The lagged form shown in this model means that a change (Δ) in the independent variable (X) will affect the change in the dependent variable (Y) for a number of time periods. In particular, a change in X during the time period (t-k-1) not only affects the change in Y during the period (t-k), but also for a number of time periods in the future (i.e., (t-k+1), (t-k+2), all the way to (t)). More formally, ΔX_{t-k-1} affects not only the change in ΔY_{t-k}, but also in $\Delta Y_{t-k+1}, \Delta Y_{t-k+2}, ..., \Delta Y_t$. The other parameter Z_{t-k} has an immediate effect on the change in ΔY_{t-k} and a permanent change in the level of Y_{t-k} during time period (t-k).

The equation actually estimated for this study is

Equation E2:

$$\Delta RP_t = \sum_{i=1}^{k} \beta_i \Delta SPOT_{t-i} + D04OCT93 + \Delta NYHUSG_{t-1} + AR, MA\ Terms + U_t$$

Where:

Δ	is the week to week change
RP_t	is the Monday motor gasoline retail price for week t
$SPOT_t$	is the average gasoline spot price for week t
D04OCT93	is the dummy variable for the Federal tax increase in October, 1993
$NYHUSG_t$	is the difference between NYH and USG gasoline spot prices for week t
U_t	is the random error term at time t
AR, MA	are autoregressive (AR) and moving average (MA) terms

Table E.1 shows the parameter estimates for the various regions. The estimation method used was Ordinary Least Squares. The AR, MA terms are used to make the regression residuals test as random. The lag length was chosen by using the one which minimized the Akaike and/or Schwarz-Bayes information criterion value; this also provided parameter estimates for the spot price which did not increase when another lag was added to the equation. *A priori*, one would expect to see an approximately 1:1 eventual pass-through of spot price changes and would also expect the influence of a spot price change to decrease monotonically over time after the first or

Table E.1 Ordinary Least Squares Regression Results (Weekly Prices to December 22, 1997)

Start Date	April 5, 1993	April 5, 1993	April 5, 1993	October 5, 1992	October 5, 1992	September 18, 1995
Independent Variable	**NYH conv/reg**	**NYH conv/reg**	**USG conv/reg**	**USG conv/reg**	**USG conv/reg**	**LARFG RFG**
Change in Retail Price (dependent variable)						
Parameter	**PADD 1A**	**PADD 1B**	**PADD 1C**	**PADD 2**	**PADD 3**	**PADD 5**
ΔSPOT(t-1)	0.155***	0.125***	0.151***	0.390***	0.118***	0.154***
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.034)
ΔSPOT(t-2)	0.129***	0.133***	0.172***	0.213***	0.189***	0.191***
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.033)
ΔSPOT(t-3)	0.099***	0.109***	0.105***	0.105***	0.099***	0.114***
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.033)
ΔSPOT(t-4)	0.112***	0.112***	0.106***	0.082***	0.094***	0.096***
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.033)
ΔSPOT(t-5)	0.114***	0.093***	0.104***	0.064**	0.076***	0.103***
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.033)
ΔSPOT(t-6)	0.076***	0.083***	0.082***	0.061**	0.080***	0.054
	(0.021)	(0.015)	(0.015)	(0.028)	(0.017)	(0.033)
ΔSPOT(t-7)	0.052**	0.070***	0.048***	0.088***	0.074***	0.088***
	(0.021)	(0.015)	(0.015)	(0.027)	(0.017)	(0.033)
ΔSPOT(t-8)	0.047**	0.076***	0.080***		0.064***	0.047
	(0.021)	(0.015)	(0.015)		(0.017)	(0.033)
ΔSPOT(t-9)	0.048**	0.047***	0.043***		0.027	0.062*
	(0.021)	(0.015)	(0.015)		(0.017)	(0.033)
ΔSPOT(t-10)	0.033	0.029*	0.018		0.024	
	(0.021)	(0.015)	(0.015)		(0.017)	
ΔSPOT(t-11)		0.025*	0.036**		0.048***	
		(0.015)	(0.014)		(0.017)	
ΔSPOT(t-12)		0.021	0.037***		0.042**	
		(0.015)	(0.014)		(0.017)	
D04OCT93	4.405***	4.443***	4.566***	4.800***	4.761***	
	(0.660)	(0.437)	(0.409)	(0.879)	(0.526)	
ΔNYHUSG(t-1)				0.134***		
				(0.049)		
AR(1)	0.587**	0.674***			0.582***	
	(0.259)	(0.113)			(0.188)	
MA(1)	-0.432	-0.328**	0.337***	-0.119*	-0.371*	0.485***
	(0.288)	(0.143)	(0.065)	(0.062)	(0.215)	(0.084)
MA(2)			0.289***			
			(0.066)			
Sum of Spot Lags	0.867	0.923	0.984	1.002	0.935	0.91
Adj. R^2	0.547	0.728	0.763	0.611	0.653	0.622
F-Statistic	25.6	47.6	57.3	48.3	37.3	22.6
D.W. Statistic	2.05	2.05	1.96	2.01	2.01	2.02

Table E.1 (Continued)

Source: Energy Information Administration calculations.
Notes: The general form of the linear model is shown in Equation E2.
All prices are in cents per gallon.
"Δ" is the weekly price change.
The (t-1), (t-2), ..., (t-12) refer to lagged values.
SPOT refers to the weekly average spot price for regular, conventional motor gasoline at New York Harbor (NYH) or U.S. Gulf Coast (USG); or it refers to the weekly average spot price for regular, reformulated motor gasoline at Los Angeles (LARFG).
D04OCT93 is a dummy variable corresponding to the change in Federal tax on motor gasoline.
NYHUSG is the (weekly average) spot price difference between NYH and USG.
Standard errors appear in parentheses below the parameter estimates.
*** indicates significant at 1% criteria (p-value < 0.01)
** indicates significant at 5% criteria (p-value < 0.05)
* indicates significant at 10% criteria (p-value < 0.10)

second time period. The estimation results reported in the table are reasonable and are very similar to those appearing in the previous study (*Motor Gasoline Assessment, Spring 1997*). These results show, depending on the area, that anywhere between 87 to 100 percent of a spot price change is passed through to retail within 3 months and that the lag effect does tend to decrease over time.

The cumulative price-pass-through results are shown in Table E.2. This table shows the price pass-through effect seen at the retail level for a 10-cent-per-gallon increase in the spot price. Using PADD 1B as an example, if the (NYH) spot price increased by 10 cents during a particular week, then this would result in the retail price increasing by 2.6 cents per gallon within two weeks, 4.8 cents per gallon within 4 weeks, 8.0 cents per gallon within 8 weeks, and 9.2 cents per gallon within 12 weeks. The table shows that for all areas other than PADD 2, for a 10-cent initial spot price change, there would be an approximate 5-cent pass-through after 4 weeks, increasing to an approximate 8-cent pass-through after 8 weeks. The reason for the more rapid pass-through to retail price for PADD 2 is not clear.

Another question that arises is whether or not the August 1997 retail price runup was anomalous. This question was addressed in two ways. First, the regression results shown in Table E.1 were recalculated to eliminate the differencing effect on the data. Figures E.1 through E.6 show the Actual retail price and Fitted (model) results during this time period. The graph for each of the areas illustrates the relatively tight fit by the model during the August period. This stability question was also addressed quantitatively by performing Chow Forecast Tests[1] with the breakpoint at the end of July. Table E.3 displays the results of this predictive test and shows that at the 5% significance level, there is only one rejection (PADD 1A) of the null hypothesis of model stability before and after the chosen breakpoint. These results show that a price pass-through model fitted for the entire data series shows no anomalous behavior (except for PADD 1A) during the August 1997 retail price runup.

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1 *Introduction to Econometrics*, 2nd edition, G.S. Maddala, Macmillan Publishing Company, 1992, pp. 174-176, provides a description of Predictive Tests for Stability.

Table E.2 Cumulative Pass-Through to Retail for a 10-Cent Change in Spot Price
(Cents Per Gallon)

Time Elapsed	PADD 1A	PADD 1B	PADD 1C	PADD 2	PADD 3	PADD 5
2 Weeks	2.84	2.58	3.23	6.03	3.07	3.46
4 Weeks	4.95	4.78	5.34	7.90	5.00	5.56
6 Weeks	6.86	6.55	7.21	9.15	6.56	7.13
8 Weeks	7.85	8.01	8.49	10.02	7.94	8.48
10 Weeks	8.67	8.77	9.10		8.45	
12 Weeks		9.23	9.84		9.35	

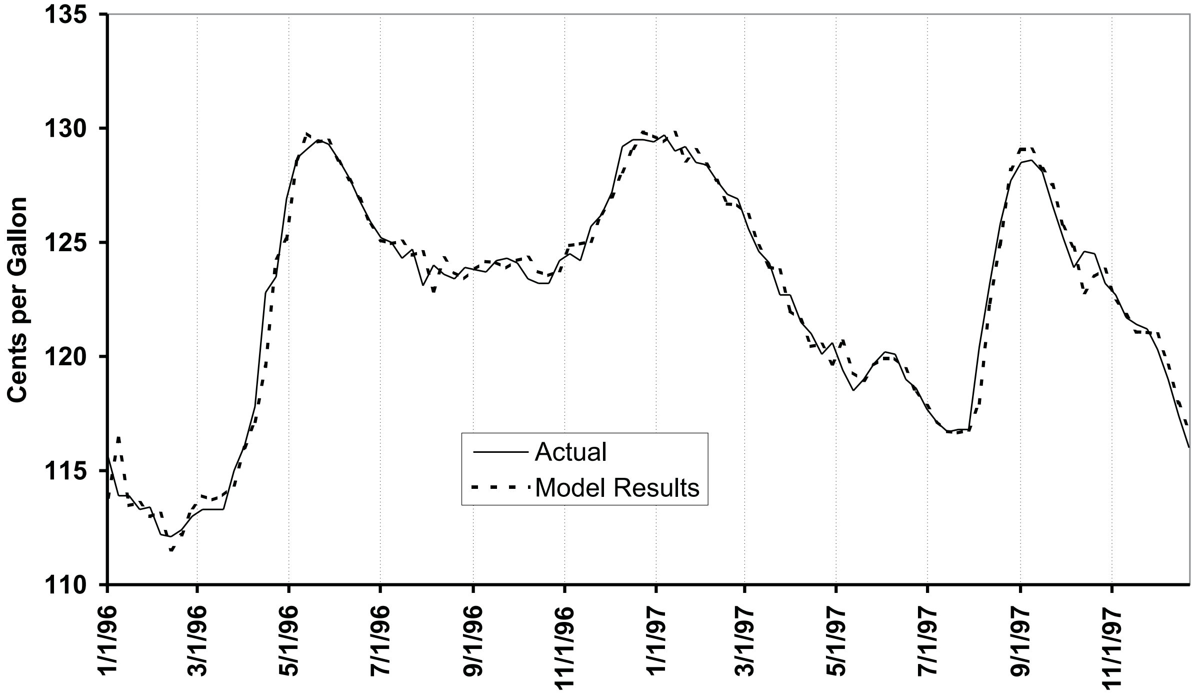
Source: Calculations from Table E.1.

Table E.3 Predictive Stability Tests for August 1997 Price Runup

Area	F-Statistic	p-Value
PADD 1A	2.1639	0.003
PADD 1B	1.1201	0.327
PADD 1C	1.1199	0.327
PADD 2	1.0162	0.445
PADD 3	0.9111	0.580
PADD 5	0.5020	0.966

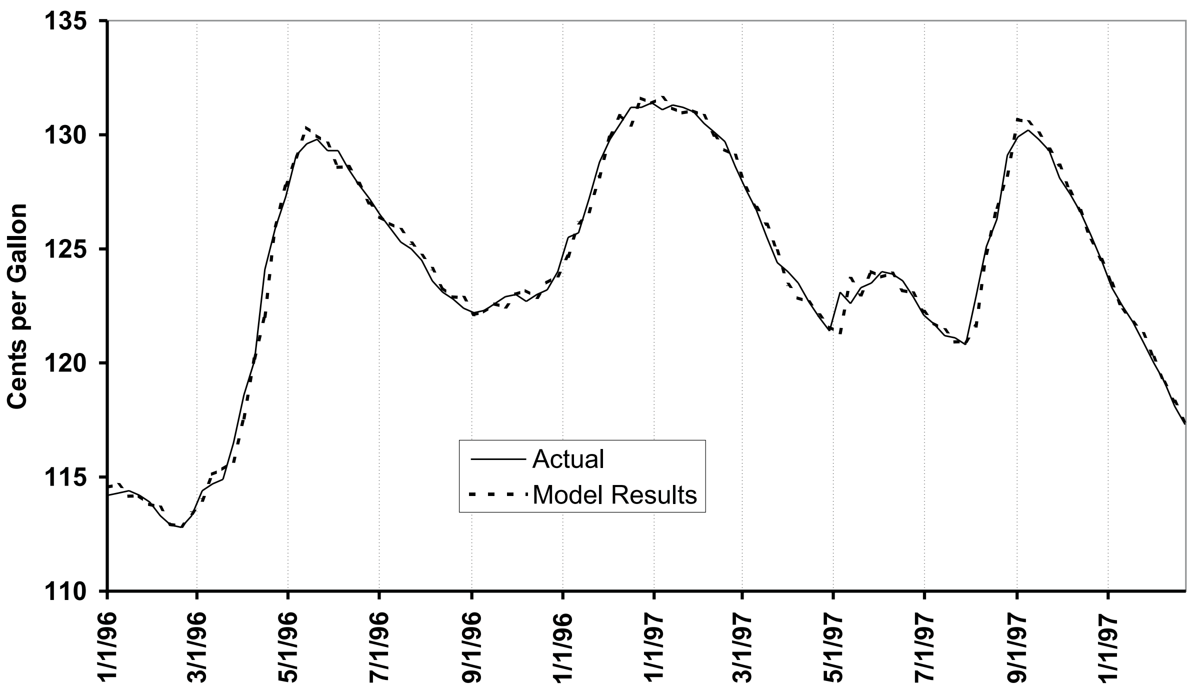
Source: Energy Information Administration calculations.

Figure E.1 PADD 1A Model Versus Actual Results



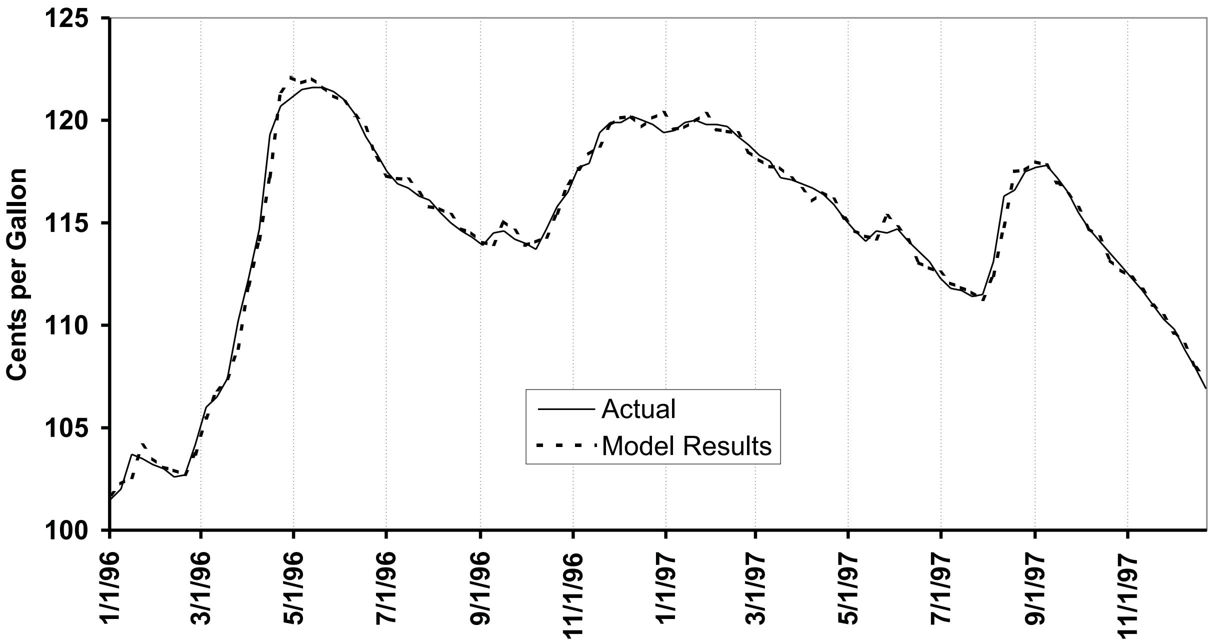
Source: Energy Information Administration.

Figure E.2 PADD 1B Model Versus Actual Results



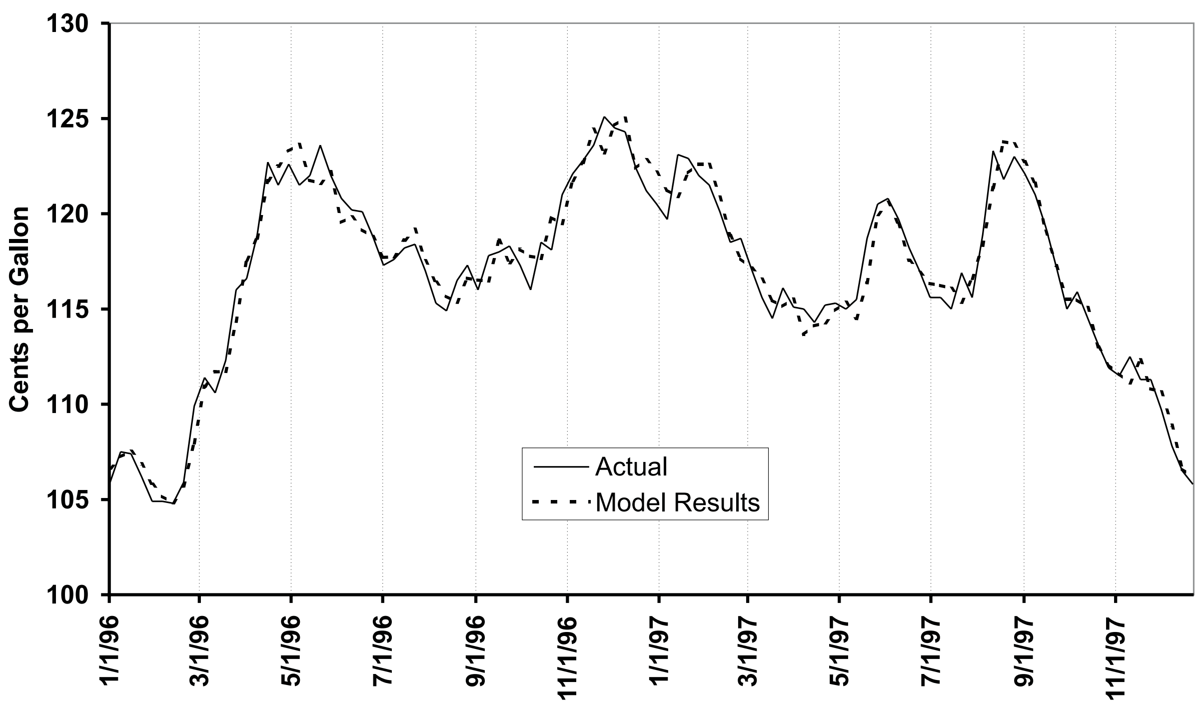
Source: Energy Information Administration.

Figure E.3 PADD 1C Model Versus Actual Results



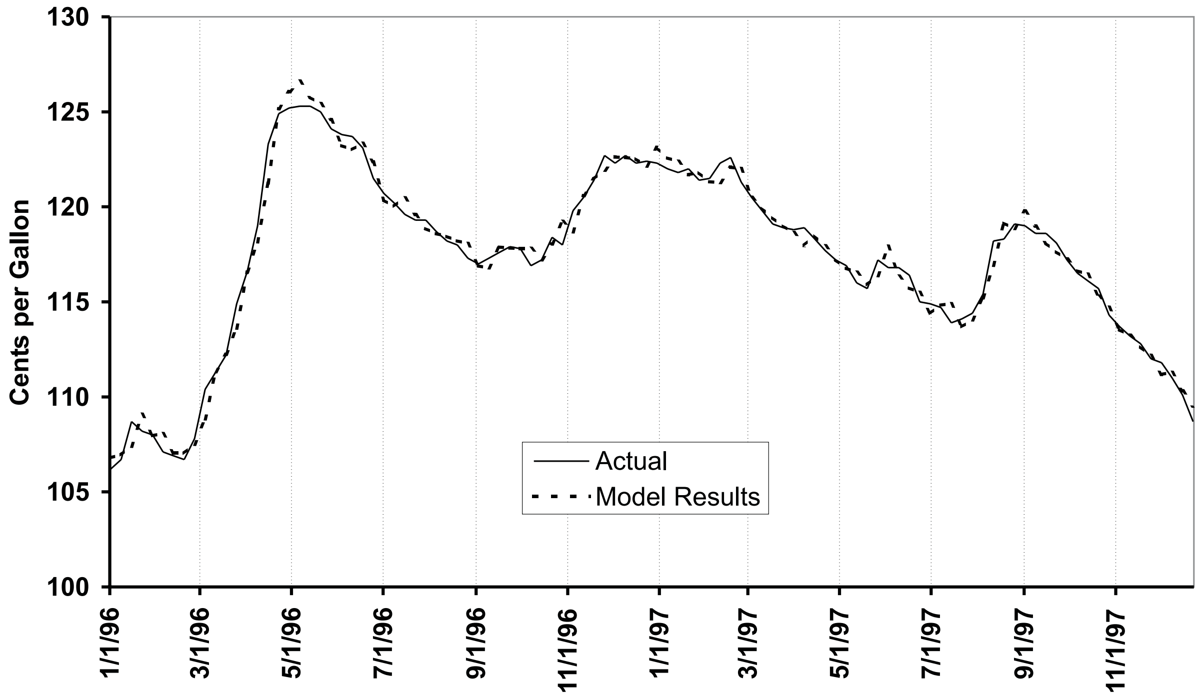
Source: Energy Information Administration.

Figure E.4 PADD 2 Model Versus Actual Results



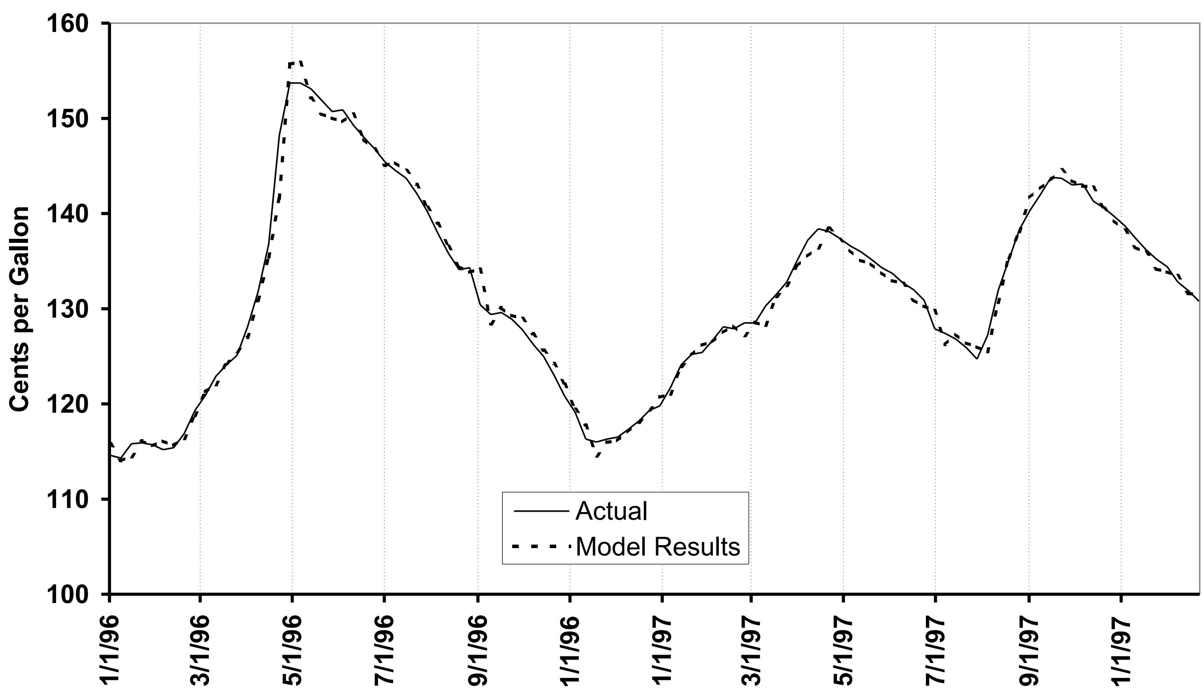
Source: Energy Information Administration.

Figure E.5 PADD 3 Model Versus Actual Results



Source: Energy Information Administration.

Figure E.6 PADD 5 Model Versus Actual Results



Source: Energy Information Administration.