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Christopher Taylor & Jeffrey Fischer

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A Review of West Coast Gasoline Pricing and the Impact of Regulations

CHRISTOPHER T. TAYLOR and JEFFREY H. FISCHER

ABSTRACT *There have been numerous proposals for legislating restrictions on vertical supply relationships on the West Coast and elsewhere. However, there has not been a systematic examination of gasoline prices on the West Cost, relative to the rest of the country, to understand the size of possible pricing anomalies. We examine the differences in the price of gasoline on the West Coast and the Gulf Coast both at the rack (wholesale) and retail. We also examine structural factors that have kept average West Coast prices higher than elsewhere, such as the higher costs to produce CARB gasoline and higher opportunity costs to produce conventional gasoline, higher shipping costs, Unocal's patents on CARB gasoline blending, higher taxes, Oregon's ban on self-service gasoline, and higher land costs. While a number of these factors are difficult to quantify, they would appear to explain most or possibly all of the measured difference in average prices.*

Key words: Gasoline Pricing; Industry Study–Gasoline; Regulation; Competition Policy.

JEL classifications: L1, L40, L71.

1. Introduction

The lead article in this special issue, by Professors Comanor and Riddle, concludes that the likely effect of an open supply policy in California, in general, would be higher, not lower, gasoline prices. There have been numerous proposals for legislating restrictions on vertical supply relationships, such as mandating open supply and divorcement, on the West Coast and elsewhere. However, there has not been a systematic examination of gasoline prices on the West Cost relative to the rest of the country to understand the size of possible pricing anomalies. Are restrictions

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Christopher T. Taylor, Bureau of Economics, Federal Trade Commission, 600 Pennsylvania Ave. NW Washington, DC 20580, USA

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such as open supply or divorcement likely to lead to significant changes in gasoline prices, or do apparently ‘anomalous’ prices merely reflect regional supply conditions? The various Western states have unique supply conditions and have enacted regulations that tend to raise the price of gasoline. Without understanding the regulatory environment, as well as the potential price impacts of these regulations, it is difficult to suggest potential policies to reduce the price of gasoline.

In the second section of the paper we examine the differences in the price of gasoline on the West Coast and the Gulf Coast both at the rack (wholesale) and retail. We also examine how these differences change when supply disruptions are removed from the average differentials. Once we determine the size of the West Coast premium, in the third section of the paper, we detail the regulations that exist on the West Coast that impact the West Coast premium, and discuss existing research on the price impacts of the regulations. In the fourth section of the paper, we detail a number of supply disruptions to illustrate the nature and impact of refinery and pipeline outages.

In the last section of the paper, we conclude that once the impact of regulations, taxes, and supply disruptions are accounted for in explaining the price of gasoline on the West Coast relative to the rest of the country, little variation remains to be explained by distributional issues or vertical market structure. With the exception of San Francisco, the West Coast retail markup is not that different from Houston, our representative city on the Gulf Coast. The higher San Francisco prices likely reflect the higher costs of opening and running a retail gasoline business in that city.

2. West Coast Gasoline Prices

This section documents gasoline prices in the three West Coast states that are the focus of the paper: California, Oregon, and Washington. We start by characterizing the difference between the prices of gasoline in these three states with the price of gasoline on the Gulf Coast (Houston); we assume that Houston prices at each level of the industry are competitive.[1] To illustrate the price differences that we are trying to explain, Figure 1 shows the average retail price of a gallon of regular unleaded gasoline in PADD V (California, Washington, Oregon, Nevada, Arizona, Hawaii, and Alaska) and PADD III (Alabama, Mississippi, New Mexico, Texas, Arkansas and Louisiana) from 1984 through 2002. These retail prices are net of taxes.[2] From the beginning of the data, in 1984, through 1992, the price of gasoline in PADD V is not noticeably higher or lower than PADD III. There are periods when one or the other has slightly higher or lower prices. It is only from 1992 onward that prices in PADD V markedly diverge from PADD III.[3] The price of gasoline in PADD V is not only uniformly higher but is also more volatile than the price of gasoline in PADD III, with the late 1990s and 2000–2001 being particularly volatile.

Table 1 documents the retail price differences between selected cities in California, Oregon and Washington compared to Houston.[4] The first row of data in the table for each city shows the average retail price difference between that city and Houston including taxes. The magnitude of these average differences explains the level of concern about the price of gasoline on the West Coast. On average, the price of gasoline in San Diego between 1997 and 2002 was 29 cents per gallon (cpg) more expensive than in Houston. Most of the other cities in California have gasoline prices that are 20 to 30 cpg higher than in Houston. The largest difference is in San Francisco, where the price of gasoline averaged 43 cpg higher than in Houston. The

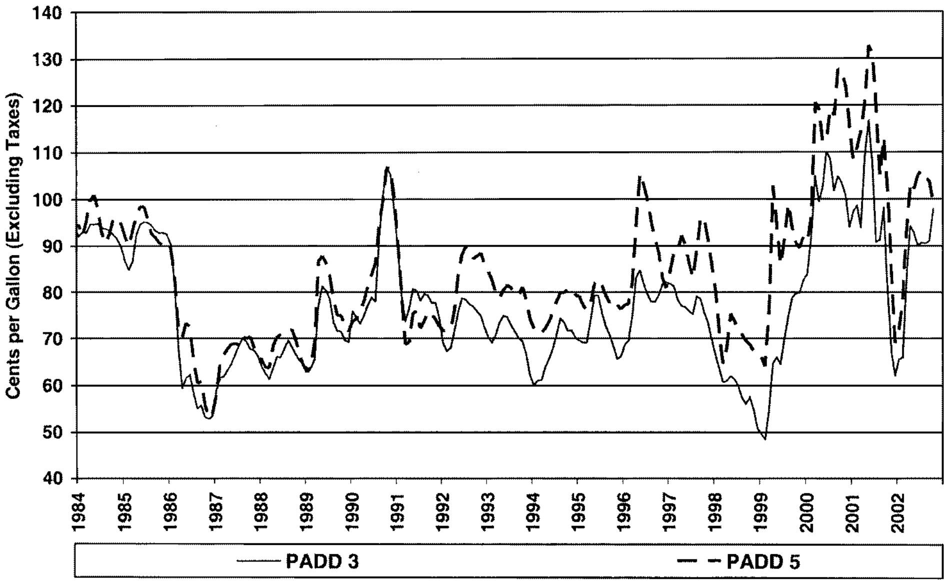

Figure 1. Price of retail gasoline (regular), PADD III & PADD IV – 1984–2002

price differences between cities in Oregon and Houston and cities in Washington and Houston are somewhat lower than California, but are still in the range of 20 cpg.

When comparing the price of gasoline net of taxes, the difference between Houston and the West Coast cities is considerably less. Gasoline taxes in California are approximately ten cpg higher than those in Houston. Therefore, removing the difference in taxes shrinks the retail price difference by about half for most cities in California. As detailed later in this paper, the state of California, in addition to a state excise tax, has an *ad valorem* sales tax as well as local sales taxes that apply to gasoline. As a result, taxes in California are city-specific, with a portion of the taxes proportional to the price of gasoline.

The tax differences between cities in Oregon and Washington relative to Houston are less than those for California cities. In Oregon, the state tax is four cpg higher than in Texas, but there are also county- and city-specific taxes. The state tax is three cpg higher in Washington than in Texas. Thus, netting out taxes, the differences between Houston and Eugene-Springfield and between Houston and Portland-Salem, both in Oregon, are reduced to approximately 15 and 16 cents a gallon, while the differences between Houston and Portland-Salem and Seattle, both in Washington, become approximately 12 and 17 cpg.

Supply problems, refinery outages, and pipeline breaks account for a sizeable portion of the remaining difference in the price of gasoline between the West Coast and the Houston. As discussed in a later section on supply disruptions, a major unplanned refinery outage in California or Seattle usually creates a sizeable, sudden increase in the price of gasoline.[5] While there were no major problems in 1997 and 1998, from 1999 through 2002 there have been a number of large refinery outages and one sizeable pipeline break that impacted prices on the West Coast. To analyse the impact of these supply disruptions we recalculated the price differentials between the West Coast cities and Houston after removing the periods with supply disruptions.

Table 1. Average retail price gaps – West coast cities relative to Houston

City		1997	1998	1999	2000	2001	2002	1997–2002 average	1997–8 average
San Diego, CA (w/tax)	ALL	27.11	25.5	31.13	26.85	36.95	28.88	29.40	26.31
		(8.06)	(5.01)	(12.35)	(12.28)	(7.19)	(3.95)		
	ALL	17.82	17.39	22.02	15.45	25.73	18.81	19.54	17.61
	ALL summer	18.46	16.31	28.32	11.04	26.99	17.89	19.84	17.39
	ALL winter	17.18	18.47	15.4	19.88	24.42	20.06	19.24	17.83
San Diego, CA	No spike	17.82	17.39	14.09	4.7	26.81	18.67	16.58	17.61
	No spike summer	18.46	16.31	15.44	3.5	34.38	17.34	17.57	17.39
	No spike winter	17.18	18.47	13.92	6.51	22.51	20.06	16.44	17.83
Los Angeles-Long Beach, CA (w/tax)	ALL	19.85	15.96	25.97	15.74	24.72	23.77	21.00	17.91
		(8.65)	(5.68)	(11.84)	(8.89)	(11.51)	(7.36)		
	ALL	10.51	8.04	16.66	4.46	13.67	13.44	11.13	9.28
	ALL summer	12.4	8.25	22.63	1.88	19.56	14.86	13.26	10.33
	ALL winter	8.62	7.83	10.41	7.06	7.49	11.51	8.82	8.23
Los Angeles-Long Beach, CA	No spike	10.51	8.04	8.17	−3.08	13.99	12.72	8.39	9.28
	No spike summer	12.4	8.25	6.74	−3.53	28.79	13.88	11.09	10.33
	No spike winter	8.62	7.83	8.35	−2.39	5.59	11.51	6.59	8.23
Bakersfield, CA (w/tax)	ALL	23.42	22.16	33.74	29.28	26.89	25.13	26.77	22.79
		(6.63)	(3.02)	(11.16)	(10.78)	(8.74)	(7.36)		
	ALL	14.98	14.8	25.05	18.45	17.08	15.97	17.72	14.89
	ALL summer	16.53	14.89	33.15	15.14	17.5	18.71	19.32	15.71
	ALL winter	13.43	14.72	16.55	21.77	16.64	12.25	15.89	14.08
Bakersfield, CA	No spike	14.98	14.8	16.51	7.71	14.85	15.28	14.02	14.89
	No spike summer	16.53	14.89	22.14	5.05	19.19	18.19	16.00	15.71
	No spike winter	13.43	14.72	15.82	11.69	12.39	12.25	13.38	14.08

Table 1. (Continued)

City		1997	1998	1999	2000	2001	2002	1997–2002 average	1997–8 average
San Francisco, CA (w/tax)	ALL	31.56	36.06	49.86	45.93	53.15	39.83	42.73	33.81
	ALL	21.02	26.32	38.39	31.94	39.59	27.93	30.87	23.67
	ALL summer	22.17	26.69	48.06	30	38.44	29.38	32.46	24.43
	ALL winter	19.86	25.94	28.2	33.89	40.79	25.96	29.11	22.90
San Francisco, CA	No spike	21.02	26.32	28.14	22.64	42.58	27.2	27.98	23.67
	No spike summer	22.17	26.69	37.91	23.44	43.35	28.38	30.32	24.43
	No spike winter	19.86	25.94	26.92	21.44	42.15	25.96	27.05	22.90
Chico-Paradise, CA (w/tax)	ALL	21.43	18.55	31.36	25.92	26.8	22.08	24.36	19.99
		(5.7)	(3.11)	(15.5)	(13.06)	(6.95)	(4.25)		
Chico-Paradise, CA	ALL	13.13	11.44	22.83	15.32	17.01	13.13	15.48	12.29
	ALL summer	13.54	11.84	33.76	13.7	16.02	12.48	16.89	12.69
	ALL winter	12.72	11.05	11.3	16.94	18.02	14	14.01	11.89
	No spike	13.13	11.44	10.38	2.45	16.09	12.65	11.02	12.29
	No spike summer	13.54	11.84	19.86	2.85	16.09	11.34	12.59	12.69
	No spike winter	12.72	11.05	9.2	1.84	16.09	14	10.82	11.89
Eugene-Springfield, OR (w/tax)	ALL	25.84	17.83	30.02	22.26	15.87	10.87	20.45	21.84
		(5.87)	(4.05)	(9.53)	(8.29)	(13.68)	(5.97)		
	ALL	21.84	13.83	26.02	18.26	11.87	6.87	16.45	17.84
	ALL summer	22.31	13.57	34.23	16.2	8.4	9.97	17.45	17.94
	ALL winter	21.37	14.09	17.41	20.33	15.51	2.69	15.23	17.73
voEugene-Springfield, OR	No spike	21.84	13.83	18.29	11.08	15.45	5.66	14.36	17.84
	No spike summer	22.31	13.57	28.51	8.25	11.58	8.55	15.46	17.94
	No spike winter	21.37	14.09	17.03	15.31	17.64	2.69	14.69	17.73
Portland-Salem, OR (w/tax)	ALL	25.46	20.47	32.07	21.62	21.47	14.23	22.55	22.97
		(5.46)	(3.57)	(9.15)	(9.46)	(13.59)	(5.07)		
	ALL	18.46	13.47	25.07	14.62	14.47	7.23	15.55	15.97
	ALL summer	17.78	12.76	33.19	10.59	7.95	6.18	14.74	15.27
	ALL winter	19.14	14.19	16.55	18.68	21.31	8.67	16.42	16.67

Table 1. (Continued)

City		1997	1998	1999	2000	2001	2002	1997–2002 average	1997–8 average
Portland-Salem, OR	No spike	18.46	13.47	17.12	5.92	19.84	6.78	13.60	15.97
	No spike summer	17.78	12.76	25.34	3.19	11.14	4.97	12.36	15.27
	No spike winter	19.14	14.19	16.11	11.51	24.78	8.67	15.73	16.67
Portland-Salem, WA (w/tax)	ALL	18.11	13.18	24.6	15.25	13.21	4.08	14.74	15.65
		(6.23)	(3.59)	(9.54)	(9.21)	(13.78)	(4.79)		
	ALL	15.11	10.18	21.6	12.25	10.21	1.08	11.74	12.65
	ALL summer	14.64	9.75	29.95	9.29	5.06	1.33	11.67	12.20
	ALL winter	15.57	10.61	12.85	15.23	15.62	0.75	11.77	13.09
Portland-Salem, WA	No spike	15.11	10.18	13.7	3.76	14.65	0.41	9.64	12.65
	No spike summer	14.64	9.75	23.07	0.95	7.76	0.09	9.38	12.20
	No spike winter	15.57	10.61	12.54	7.97	18.57	0.75	11.00	13.09
Seattle, WA (w/tax)	ALL	19.63	16.52	26.35	20.33	22.58	15.03	20.07	18.08
		(4.09)	(3.32)	(8.03)	(7.86)	(13.08)	(4.86)		
	ALL	16.63	13.52	23.35	17.33	19.58	12.03	17.07	15.08
	ALL summer	15.86	12.29	30.43	14.32	12.67	10.93	16.08	14.08
	ALL winter	17.39	14.76	15.93	20.35	26.83	13.52	18.13	16.08
Seattle, WA	No spike	16.63	13.52	16.62	10.73	24.99	11.66	15.69	15.08
	No spike summer	15.86	12.29	23.32	8.34	16.06	9.88	14.29	14.08
	No spike winter	17.39	14.76	15.8	14.33	30.06	13.52	17.64	16.08

Source: Oil Price Information Service.

The portion of Table 1 for each city labeled 'no spike' is the average differential with Houston omitting the time periods with supply disruptions.[6] The impact of the spike periods on the overall average price differentials is substantial. The average price difference between West Coast cities and Houston drops by two to four cents per gallon when periods of supply disruption are removed. The average price gap between San Diego and Houston drops by over three cpg, to 16.6 cpg. All the other California cities show a three to four cent per gallon drop in the differential. The decline in the price difference between Houston and cities in Washington and Oregon is slightly lower than the decline in California, approximately two cpg; in percentage terms, removing supply disruptions decreases the price gap by 12–28%. The smaller change in the differentials in Washington and Oregon State is not surprising given that a disproportionate share of the refinery outages on the West Coast were in California. However, the fact that removing the disruption periods from the cities in the states of Washington and Oregon significantly decreases the average differential with Houston does suggest the interconnected nature of the West Coast gasoline supply situation. As a check on the whether the impact of the supply disruptions had been effectively removed from the data, we calculated the average differential of each city with Houston for the years 1997 and 1998 only. Since there were no major disruptions in those years, the averages from 1999–2002 without the supply disruptions should be similar. In general, the 1997–8 differentials are roughly similar to the differentials with the supply disruptions removed.

Since many factors that impact the West Coast price of gasoline may differentially affect the retail and wholesale price of gasoline it is useful to examine wholesale (rack) prices as well as retail prices. In addition, there are more retail areas than wholesale areas, which makes it possible to look at the effect of localized regulations at retail that affect only one portion of an area served by a rack.

Table 2 contains the average rack price differentials between major West Coast cities and Houston. The average rack price differentials for San Diego and Los Angeles, 22.1 cpg and 19.7 cpg, are similar to the retail price differences of 19.5 and 11.1 cpg. With the spikes removed from the data, the rack price differentials in San Diego and Los Angeles shrink to 16.8 and 14.4 cpg, which are even closer to the 'no spike' retail differentials in those two cities of 16.6 and 8.4 cpg.

San Francisco has a much lower rack price differential with Houston, 19.1 cpg, than its retail price differential of 30.9 cpg. This larger retail price differential in San Francisco may be caused by a number of regulatory issues that should influence the retail but not wholesale price in San Francisco; we discuss these later in this paper. One piece of evidence supporting the hypothesis that the San Francisco differential relates to the retail market is that the retail price differential in Chico, California, which is fed from San Francisco by pipeline, is 15.5 cpg, much more in line with the 19.1 cpg differential at the San Francisco rack. The average differential at the San Francisco rack drops five cpg, to 14.1 cpg, when the periods of supply disruption are removed from the data. The average rack price is slightly lower in San Francisco than in Los Angeles, both with spikes included (19.1 versus 19.7 cpg) and excluded (14.1 versus 14.4 cpg). Since gasoline typically flows from San Francisco to Los Angeles, this is the relationship one would expect.

While we have limited data on rack prices in Portland, the average difference between rack prices in Portland and Houston, 10 cpg, and Seattle and Houston, 12 cpg, is relatively similar. With the supply disruptions removed, the differentials drop into the range of seven to nine cpg. These rack differences are somewhat lower

Table 2. Average rack price gaps – West Coast cities relative to Houston

City		1997	1998	1999	2000	2001	2002	1997–2002 average	1997–8 average
	ALL	17.81	16.06	26.56	24.16	26.33	21.71	22.11	16.9
		(6.86)	(3.83)	(13.46)	(12.19)	(12.07)	(5.5)		
	ALL summer	16.26	15.81	34.59	24.71	28.65	21.82	23.64	16.0
San Diego	ALL winter	19.36	16.3	18.47	23.61	24.03	21.59	20.56	17.8
	No spike	17.81	16.06	15.74	11.78	18.57	20.94	16.82	16.9
	No spike summer	16.26	15.81	14.05	13.65	19.8	20.21	16.63	16.0
	No spike winter	19.36	16.3	15.95	8.97	17.95	21.59	16.69	17.8
	ALL	15.87	13.11	24.25	23.83	22.61	18.23	19.65	14.5
		(7.79)	(3.9)	(12.34)	(11.51)	(12.33)	(5.32)		
	ALL summer	13.85	13.33	31.87	24.07	24.64	18.96	21.12	13.6
Los Angeles	ALL winter	17.89	12.89	16.58	23.59	20.42	17.24	18.10	15.4
	No spike	15.87	13.11	14.29	11.77	14.09	17.14	14.38	14.5
	No spike summer	13.85	13.33	14.52	13.46	15.42	17.05	14.61	13.6
	No spike winter	17.89	12.89	14.26	9.25	13.33	17.24	14.14	15.4
	ALL	15.62	13.99	25.08	20.76	20.2	19.2	19.14	14.8
		(7.66)	(4.45)	(13.52)	(11.81)	(11.55)	(5.5)		
	ALL summer	14.2	13.61	32.26	21.94	21.12	19.71	20.47	13.9
San Francisco	ALL winter	17.04	14.38	17.85	19.56	19.21	18.51	17.76	15.7
	No spike	15.62	13.99	14.49	9.77	12.75	18.07	14.12	14.8
	No spike summer	14.2	13.61	11.86	10.84	12.82	17.65	13.50	13.9
	No spike winter	17.04	14.38	14.83	8.15	12.72	18.51	14.27	15.7
	ALL				12.73	11.34		10.18	
					(9.44)	(11.56)			
	ALL summer				13.67	13.59		13.63	

Table 2. (Continued)

City		1997	1998	1999	2000	2001	2002	1997–2002 average	1997–8 average
Portland	ALL winter				11.78	9.09		9.12	
	No spike				3.81	9.24		6.51	
	No spike summer				1.89	13.56		7.73	
	No spike winter					6.68	7.01		6.72
	ALL	8.92	8.86	17.46	14.92	12.07	10.53	12.13	8.9
		(6.07)	(4.29)	(9.36)	(9.4)	(11.35)	(4.67)		
	ALL summer	9.53	10.05	24.21	15.61	13.47	12.36	14.21	9.8
Seattle	ALL winter	8.3	7.66	10.66	14.22	10.56	8.04	9.91	8.0
	No spike	8.92	8.86	9.97	5.28	10.3	9.31	8.77	8.9
	No spike summer	9.53	10.05	12.28	3.21	14.09	10.53	9.95	9.8
	No spike winter	8.3	7.66	9.68	8.4	8.11	8.04	8.37	8.0

Source: Oil Price Information Service.

than the retail differences of 14 cpg in the Oregon cities and ten to 16 cpg in the Washington cities with the supply disruptions removed.

As shown in the averages in Tables 1 and 2, a sizeable portion of the higher price of gasoline on the West Coast is explained by taxes and supply disruptions. Both of these issues will be discussed in greater detail in later sections of the paper. The remaining price difference to be explained is approximately 10 to 15 cpg in most cities on the West Coast.

3. Structural Explanations for West Coast Prices

Concerns about West Coast gasoline pricing fall into two categories: higher average prices, relative to the rest of the US, and price spikes. While the latter is more visible to consumers, the former may be more costly over time. Various structural factors contribute to higher average prices; these factors include: higher-than-average taxes, refinery capacity constraints, higher gasoline production costs for CARB gasoline, Unocal's patents on blending CARB gasoline, land costs, and other regulatory costs. This section examines each of these factors, while the following section discusses unanticipated factors that explain why price spikes occurred.

Taxes

State gasoline taxes are a large component of the state-to-state variation in gasoline prices at the pump. As of 2002, the federal gasoline tax is 18.4 cents per gallon. Table 3 shows the state and local gasoline taxes in California, Oregon, Washington, and Texas. In Texas, the state gasoline tax has remained constant at 20 cents per gallon between 1997 and 2002. California taxes were 19.2 cpg in 1997 and have remained at that level. California also imposes a 7.25% *ad valorem* tax on gasoline.[7] The state sales tax was reduced for one year in 2001 by 0.25%. There are also local sales taxes throughout the state, e.g. 1.5% in San Francisco. In addition, California is one of only four states that calculate gasoline sales taxes on the sales price including state and federal taxes, effectively imposing an additional 2.7 cpg through this tax-on-a-tax.[8]

In total, the gasoline taxes in California are roughly 10–12 cpg higher than the taxes in Houston. However, as shown in Table 1, the difference between the tax-inclusive price and the tax-exclusive price widens in years of supply disruptions. These proportional taxes also act to reinforce price increases. For a 25 cent per gallon increase in the price of gasoline, the amount of tax increases by over 2 cpg.

The state gasoline tax in Oregon is 24 cpg while Washington State adds 23 cpg. In Oregon, local taxes for some cities or counties add between one and three cents per gallon to the pump price. Unlike California, the local taxes in Oregon are not proportional to the sales price. Thus, relative to Houston, taxes typically add five to seven cpg to the price in Oregon and three cpg to the price in Washington.

Taxes account for roughly 30–40% of the retail price differential in California, and 15–20% of the price differential in Oregon and Washington. As Table 1 shows, the retail price gap relative to Houston averaged 21 cpg in Los Angeles, 24 cpg in Chico, 27 cpg in Bakersfield, 29 cpg in San Diego, and 43 cpg in San Francisco; while taxes accounted for about 10 cpg of the differential in Los Angeles and San Diego, 9 cpg in Bakersfield and Chico, and 12 cpg in San Francisco. The retail price

Table 3. State gasoline and under ground storage taxes/fees and state and local sales taxes

State/City	1997	1998	1999	2000	2001	2002
California	19.2 cpg	19.2 cpg	19.2 cpg	19.2 cpg	19.2 cpg	19.2 cpg
San Diego	7.75%	7.75%	7.75%	7.75%	7.50%	7.75%
Los Angeles	8.25%	8.25%	8.25%	8.25%	8.00%	8.25%
Bakersfield	7.25%	7.25%	7.25%	7.25%	7.00%	7.25%
Oakland	8.25%	8.25%	8.25%	8.25%	8.00%	8.25%
San Francisco	8.50%	8.50%	8.50%	8.50%	8.25%	8.50%
Chico/Paradise	7.25%	7.25%	7.25%	7.25%	7.00%	7.25%
Oregon	24 cpg	24 cpg	24 cpg	24 cpg	24 cpg	24 cpg
Washington Co.	1 cpg	1 cpg	1 cpg	1 cpg	1 cpg	1 cpg
Multnomah Co.	3 cpg	3 cpg	3 cpg	3 cpg	3 cpg	3 cpg
Washington	23 cpg	23 cpg	23 cpg	23 cpg	23 cpg	23 cpg
Texas	20 cpg	20 cpg	20 cpg	20 cpg	20 cpg	20 cpg

Sources: US Department of Transportation, Federal Highway Administration, *Highway Statistics*, American Petroleum Institute, *State Motor Fuel Taxes*, State of California, Board of Equalization, Fuel Tax Division, Tax Rates, and State of Oregon, Department of Transportation.

gap before taxes in both Eugene, Oregon and Seattle, Washington relative to Houston was about 20 cpg, and the gap averaged 15 cpg in Portland, Oregon; taxes accounted for between three and four cpg in each city.

Capacity Constraints

Refinery capacity utilization in the United States is extraordinarily high, particularly during times of peak demand. US refinery capacity utilization has been above 90% every year since 1993, and ranged between 94% and 96% between March and July 2000, when gasoline demand was heavy because of the summer driving season.[9] These figures may understate true capacity utilization because some closed refineries may be counted as idle capacity. A number of refineries closed during the 1980s as the industry attempted to better use its existing capacity, and no new US refineries have been constructed in more than 25 years. Several California refineries chose to close entirely or to not produce CARB gasoline,[10] further reducing gasoline production capacity on the West Coast.

Because refineries involve substantial capital investments, they generally run at or near capacity as much as possible. Refinery operators shift output among the various products as relative prices change so, for example, more gasoline is produced in the summer months while more heating oil is produced in the winter. Refiners have only limited flexibility in the output mix of a refinery, however, and they are increasingly constrained as the time horizon becomes shorter. As a result, the short-run supply elasticity for a refinery is likely to be very small, although no reliable estimates are available.

Tables 1 and 2 break out retail and rack prices into summer (defined as April through September) and winter months, both with and without price spikes. There are no sizeable changes in the price spread between Houston and the West Coast between summer and winter. Many of the yearly comparisons show that the gap widens in the summer but for a number of years the difference is greater in the winter than the summer.

CARB Gasoline Raises Costs for all West Coast Consumers

California's decision to use a cleaner gasoline had several consequences for gasoline prices throughout the West Coast. The most direct effect is that CARB gasoline raises the variable cost of refining by at least 4–5 cpg.[11] In addition, refiners spent over $3 billion in refinery capital improvements in order to meet the CARB standard. Several refineries chose to shut down entirely, while Paramount Refining continues to operate but does not produce CARB gasoline.[12] These capital expenditures must be recouped over time in the form of higher gasoline prices in order to provide California refiners with a normal economic rate of return.

Another consequence of CARB gasoline is that it reduces gasoline mileage. The Air Resources Board estimated that mileage would decline by about 1–3%.[13] All else equal, a decrease in gas mileage is equivalent to an increase in gasoline demand.

It is not only California drivers who are affected by the CARB standard. Although consumers in Oregon, Nevada, and Arizona generally use conventional gasoline,[14] the incremental supply of gasoline in Oregon comes from California refineries, while a very high fraction of the gasoline used in Nevada and Arizona is from California. As a result, stations in these states must compete with those in California for supply of gasoline. Put another way, California refiners decide on the amount of CARB gasoline versus conventional gasoline to produce based on the relative margins of the two products. Because the margin for CARB must, on average, cover the billions of dollars invested, the refinery margin for conventional gasoline must also be higher than elsewhere in the country.

A 4–5 cpg cost disadvantage for producing CARB gasoline accounts for between 13% (in San Francisco) and 44% (in Los Angeles) of the after-tax differential between California cities and Houston. The presence of CARB gasoline in California likely affects the retail price in Oregon and Washington, but to an unknown degree. If prices of conventional gasoline in those states are increased by the full 4–5 cpg of the CARB production cost penalty (likely to be an overestimate), this would account for between 24% and 33% of the after-tax differential between Oregon and Washington cities and Houston.

Unocal Patents

In the early 1990s, as California officials considered how to craft a gasoline specification that would meet its clean-air law, Unocal applied for and received a patent that covered a variety of formulae for blending lower-emissions gasoline. Unocal announced its initial patent in 1995, at which point six California refiners filed suit in federal court to have the patent declared invalid. Unocal countersued for patent infringement. A jury upheld the patent, found that it had been infringed, and awarded Unocal royalties of 5.75 cpg. In March 2000, the Federal Circuit upheld the jury's verdict.[15] Unocal has since received four additional patents related to gasoline blending.

The effect of Unocal's patents is difficult to quantify. If refiners had to pay nearly six cents for every gallon of CARB gasoline produced, the result would be roughly six cent higher gasoline prices in California. However, two facts suggest the ultimate effect may be significantly less. First, Unocal has been negotiating royalty rates with refiners; the press reports that the royalty ranges from 1.2 to 3.4 cpg, with Citgo, Tesoro, and an unnamed third refiner agreeing to terms with Unocal. Second, Unocal claims that refinery data that the company has seen show that only 5–15%

of reformulated gasoline production actually infringes the Unocal patents, so the royalties may affect a relatively small proportion of CARB output.[16]

Oregon's Ban on Self-Service Gasoline

Oregon and New Jersey are the only states that prohibit self-service gasoline sales. Vita (2001) estimates that the effect of this ban increases prices by about 3.5 cpg. Johnson and Romeo (2000) estimate a slightly lower figure for Oregon, 2.5 cpg, and a slightly higher one for New Jersey, 4.3 cpg. These estimates may seem low in comparison with observed differences between full- and self-service prices. However, as Shepard (1991) and Barron *et al.* (2001) note, retail stations with the ability to sell both types of service can exploit some consumers' willingness to pay for full service. As a result, the price differential between full- and self-service will be greater than when self-service is prohibited.

As Table 1 shows, the difference in prices net of taxes between Portland, Oregon and Salem, Washington, just across the border from Portland, is slightly less than four cents per gallon, which is very similar to the estimates of the premium for the no self-serve states. This result holds whether price spikes are included or excluded from the data.

Land Costs

One of the costs of gasoline retailing is acquiring the land for the station. Clearly, the higher are these costs, the higher will be gasoline prices. California has one of the highest costs of land in the country. The consumer price index for housing published by the Bureau of Labor Statistics shows that the costs of housing in San Francisco was 41% greater than Houston in 2000. Likewise, the costs of housing in Los Angeles, San Diego, Seattle, and Portland were 25, 35, 34 and 33% higher than Houston. While difficult to quantify without more and better data, real estate costs explain at least part of the retail price differential between San Francisco and other West Coast cities from the Gulf Coast.

Regulatory Costs

The price effects of many regulations are difficult to quantify. This is all the more so when regulations do not prohibit a course of action, but instead merely increase the cost to firms of doing business. Nevertheless, regulations have the effect of raising costs and discouraging entry and thereby raising prices to consumers.

In San Francisco, zoning regulations discourage gas stations without service bays. Throughout the country the traditional gas station, with a small number of pumps and several service bays, is giving way to larger stations with many pumps and, often, a convenience store or a car wash, but without service bays. To the extent that this transformation is efficient, and San Francisco makes this transition more difficult, one would expect gasoline prices to be higher. Other zoning regulations throughout the West Coast also discourage gasoline station construction in major cities. Thus, relative to areas of the country without these constraints, one would expect San Francisco to have higher retail prices. A comparison between Tables 1 and 2 suggest that San Francisco's high retail prices are a result of higher retail margins. While the differential net of taxes between San Francisco and Houston is about 31 cpg at retail, the differential is a little more than 19 cpg at the rack. In contrast, Chico, California, which is served by pipeline from San Francisco, has a retail price differential net of taxes below 16 cpg relative to Houston.

Another innovation in gasoline retailing is the use of an unused part of a parking lot for gasoline pumps, particularly in conjunction with club stores. Costco has been a leader in this concept, with low gasoline prices as an added inducement to consumers to pay the annual membership fee. In Portland, local regulation appears to be less amenable to this kind of gasoline retailing than across the river in Vancouver, Washington. In the Portland metropolitan area, eight 'megastores' – principally Fred Meyer and Costco – applied for permits to add gasoline pumps, but seven applications were for sites in Vancouver, while only one was in Portland (Brettmann, 2000). To the extent that entry by megastores is efficient, and local regulations are inhibiting this entry in Portland, local gasoline prices will be a little higher than otherwise.

4. Explanation of Spikes

The structural factors discussed in the previous section explain a number of the reasons West Coast consumers face higher gasoline prices on average than consumers in the rest of the United States. To explain why the differential grows or shrinks over time, however, we need to identify regional supply or demand shocks. The West Coast gasoline market is relatively isolated, with no pipeline connections to the markets east of the Rockies – and, in particular, to the Gulf Coast refining hub. Demand and supply are both highly inelastic in the short run, which exacerbates any supply problems.[17] In addition, California's unique gasoline specification requires Gulf Coast refiners to disrupt their usual production runs, load the product onto inefficiently-sized Jones Act tankers in order to fit through the Panama Canal, and wait another three weeks for the product to arrive in Los Angeles, by which time the market price may be very different from when the refiner made the gasoline. As a result, supply shocks are longer-lived on the West Coast than in areas of the country that are more interconnected. For example, in the Midwest gasoline price spike in the spring of 2000, prices increased rapidly, but declined even more rapidly only six week later as additional gasoline flowed to the region. (Bulow *et al.*, 2001). Table 4 details the major supply disruptions on the West Coast during the years analyzed in this paper, January 1997 until July 2002.

We begin with a brief discussion of the costs associated with the Jones Act. While the Jones Act is not a supply shock, it serves to exacerbate California supply shocks by increasing the cost of shipping CARB gasoline into California. We then examine two types of supply shocks: first, in 1999, several West Coast refineries had serious production problems for extended periods; second, in June 1999, the Olympic Pipeline, the main conduit for gasoline from the major Puget Sound refineries to Seattle, Portland, and other markets along the coast, suffered a rupture that cut off efficient access to two refineries until February 2001.

The Jones Act Increases the Incremental Supply Cost from Outside the West Coast

The West Coast is not integrated into the pipeline system that connects much of the US east of the Rockies. No pipeline currently can deliver gasoline into PADD V from one of the other major US refining centers. As a result, incremental supplies into the West Coast come via tanker, generally to Los Angeles or Portland. This makes the cost of incremental supplies much higher for West Coast consumers than

Table 4. West Coast supply disruptions

Year	Dates	Brief description
1997	None	
1998	None	
1999	03/05/99–09/10/99	There were multiple refinery outages during the summer of 1999 beginning with the Tosco Avon refinery fire. Additional outages occurred at the Arco Carson City, the Mobil Torrance and the Chevron Richmond refineries. The Olympic Pipeline also ruptured during this period.
2000	02/12/00–05/06/00	Refinery problems at the Mobil Torrance and Arco Carson refineries.
	07/10/00–12/31/00	Multiple refinery problems at Chevron, El Segundo, Chevron, Richmond, Arco, Carson, Equiva, Los Angeles, Tosco, San Francisco and Mobil Torrance refineries.
2001	02/12/01–06/04/01	Refinery Issues at Valero's Benecia Refinery and Arco's Carson City refinery.
	08/13/01–09/30/01	There was a refinery outage at the Equilon Anacortes, Washington refinery.
2002	06/10/02–07/08/02	Refinery problems at the Valero's Benecia refinery.

Sources: Energy Information Administration (2001), *The Oil Daily*, and *Platt's Oilgram News* various issues.

elsewhere in the country. For example, the tariff on the Explorer Pipeline is about two cpg from the Gulf Coast to Chicago, while tanker costs to the West Coast as of 1997 were on the order of 6.4 to 10.6 cpg.[18] In addition, while pipeline shipments can be relatively small, on the order of 10–20,000 barrels, tankers can carry 250,000 barrels or more, which is likely to have a significant impact on West Coast prices. Consequently, firms will require a greater price differential between West Coast markets and markets elsewhere in the US in order to find it profitable to send a tanker instead of a pipeline shipment of gasoline.

Although the Gulf Coast is the closest major refining complex to the West Coast markets, and may be in the best position to produce CARB gasoline on short notice without serious disruption to the markets these refiners normally serve, the cost of shipping from the Gulf Coast to Los Angeles is actually higher than from some non-US refineries. This is because of the additional costs imposed by the requirement to ship gasoline from the Gulf Coast on US built, flagged, and crewed vessels, a law generally referred to as the Jones Act.

A recent estimate by the US International Trade Commission estimates that shipping costs would be about 45% lower in the absence of the Jones Act (USITC, 1999). The California Energy Commission (1998) estimated that shipping costs from the Gulf Coast in 1997 were about 9.3 cpg, implying that the additional cost the Jones Act imposes is about 4.2 cpg. Thus, the Jones Act raises the price of gasoline in California by this amount during the times of the year when it is necessary to import gasoline from the Gulf Coast.[19]

Refinery Disruptions in 1999

Disruptions in at least five different West Coast refineries contributed to higher-than-average price differentials in 1999. First, in November 1998, an explosion occurred at Texaco's Anacortes, Washington refinery, and full production did not resume until five months later. Second, in February 1999, an explosion at Tosco's Avon, California refinery shut the refinery completely for some period, and full production did not resume until August. Third, in March 1999, a fire caused Chevron to shut down the hydrocracker unit at its Richmond, California refinery. The same refinery lost its fluid catalytic cracker unit in late May and again in the fourth quarter of 1999. Fourth, in the spring of 1999, a crude processing unit and a coker unit at ARCO's Cherry Point, Washington refinery were idled for over a month. Finally, in July 1999, a fire disrupted production at Mobil's Torrance, California refinery.[20]

In addition to these refinery problems, ARCO's Cherry Point refinery had to curtail production as a result of the Olympic Pipeline rupture.[21] We discuss the pipeline break in greater detail in the following section.

The trade press do not quantify the gasoline production lost as a result of these unexpected refinery problems. One issue making this kind of quantification difficult is that a shutdown of one unit may permit the refinery to keep running, but may have a substantial impact on the amount of gasoline the refinery can produce. For example, a shutdown of a coker may not close a refinery entirely, but may result in greater output of heavy fuels and lower output of gasoline than unconstrained optimization would allow.

The effect of these refinery problems on gasoline prices is difficult to measure. Public data do not show the reduction in the quantity of crude oil refined, nor is it possible to show how much additional gasoline supply arrived from outside the area in response to refinery problems on the West Coast. Further complicating the problem, refiners are likely to react to refinery problems by adjusting the mix of products produced; the result can be a reduction in gasoline production either greater or less than the overall reduction in refinery output. Nevertheless, as Table 2 shows, West Coast rack prices in 1999 averaged nine to ten cents per gallon higher, relative to Houston, than the 1997–98 average.

Olympic Pipeline Rupture

The Olympic Pipeline is a 400-mile refined products pipeline that connects the four major Puget Sound refineries – ARCO's Cherry Point refinery, Tosco's Ferndale refinery, Tesoro's Bellingham refinery, and Texaco's Anacortes refinery – to markets along the I–5 corridor, including Seattle, Sea-Tac Airport, and Portland. When the pipeline is operating normally, it carries most of the gasoline used in western Washington and Oregon.

On June 10, 1999, the pipeline ruptured in Bellingham, Washington, and was shut between Cherry Point and Allen station until February 8, 2001 for repairs and testing. During this time the refineries at Cherry Point, Ferndale, and Bellingham had to ship gasoline and other refined products by barge around the break. Since February 2001 the pipeline has been operating at only 80% capacity, with this limitation expected to continue until some time in 2002.

The direct cost in Oregon of the pipeline break was at least two cpg, which is the additional cost of barge transportation to Oregon over the pipeline tariff (Christensen and Long, 1999). The cost may have been significantly higher, at least in the short run, if scarcity of barges drove up the cost of renting a barge.

Furthermore, the pipeline break reduced the amount of gasoline coming to Oregon from the Puget Sound. Shipments on the Olympic Pipeline were 25% less in 1999 than in 1998, and more than 45% less in 2000 than 1998. As noted above, ARCO had to reduce refinery output because of a constraint in its dock facilities. Shippers compensated somewhat by carrying more gasoline and jet fuel, the relatively high-value products, than ordinarily. Gasoline and jet fuel shipments in 1999 were 27% below the 1998 level, and were 26% less in 2000 than in 1998.[22] Barge and tanker shipments from Washington to Oregon were up 150% in 1999 versus 1998, while imports from foreign refineries were up almost five times.[23] Perhaps reflective of the California refinery problems in 1999, waterborne gasoline shipments from California to Oregon fell by 3.6% from 1998 to 1999.[24]

5. Conclusion

West Coast consumers have felt the pinch of higher gasoline prices relative to the rest of the US for a number of years, and particularly during some recent price spikes. Structural factors that have kept average West Coast prices higher than elsewhere include tight refining capacity; higher costs to produce CARB gasoline and, hence, higher opportunity costs to produce conventional gasoline for West Coast markets outside California; higher shipping costs for marginal barrels of gasoline blending components, including costs imposed by Jones Act shipping restrictions; Unocal's patents on CARB gasoline blending; higher taxes, especially in California; Oregon's ban on self-service gasoline; higher land costs; and a more restrictive regulatory environment. While a number of these factors are difficult to quantify, they would appear to explain most or possibly all of the measured difference in average prices leaving little to be explained by vertical market structure.

The West Coast gasoline market is also prone to substantial price volatility as a result of the relatively isolated nature of the market and, in part, because of the unique requirements for CARB gasoline. When supply disruptions occur, incremental supplies are costly to obtain and a long way from the market. The past few years have seen a variety of supply shocks, from widespread refinery problems in 1999 to the Olympic Pipeline break that affected prices from mid-1999 through early 2001.

Unfortunately, the problem is easier to define than to solve. California Attorney General Bill Lockyear supported proposals to create a state-owned gasoline reserve and for the state to purchase gasoline from out-of-state sources when California gasoline prices rise (State of California, 2000). Both these proposals seem likely to crowd out private investments in gasoline inventories and private imports of gasoline, and at a substantial taxpayer cost. Any effective relief from price spikes requires getting gasoline to California more rapidly than by tanker from the Gulf. For example, California could grant a waiver from the requirement to sell CARB gasoline during price spikes, with a levy on any wholesaler selling conventional gasoline equal to the normal CARB-conventional price differential, less the incremental cost of supplying conventional gasoline into California. This would have the effect of better integrating California into the gasoline supply system of the rest of the country.

Notes

1. This assumption is easiest to defend at the bulk supply level because of the abundance of refining capacity and low concentration in the Gulf region. We also did the same comparisons using Newark, New Jersey and New Orleans, Louisiana. The price differences between the California cities and Newark and New Orleans were somewhat smaller but followed the same pattern.

2. As we discuss in greater detail below, West Coast taxes are generally higher than those elsewhere in the country, and explain some of the retail price differential.
3. In 1992, California Air Resource Board (CARB) I gasoline regulations went into effect. These regulations required new more stringent specifications for gasoline formulating which affected the detergents, lowered the Reid vapor pressure (RVP) and removed any trace lead. In 1996 phase II CARB regulations went into effect which required more substantial changes in the formulation of gasoline including reductions in benzene content and certain hydrocarbons.
4. These comparisons are based on Oil Price Information Service (OPIS) retail prices collected from Wright Express using fleet card transactions from 60,000 to 80,000 gasoline stations. For the wholesale comparisons we use OPIS rack prices.
5. There are three main refining centers on the West Coast, Los Angeles, San Francisco, and Seattle. In California, Los Angeles serves San Diego and San Francisco serves primarily the northern part of the state, although some product flows to Los Angeles. The refineries in and around Seattle primarily serve Washington and Oregon states. In addition to the pipelines leading out of these refining areas, waterborne shipments along the coast between the refining centers and some consumption points serve to balance supplies within the region. Imports of gasoline from outside PADD V either from others parts of the United States or abroad are small.
6. To identify supply disruptions for California from 1996 to spring 2002 we relied on the Energy Information Administration (2001). Additional supply disruptions were identified by examining relative prices between the cities. When the price differences were twice the average size we reviewed the trade press for information on refinery or pipeline outages.
7. Office of Highway Policy Information, Monthly Motor Fuel, Table MF-121T.
8. Georgia, Michigan, and New York also charge sales tax on the volume tax. Georgia and Michigan charge only 4%, however (New York charges 6%), and Georgia has the lowest volume tax rate in the country, at 7.5 cpg.
9. Federal Reserve Board.
10. Golden West (Santa Fe Springs; 44,700 barrels per day) ended its refining operations in 1992 and now operates as a terminal only. Fletcher (Carson; 30,000 barrels per day) closed in 1992. Pacific Refining (Hercules, California; 55,000 barrels per day), and Powerine (Santa Fe Springs, California; 37,000 barrels per day) both closed in 1995. Edgington Oil (Long Beach, California; 41,600 barrels per day) also closed. Paramount Refining (Paramount, California; 46,000 barrels per day), while still operating, produces no CARB gasoline. See Leffler and Pulliam (1999) and McAfee (2001). The timing of these closures coincides with the introduction of CARB I and CARB II gasoline.
11. The US Energy Information Administration (EIA) issued a report (Lidderdale and Bohn, 1999) estimating that Phase II RFG regulations would increase refining costs by about 3–4 cpg over the cost of conventional gasoline. As the CARB standard is more stringent than the Phase II RFG standard, the EIA estimate is likely to be a lower bound for the CARB cost increase. The report did not directly estimate the cost of CARB gasoline, but did observe that the actual wholesale price difference between CARB and conventional gasoline in 1997 and 1998 was 4.2 cpg.
12. See footnote 10, *supra*.
13. California Air Resources Board press release, 'Fuel-Economy Reduction from Cleaner-Burning Gas Within Expected Range, According to Statistics,' Oct. 10, 1996.
14. Oregon requires the use of both oxygenated and summertime low-RVP gasoline in the Portland-Salem metropolitan areas. This gasoline requires the use of some of the same high-quality components used in CARB gasoline, and therefore its production is directly affected by the cost of producing those components for CARB gasoline.
15. Union Oil Co. of Cal. v. Atl. Richfield Co., 208 F.3d 989 (Fed. Cir.).
16. 'Exxon Says Unocal Gained Monopoly with Gas Patents,' May 8, 2001, biz.yahoo.com/rf/010508/n08599904.html.
17. See, for example, Archibald and Gillingham (1980), Espey (1996), Puller and Greening (1999), and Kayser (2000) for estimates of gasoline demand elasticity. Most estimates are in the range of –0.1 to –0.4, with a mean of about –0.2.
18. Explorer Pipeline, www.expl.com; California Energy Commission (1998: 110).
19. In 1999, there were 8 tanker movements between the Gulf and West Coasts in the first quarter, 10 in the second quarter, 14 in the third quarter, and 4 in the fourth quarter, totaling about 2.4 million metric tons. These shipments were primarily CARB and gasoline blending components. US Maritime Administration, based in part on information from Lloyd's Maritime Itineraries.
20. *Octane Week, Platt's Oilgram News, and Oxy-Fuel News* (various issues, 1999).

21. Atlantic Richfield SEC Form 10-K, (1999: 9–10). Tosco Corporation, which operates the Ferndale, WA refinery which is on the same segment of the Olympic Pipeline did not publicly report the effect of the Olympic shut down on its operations, but news accounts at the time suggested that it was also affected.
22. Olympic Pipeline Company, FERC Form 6, 1998–2000.
23. Waterborne Commerce of the US Public Domain Data Base, 1998–9. In 1999, there were 8 tanker movements between the Gulf and West Coasts in the first quarter, 10 in the second quarter, 14 in the third quarter, and 4 in the fourth quarter, totaling about 2.4 million metric tons. These shipments were primarily CARB and gasoline blending components. US Maritime Administration, based in part on information from Lloyd's Maritime Itineraries.
24. Waterborne Commerce of the US Public Domain Data Base, 1998–9.

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