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Chapter 5: Ethanol Distribution, Trade Flows, and Shipping Costs

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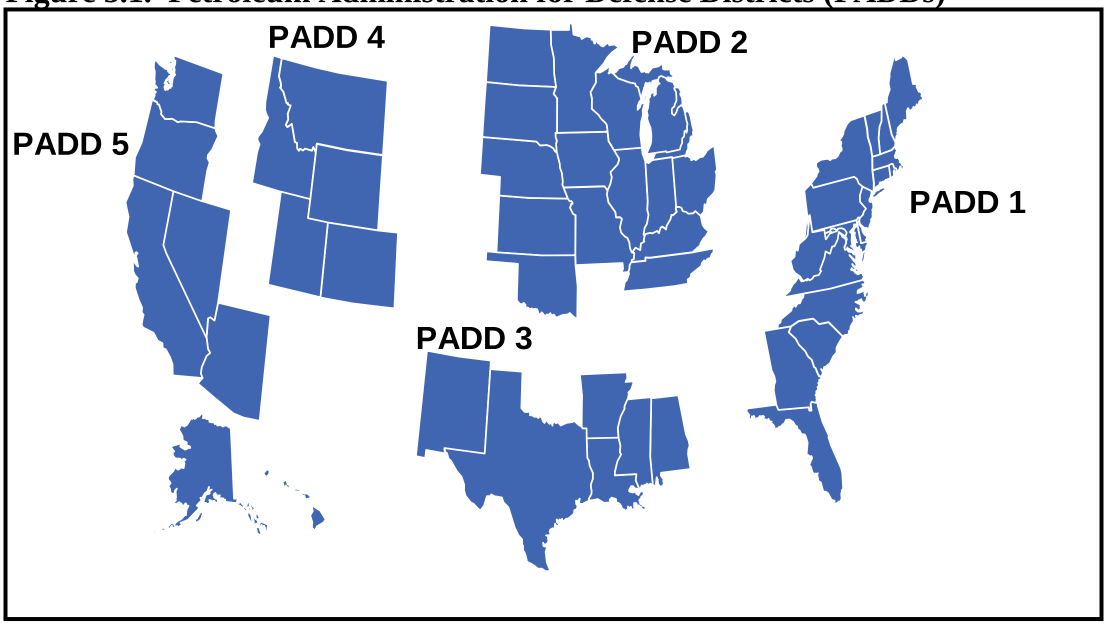
Introduction

The distribution system for U.S. transportation fuels evolved over many decades. The infrastructure and equipment were originally developed for liquid petroleum fuels, and ethanol was integrated into the system as it became an important component of gasoline. Petroleum fuels are distributed from the major refining areas in the U.S. Gulf Coast, and to a lesser extent, from western and eastern ports to consumer markets. Since oil refineries are not evenly distributed throughout the United States, the industry has developed a sophisticated transportation network to deliver its products nationwide and also meet the demand of high-consumption areas with dense populations, such as the East Coast, the West Coast, and along the Gulf Coast. Petroleum fuels are generally transported long distances by pipeline, ship, and barge to fuel terminals. When gasoline arrives at a terminal, it usually is blended with up to 10 percent ethanol to make E10. Trucks are then used to move the finished fuel to local retail gas stations or other end-use locations.

Ethanol plants are located throughout the country; however, ethanol capacity is concentrated in the Corn Belt—mostly west of the Mississippi River (Figure 5.1). Ethanol transport relies primarily on rail and trucks, and a small amount of Midwest ethanol is moved on barges. The geographical distribution of ethanol consumption is similar to gasoline, since it is usually blended with gasoline to produce E10. The renewable fuel requirement has made E10 the most

Figure 5.1. Petroleum Administration for Defense Districts (PADDs)



Source: U.S. Energy Information Administration, 2012.

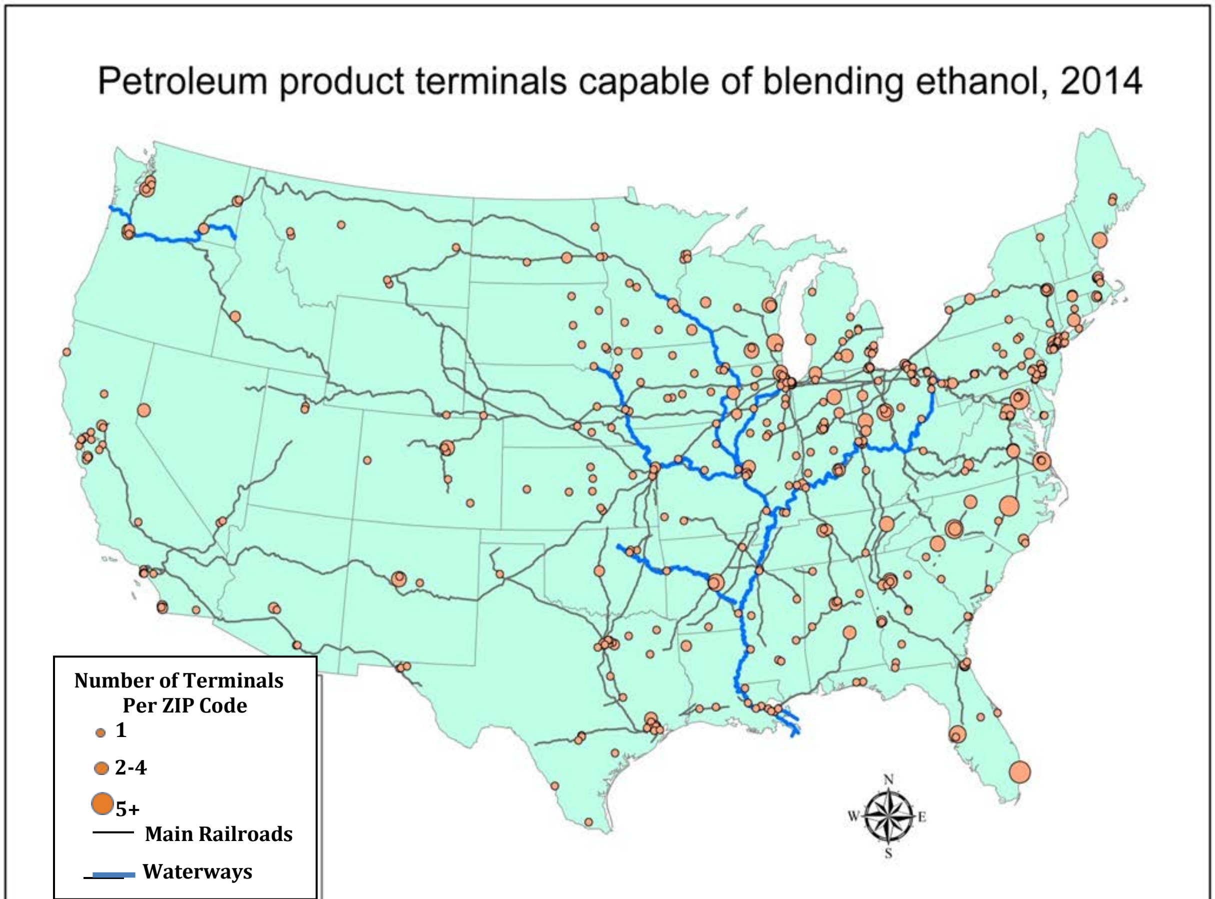
common fuel in the United States. Ethanol is typically delivered by rail to petroleum storage hubs or terminals for blending and/or storage. Trucks are then used to deliver the finished blended fuel to retailers. The rapid growth experienced by the ethanol industry in recent years has caused its transportation network to expand significantly. The remainder of this chapter will describe the transportation infrastructure and technology that has developed to facilitate the increased transportation needs of ethanol. An examination of the ethanol transportation system shows that it is similar to those used to transport large-scale agricultural commodities. Furthermore, it is reasonably efficient and cost competitive.

Ethanol Distribution and Trade Flows

Economic and policy factors likely determined the location of ethanol production in the corn production area of the United States and consumption in the populated coastal areas. On one hand, production costs are reduced using the cheapest corn in the most remote areas of the Corn Belt. Processing near the raw material saves on shipping costs, since on a gallon basis, ethanol weighs far less than corn (e.g., a 56 pound bushel of corn yields about 20 pounds of ethanol). On the other hand, fuel consumption is concentrated in the more densely populated coastal areas. A few plants located outside of the Corn Belt, so-called destination plants, face more involved logistics, and corn transport increases variable costs.

As stated earlier, U.S. ethanol production is concentrated in the Midwestern Corn Belt, while consumption is concentrated in the populated Coastal areas of the East, West, and South. Domestic ethanol trade flows can be examined using data from five "Petroleum Administration for Defense Districts" or PADDs, which provide data on regional fuel movements (Figure 5.1). The Midwest (PADD 2) produced 12.3 billion gallons of ethanol in 2012 and only consumed 28 percent of its production. About one-half (4.3 billion gallons) of PADD 2 out-of-State shipments went to the East Coast (PADD1). Otherwise, Midwestern shipments were evenly split between the West Coast (PADD 5) with 2.0 billion gallons, and the Gulf Coast (PADD 3) with 2.0 billion gallons. About 10 percent of ethanol production is located in the consuming areas. For more details on domestic trade flows see Appendix Figure 1. Foreign trade was not much of a factor in 2012. About 4.7 percent of U.S. production was exported, 0.36 billion gallons from the Gulf Coast and 0.28 billion gallons from the Midwest. Regarding imports, the East Coast acquired 0.38 billion gallons and the West Coast brought in 0.1 billion gallons, together accounting for 3.8 percent of U.S. ethanol consumption. Most imports are Brazilian sugarcane ethanol, which qualifies as an advanced biofuel under the RFS program and California's low carbon fuel standard (see Chapter 1).

Figure 5.2. Location of petroleum product terminals capable of blending ethanol



Source: USDA Agricultural Marketing Service Analysis of Oil Price Information Service/STALSBY Petroleum Terminal, 25th edition.

Ethanol is transported by truck, train, or barge from production points to petroleum blending terminals equipped to store and/or blend ethanol (Figure 5.2). Rail and truck are the main modes of ethanol transport, with some locations capable of receiving barges and tanker vessels. Trucks are competitive for relatively short hauls of ethanol, 125 miles or less (Gallagher et al., 2000). Trucks also transport blended fuel to retail gas stations. But rail is the dominant mode for transporting ethanol from the Midwest to Coastal areas-rail accounts for approximately 70–75 percent of ethanol shipments.

History

Shortly after the time the ethanol expansion began in 2005-2006, there were public concerns over the transportation infrastructure regarding shipments from Midwest to Coastal areas (Denicoff, et al.). There was concern that the mandated large volumes of ethanol would strain the rail transportation network. A publicly funded investigation of building a dedicated ethanol pipeline from the Midwest to the major consumption area on the east coast was mandated by the 2007 Energy Act (U.S. Department of Energy, 2010). A dedicated pipeline was preferable for ethanol because it has different fuel properties than petroleum fuels and, with the exception of a short-distance pipeline in Florida, the two fuels are not shipped in the same pipelines. Nevertheless, a dedicated long-distance pipeline was not recommended because the break-even transport rate estimate of $0.29/gallon at 2.88 billion gallons of annual throughput was considered too high to be competitive. The rapidly expanding ethanol industry went through a period of transportation-related infrastructure adjustments during 2006-2008. These adjustments included a large backlog of new rail tank car orders, expansion of petroleum blending terminals, development of unit train destinations, and construction of hubs for ethanol storage. The railroads generally welcomed the new freight business and, with the exception of a few bottlenecks (at times, railroads had to establish embargoes on ethanol trains due to congestion at destinations), were able to accommodate the expansion in interregional trade. The railroad capacity for shipping ethanol from the Midwest to U.S. Coastal areas was already in place from the grain export expansion of earlier decades; and the grain export market and other freight movements were stagnant during this period. The new large bio-refineries also invested in unit or shuttle-train capacity, another technology widely used in the grain trade. They are long trains with identical cars that carry a single commodity directly from origin to destination. Unit trains are the most efficient way for railroads to transport ethanol. They avoid gathering and switching delays, can be more easily “slotted” onto a railroad’s network, and result in quicker “turns” (i.e., cars loaded, shipped, unloaded, and returned for another load). Unit trains can be used by smaller ethanol producers, but they may need to store product until enough ethanol is ready to fill a train, or multiple producers may share a train.

Ethanol became a small but rapidly growing commodity for railroads. Record-setting ethanol production in 2011 coincided with the peak of movements of ethanol by rail. In 2011, railroads terminated over 340,000 carloads (10 billion gallons) of ethanol, up from just 40,000 carloads in 2000 and 43,000 in 2001. By 2012, the most recent year for which data are available, ethanol accounted for 1.0 percent of total rail carloads (up from 0.21 percent in 2003), 1.5 percent of rail tonnage (up from 0.3 percent in 2003), and 2.0 percent of rail ton-miles (up from 0.4 percent in 2003).[1] Although ethanol is a small percentage of the overall rail ton-miles, the majority of the shipments travel along several main corridors that at times may experience congestion. Railroad capacity has not been a huge issue for ethanol shippers in the recent years, but competition for rail service has been rapidly rising from the gas production boom in the Bakken formation of Montana and North Dakota.[2]

[1] Association of American Railroads, Policy and Economics Department, “Railroads and Ethanol”, May 2014.

[2] Surface Transportation Board, RETAC meeting, EIA Presentation, September 20, 2012

Evaluation[3]

The following analysis examines the impact of transportation costs on ethanol profit margins, since the ethanol producer typically pays for the transportation costs. Consider the freight rates for major rail transportation routes given in Table 5.1. The east-bound routes originate in Chicago and end in three major consumption centers: New York, New Orleans, and Tampa. The eastward rates are calculated from public rates given by CSX, a major railroad corporation. Specifically, a rate-distance function was estimated from 490 rates given for various routes in the Eastern United States. The rail cost estimate is a regression estimate for that distance, which is, in effect, the average of the many rates in the sample near that distance. A rate-distance regression model was defined with the CSX ethanol transport rate as the dependent variable, expressed in $/gallon/mile, and the independent variable was distance, expressed in miles. The exponent of the non-linear freight-distance function was varied in order to obtain the

Table 5.1. Rail freight rates by distance and gasoline pipeline margins for various locations, 2013

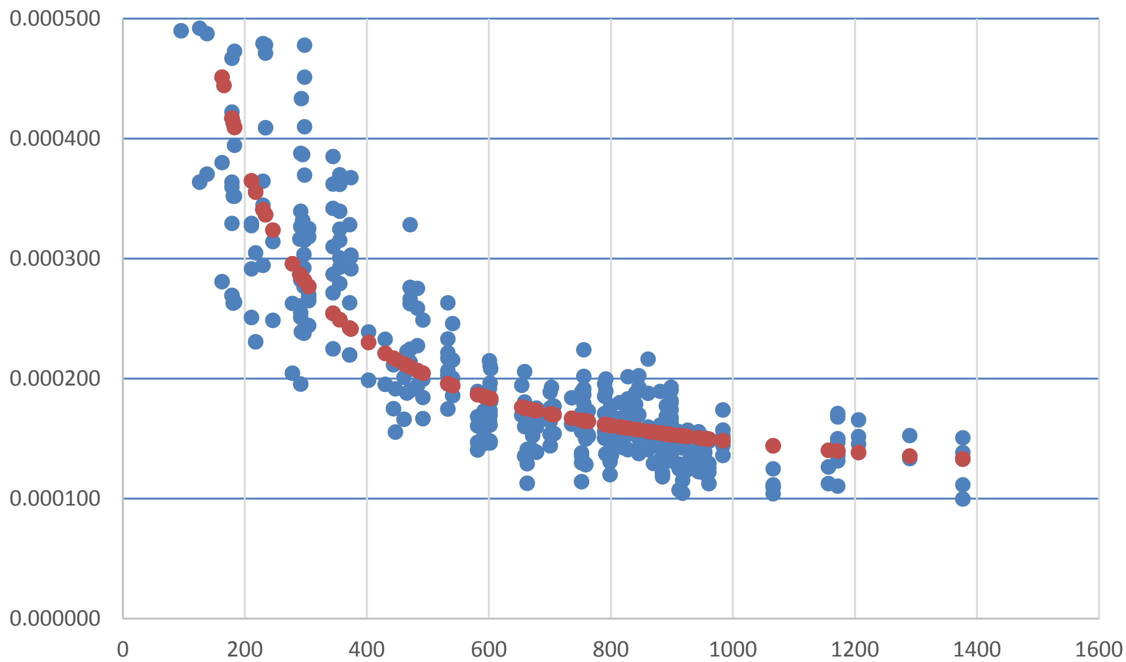
From:	To:	Distance	Cost	Gasoline Margins		
		Miles	Dollar per gallon	Dollar per gallon		
				27-May	19-Aug	Ave.
Chicago, IL	New York, NY	790	0.128	0.122	0.225	0.174
Chicago, IL	New Orleans, LA	926	0.140	0.157	-0.009	0.074
Chicago, IL	Tampa, FL	1,172	0.164	0.235	0.157	0.196
Fairmont, NE	Houston (Deer Park), TX	834	0.143	0.142	0.173	0.158
Fairmont, NE	Los Angeles, CA	1,464	0.189	0.245	0.318	0.282
Fairmont, NE	Seattle, WA	1,642	0.237	0.163	0.210	0.187

best fit (Figure 5.3). The cost per mile charge implied by these rates flattens to about 1.4 cents per 100 mile at distances of 1,200 miles or greater.

The westward rate estimates originate at Fairmont, Nebraska, a major westward and southward shipping point in the ethanol industry. Rates for the main destinations are in the South (Houston) and West (Los Angeles and Seattle). These rates were obtained in a consultation with a representative from a major railroad that operates in the Midwest, South, and West. The rate estimates in Table 5.1 range from $0.128 per gallon of ethanol for Chicago to New York to $0.237 per gallon from Fairmont to Seattle. From discussions with railroad management, it was determined that unit trains of ethanol are uncommon in the Fairmont-to-Seattle route, and Seattle may actually source ethanol more often from Eastern North Dakota.

[3] Paul Gallagher is solely responsible for the modeling and rate estimates presented in this section.

Figure 5.3. Rail rate ($/gallon/mile) versus distance (miles), actual and regression estimate

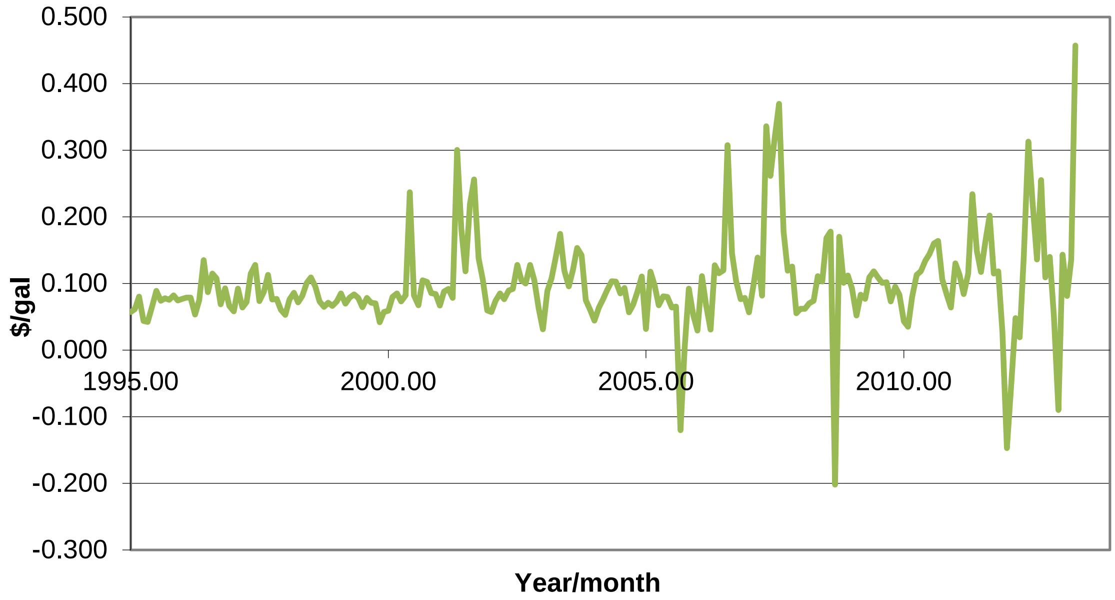


* Regression equation: $Cd = 0.00009823 + 0.08978\ d^{-1.0875}$ where Cd is the freight rate and d is distance. Adj-R^2=0.95

When examining the rail costs for ethanol in Table 5.1, they are generally about the same size as the ethanol price margin snapshot taken in May of 2012. In particular, costs are about equal to the price spread for Houston ($0.142 vs $0.158), Tampa ($0.164 vs $0.196), and Seattle ($0.237 vs $0.187). But costs are somewhat lower than spreads for New York ($0.128 vs $0.174), and Los Angeles ($0.189 vs $0.282). A complete rate-cost analysis would also consider back-hauls, contract rates, fuel surcharges, and destination terminal conditions. But the predictions of the rate-distance regression for actual rates to Houston, Seattle, and LA in table 5.1 are only slightly lower, 6.2 percent on average. Also, a more recent history of price spreads could be helpful. Overall, these rates and costs seem consistent with competitive arbitrage between the source and destination markets on railroads.

Comparisons between ethanol shipment costs by rail versus wholesale gasoline margins between the Midwest and the Gulf Coast also provide a rough idea of the competitiveness of a rail transport system for ethanol. First, the ethanol rail rate from Fairmont to Houston is $0.143 per gallon. Compare this to the difference between wholesale prices of regular gasoline in Iowa and on the U.S. Gulf (Figure 5.4). This margin reflects the cost of pipeline shipment in a competitive market. A gasoline pipeline margin of $0.10 per gallon was typical during the 2003-2009 period. However, the gasoline pipeline margin has become more variable and the average has increased to about $0.15 per gallon during the last 2 years. The ethanol freight rate and marketing margin for the Freemont to Houston route compares very favorably with marketing margins for gasoline moving in the opposite direction between similar locations. Second, in comparison to the pipeline study mentioned above, the Chicago-New York ethanol freight rate is less than one-half of the breakeven rate for a pipeline, underscoring the competitiveness of the rail system.

Figure 5.4. Gulf-Iowa wholesale gasoline price margin, 1/1995 -1/2013



Conclusions

Transportation is typically the third-highest expense to an ethanol producer—after feedstock and energy. Balancing transportation operating expenses with fixed infrastructure costs can be critical to sustained profitability for each ethanol plant. The rail transport system that has emerged after a decade appears to be performing well. Our evaluation suggests that ethanol rail rates are generally near costs. Furthermore, the rail freight charges for ethanol compare favorably to pipeline rates. So pipeline transportation of ethanol does not seem to be an urgent matter. Still, PADD 2-to-PADD 1 ethanol shipments of 4.3 billion gallons (BGYs) shown in Appendix Figure 1, clearly exceed the 2.9 BGY feasibility threshold mentioned earlier, suggesting another look at the feasibility of an ethanol pipeline.