# PRICES AND COSTS IN TRANSPORTATION:

## A CASE STUDY OF RAILROAD PRICING OF CORN SHIPMENTS UNDER PARTIAL DEREGULTION AND COMPETITIVE ALTERNATIVES†

by

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### ABSTRACT

Railroads have been federally regulated since 1887, but were partially deregulated in 1980 with passage of the Staggers Rail Act, which placed greater emphasis on the market to establish rail rates. Since this partial deregulation of the rail industry, there has been a massive consolidation of railroads, with the result that intramodal competition is essentially non-existent. However, there still remains significant competition from other modes of transportation, and from other options that shippers have. In this chapter, we examine pricing and costing using the example of how railroads charge corn shippers for movements from the Upper Midwest to the Gulf of Mexico. The prices railroads charge emanate directly from conditions of profit maximization and, hence, are a function of costs and competitive pressures. While we control for railroad competition, we find that railroad prices are constrained, in some locations, by the options that shippers have. These include: alternative modes of transportation, most commonly truck-barge, and the presence of alternative markets; i.e., ethanol locations. Both sources of competition have large and significant effects on railroad pricing. In particular, truck-barge competition lowers rail rates by as much as 13.9 percent, while ethanol markets reduce rates by about 8.4 percent.

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## 1. INTRODUCTION

Railroads have been regulated for over 100 years. Regulation covered the prices that railroads charged (price regulation) and the locations served (entry/exit regulation). The railroad network was largely developed in the 1800s, and continued until about 1920. In 1916, the railroad network was 254,000 miles (Gallamore (1999)). However, new modes of transportation, i.e., truck, barge and air, along with the development of new products which displaced traditional rail mainstays, e.g., plastics replaced metals, coupled with union work rules and diminished productivity, led to a market in financial ruin.[1] In the 1970s, these factors led to the bankruptcy of several major railroads, and ultimately passage of the Railroad Revitalization and Regulatory Reform Act of 1976 (the 4-R Act) and the Staggers Rail Act of 1980 (Gallamore (1999)).

These pieces of legislation reflect the growing concerns that government regulation can fail, and that the marketplace can amply substitute for direct regulation in many instances. Indeed, after partial deregulation, the jurisdiction of the Interstate Commerce Commission (ICC) was limited to markets in which the revenue to variable cost ratio exceeded 180 percent (Wilson (1996)). A ratio of greater than 180 percent allowed the regulatory body to consider the reasonableness of the rate.

A second major effect of the legislation was to reduce impediments to mergers. Indeed, since passage of the Staggers Rail Act of 1980, there has been an unprecedented reduction in the size of the US rail network held by the major railroads, along with a dramatic consolidation of firms through merger activity.[2] This has meant that many

[1] There are many studies of railroad regulation and deregulation. See Gallamore (1999), Wilson ((1994); 1996; and 1997), Wilson and Burton (2011), Winston et al. (1990) for excellent discussions.
[2] See Bitzan (1999), Wilson and Bitzan (2007) and Wilson and Burton (2011) for more details on this evolution.

shippers have fewer rail options available to them. That is, there are both a smaller number of major railroads and a much smaller network.

The smaller network and the smaller number of firms certainly points to greater market power. Competition is often considered in a given market. However, markets for transportation are not easily defined. In particular, transportation involves the movement of a large number of commodities over a network. The relevant market i.e., the market(s) priced by the railroad are origin-destination-commodity specific. Each product transported has a set of underlying supply and demand characteristics (upstream and downstream) and each node in the network has a set of underlying factors, e.g., the availability of other railroads and other modes. As such, the ability to price in excess of costs depends on the upstream and downstream characteristics of the product transported as well as the attributes of the originator and receiver of the commodity transported. These include ability of the shipper to receive the product from alternative destinations and/or to ship the product to alternative destinations; and the ability to use different railroads and/or modes.

The falling number of railroads and the smaller network (meaning that the distance to available rail alternatives is likely longer for most shippers) certainly point to greater market power, especially in locations where there is no available alternative railroad.[3] Yet, for many commodities, this increased market power may be offset by the

[3] The dispersion of prices over locations has a long history in the economics literature. Much of this research has been theoretical in nature (e.g., Holahan (1975); Greenhut and Greenhut (1975); Greenhut and Ohta (1979); Norman (1981); Hobbs (1986); Thisse and Vives (1988); Anderson and de Palma (1988); and Anderson, de Palma and Thisse (1989)). However, there are also several examples of empirical studies of prices and location including Greenhut (1981) who examines differences in prices across countries and Lindsey and West (1997) who look at the use of parking coupons. For a detailed survey of the spatial price discrimination literature, see Philips (1983), Greenhut, Norman and Hung (1987) and Varian (1989).

presence of alternative markets for goods shipped and/or other modes of which may serve to constrain rail pricing.

In this chapter, we examine railroad pricing of corn shipments. Corn is grown largely in the Midwest of the U.S. and is shipped to a wide variety of locations. Chiefly, movements travel from the Midwest to export ports, to nearby feedlot and processing plants, and to ethanol plants. Railroads may or may not face competition at a particular location from other railroads, but at each location, there are other options open to shippers, and these options may constrain rail prices. The effect of the rise of ethanol plants is an example. Prior to 1980, the ethanol market was non-existent. Over the course of the last thirty years and, most notably, since 2000, ethanol has grown to be a major alternative market for corn. Generally, ethanol plants, like feedlots plants, tend to be located in major production areas, which can be efficiency served by truck, while truck-barge shipments to the Gulf of Mexico offers sound alternatives to rail.[4]

In the context of corn shipments, we examine the effects of intramodal (other railroads), intermodal (truck-barge), and alternative markets (ethanol) on railroad pricing. There is a long history of related research from which much of the work follows. The idea that alternative modes constrain prices is intuitively obvious. The role of truck-barge is often termed "water compelled pricing". Empirically, water compelled pricing is a longstanding fact in railroad economics. MacDonald (1987; 1989) and Burton (1995) examine the effects of the waterway on railroad pricing.[5] Each of these studies uses the

[4] Dooley (2006) and Jessen (2006) both examine these relationships between ethanol and transportation, with Jessen focusing on the impact on rail transportation. Also, the USDA (2007) has looked into the impact of ethanol on the transportation industry, predicting large increases in the demand for rail transportation from the ethanol industry.

[5] Note that Wilson, Wilson and Koo (1988) look at the pricing of railroads with market power in the presence of the truck market as a competitive pressure.

ICC's Annual Rail Waybill data set.[6] MacDonald (1987; 1989) incorporates two measures of barge competition in the rail market including the distance between each originating point and the nearest waterway and a dummy variable for "port" locations that are less than a mile from the waterway. Using this specification, he finds that the rail rate charged increases as one moves away from the river.[7] He also finds that the rail rate is higher for "port" locations that are within one mile of the waterway.[8] Rather than using the distance from the waterway as a measure of barge competition, Burton (1995) includes a dummy variable for the availability of barge transportation. Applying this model to Waybill data from 1973-1987, Burton (1995) finds that the existence of barge as an alternative reduces the rail rate for food products, for non-metallic minerals, and for clay, concrete, glass and stone products. However, the effect of water is found to be statistically insignificant for coal, metallic ore, chemicals, and scrap materials.

Theoretically, Anderson and Wilson (2008) develop a model of specific interest to the present work. In their model, shippers are located over geographic space. They have an option to use truck-barge or rail to get goods to market. They assume that rail costs are higher than barge but lower than truck. Shippers have the option of using rail or truck-barge. They find that railroads price in order to "beat the competition" which happens "close to" the waterway. The present model is similar in the sense that railroads price in order to "beat the competition" but is general enough to capture service characteristics

[6] The Waybill data is a stratified sample of individual railroad shipments. There are different forms of the Waybill data, which are amply described in the Surface Transportation Board's website (http://stb.dot.gov). MacDonald (1987) uses the Waybill Sample Master while Burton (1995) uses the Waybill public file.
[7] MacDonald (1987) finds that rates for wheat shipments are 40% higher for a shipper located 400 miles from the river than for a shipper located 100 miles from the river. The estimated effect for corn and soybeans, while significant, are much smaller with a 1% increase in the distance from the water increasing revenue per ton-mile (rate) by 0.086 for both corn and soybeans, a result similar to that found in this study.
[8] Note that this finding could be indicating that the railroad is pricing a monopoly segment of an intermodal movement as is demonstrated by Burton and Wilson (2006).

(product differences) and adds an empirical application.

The research presented below follows the previous research closely, but differs in three major respects. First, we use posted rather than waybill records (the latter are a selected sample). Second, we fix the destination of the movements, but allow for the effects of alternative destinations for corn. Finally, and perhaps most importantly, we model non-rail competition from several markets by including a direct measure of modal options (truck-barge costs) rather than railroad distance to market, and we also include the capacity of ethanol producers within 100 miles of the origin as an alternative outlet for the corn shipment. This approach allows the responsiveness of rail prices to alternative modes/markets to be directly evaluated. Using rail-pricing data for corn shipments collected directly from the railroad websites, we then estimate the impact of barge competition and the existence of ethanol on rail rates, with our results indicating that both barge competition and ethanol production impact rail rates. Specifically, we find that waterway competition explains up to 13.9% of the difference in rail rates and ethanol production explaining an additional 8.4%. Given that shippers are most often using numerous rail cars in a given shipment, this translates into a $20,751.50 and $13,366.50 difference in shipping costs per fifty cars, attributable to differences in waterway competition and ethanol production, respectively.

Beyond the evaluation of the determinant of railroad pricing, the results are central to policy-makers. The results allow for the level and source of railroad prices across shippers which are necessary for evaluating reasonableness of the rate by the regulator. In addition, other agencies can use the results. In particular, the Army Corps of Engineers manage the nation's waterways. When they make an investment decision, they are mandated to examine the costs and benefits of the investment. Investments offer lower costs of barge transportation, but these lower costs may be offset by the response of railroads to the lower rates offered by barge.[9]

The remainder of this chapter is divided into four sections. Section 2 presents a conceptual model of rail pricing with competitive pressures from other modes of transportation and alternative markets. Section 3 then develops an empirical model stemming from this conceptual model and discusses the data used in this analysis. Section 4 presents the results of this study, while Section 5 offers concluding comments.

## 2. CONCEPTUAL MODEL

In general, shippers of any product use some combination of truck, rail and barge in order to get their products to market. The prices attached to movements and the mode used depends critically on the product, the distance to market, and the availability of options to the shipper. In serving a shipper, a transport firm must incur costs that are independent of distance; e.g., switching costs then move the product to its ultimate destination. Generally, these costs independent of distance tend to be higher for rail and barge than for truck. In contrast, the rate at which shipment costs change with distance tends to be lower for barge and rail than for truck. This gives rise to what Locklin (1972) terms the "tapering principle". That is, the rate attached to a shipment on a per volume unit (e.g., tons) increases at a decreasing rate with distance. This naturally gives rise to truckers handling short distance movements, while either rail or barge handle longer

[9] Note that many of these assumptions underlying the Army Corps' planning models have been called into question previously by the National Academy of Science (NRC 2001, 2004). These assumptions primarily focused on the shape of the demand function, the forecasting methods, etc. Historically, the models have used price inelastic demands to a threshold rate for the movement of a commodity from one location to another. Generally, the threshold is the rail rate and the models take the railroad price as given. The present research allows the response of railroad prices to changes in barge prices.

distance markets. However, truck also provides both the fastest method of transportation, which reduces inventory costs, and a mechanism through which shippers can access other, lower cost, modes of transportation. Because of these modal differences in the costs of transportation, most grain shipments going beyond the local markets use either rail or barge, with trucks commonly used to move commodities from off river locations to barge terminals on the inland waterway system or to rail terminals located some distance away. This reliance on the higher cost trucking industry has meant that the barge industry's ability to compete with rail depends on the distance between the origin location and the waterway; i.e., the truck distance of the truck-barge movement.

These cost differences across the different modes of transportation, along with the pricing freedom afforded by partial deregulation, give a railroad the ability to price shippers located at different points in their network differently. Specifically, each shipper has options whether from other railroads, other modes or from other markets which can serve to limit the price a railroad charges. Under partial deregulation, the number of railroads serving a location or serving nearby locations has dramatically fallen as a result of consolidation. To illustrate, the rail networks in the Upper Midwest are presented in Figures 1, 2 and 3. Figure 1 shows the network of Burlington Northern Santa Fe Railroad in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota and Wisconsin. Figure 2 illustrates Union Pacific Railroad's network in these same states, while Figure 3 shows the combined network of the five other Class 1 railroads in 2011.[10] Taking these three figures together, it becomes immediately obvious that

[10] Note that the five other Class 1 railroads included in Figure 3 (Norfolk Southern Railway; CSX Transportation; Kansas City Southern Railway; SOO Line Railroad, which is owned by Canadian Pacific Railway; and Grand Trunk Corporation, which is owned by Canadian National Railway) individually have

shippers located in certain areas are "captive" in the sense that the shippers have but one rail alternative. For example, shippers in large parts of North and South Dakota are only served by one Class I railroad, Burlington Northern Santa Fe.[11]

With competition from alternative railroads non-existent for many shippers, the only competitive pressures constraining a railroad's pricing power are the existence of intermodal competition from barge and/or truck-barge, and the presence of alternative markets for the commodity being shipped, which includes ethanol plants for shipments of corn in the Midwest. The railroad's objective is then to charge the highest rate possible at each location subject to procuring the shipment, i.e., subject to the shipper choosing rail as their mode of choice. As such, the conceptual model developed in the remainder of this section follows from Wilson (1996), which examines market dominance in regulating railroad rates.[12]

Following Wilson (1996), we focus on a shipper's profit maximizing decisions. A shipper typically has many destinations *(d)* to which it can ship a good and a variety of modal options *(m)*; e.g., rail, truck, truck-barge, barge, etc. Each of the modes offers different service attributes such as transit times, reliability, etc. Indeed, shippers can and often do ship by higher-priced modes favoring their faster or more reliable service. In the model development, the shipper chooses the profit-maximizing quantity shipped for each possible option then compares the maximum profit of each option to determine the specific shipment to make. These profits depend on the price received at the destination

much smaller networks within the states being examined; therefore, they are combined in Figure 3 to illustrate the areas in which at least one of these carriers can provide competition.

[11] While there are a number of regional and short-line railroads, these railroads typically interchange with the major railroads. The latter have the ability to extract the "monopoly" rate by pricing the interchanging railroad optimally, leaving no profit to the interchanging railroad.

[12] In some cases, it may be profitable for the shipper to choose a faster mode even though its rate is higher; e.g., contractual obligations.

($P_d$) the freight rate ($r_{md}$) and the attributes of the mode that is chosen to make the shipment. The actual quantity shipped mandates that it is the profit-maximizing quantity attached to the option (destination-mode).

Given this framework, the railroad must price to be the preferred option, and there are limits to its pricing behavior. That is, the railroad takes the shipper demand function and the shipper's options as given. It chooses the profit-maximizing price ($r_{Rd}$) subject to the constraint that it remains the preferred option; i.e., if it prices too high, the shipper switches to an alternative option and demand is zero. Let $X_{Rd}(P_D, r_{Rd})$ be the shipper's demand function given it ships by rail ($R$) to a given destination ($d$). This demand function is non-zero so long as it is the preferred option of the shipper compared to all other modes; i.e., in terms of shipper profit ($\pi$), $\pi_{Rd} \geq \pi_i$. The railroad takes these as given and then chooses the rate to charge the shipper for movements to $d$ by rail. More formally, it is a constrained profit maximization problem given as:

$$\text{Max}_{r_{Rd}}\, \pi = r_{Rd} X_{Rd}(P_d, r_{Rd}) - C(X_{Rd}(P_d, r_{Rd})) \qquad (1)$$
$$s.t.\, \pi_{Rd} \geq \pi_i, \forall\, i \neq Rd$$

Where $X_{Rd}(P_d\,, r_{md})$ is the demand for rail service to market $d$, making $r_{Rd}X_{Rd}(P_d\,, r_{md})$ the railroad's revenue associated with charging rate $r_{Rd}$, and $C(X_{Rd}(P_d\,, r_{Rd}))$ is the railroad's cost associated quantity $X$ which depends on the choice variable (i.e., the rail rate) and so is written as a function of the rail rate $r_{Rd}$. This formulation has the typical profit maximization objective function. But, it also has an explicit constraint that it is the preferred option of the shipper. Of course, if the railroad prices its service too high it prices itself out of the market. Therefore, the options that shippers have can temper the pricing behavior of the railroad.

From this setup, the MR=MC condition for profit-maximization results. In this case, MR is directly affected by the alternatives shippers have and their effectiveness. Specifically, the condition can be written as:[13]

$$\frac{r_{Rd} - MC}{r_{Rd}} = \frac{(\lambda - 1)}{\varepsilon} \qquad (2)$$

Where ε is the price elasticity of the demand for railroad service, and λ reflects the constraint on railroad pricing from the presence of shipper alternatives. Technically, it reflects the difference in profits between shipper alternatives and railroad cost dominated traffic.[14] The left-hand side of equation (2) represents the difference between the rail rate and marginal cost, which is by definition the Lerner Index of market performance. There are a number of special cases in equation (2). First, if the constraints on railroad pricing are not binding (i.e., $\lambda = 0$) then equation (2) gives the usual monopoly markups -- there are not constraints on railroad pricing. Second, if $\lambda = 1$, the railroad prices at marginal costs. And, third, if $0<\lambda< 1$ then the railroad provides the service, but at a price somewhere between marginal cost and the monopoly price. More generally, the railroad's profit maximizing rate, $r^*$, is a function of the restrictiveness of the constraint that the railroad's rate be low enough to procure the shipment, λ. Put another way, the railroad's profit maximizing rate deviates from marginal cost pricing by a "markup" which reflects constrained market dominance as defined by Wilson (1996).[15] Rearranging equation (2), this markup can be seen more directly as:

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[13] See Wilson (1996) for a more detailed exposition of the mathematical derivation of the first order conditions. The lambda (λ) is the Lagrangian multiplier attached to the constraint that the railroad is the preferred option. It is bounded by 0 and 1.

[14] Note that this model requires that the railroad is the low-cost mode, i.e., the cost of the railroad is lower than the cost of trucking firms, barge, truck-barge, etc. Hence, if railroads are not the low cost mode, and the other modes have competitive prices, railroads cannot compete *even at marginal cost*. In such cases, railroad movements are not observed.

[15] Note that Wilson (1996) used this model to assess the Interstate Commerce Commission's market dominance rules. These rules stated that the reasonableness of a railroad's rate for a given movement could only be considered if the rate charged by a railroad was first found to be market dominant.

$$\log\ (r_R) = \log\ (MC) - \log (markup) \tag{3}$$

Where *markup* = $f(\lambda\ , \varepsilon)$. Note that the markup term, representing the level of market dominance, is measured by λ, and depends critically on the spatial environment of these shipping alternatives. In particular, for shippers with attractive options in the sense that the prices that railroads charge are constrained (i.e., they are located near a waterway, ethanol plants, or are shippers who have alternative modes of transportation available) the railroad must lower its rate in order to procure the traffic. As these alternatives become less competitive, the attractiveness of each alternative relative to rail service dissipates and the railroad gains greater pricing power. Therefore, the test stemming from this theory is whether the railroad's pricing decision varies with the restrictiveness of competitive pressures. If so, one would expect the railroad to have market dominance at locations where there are fewer competitive options available.

## 3. DATA AND EMPRICICAL MODEL

The data used for this analysis originate from warehouse locations identified by the Farm Service Agency (FSA).[16] In particular, a random sample of locations in corn producing states that are either first or second degree contiguous to the Mississippi River System is drawn from the universe of warehouses listed by the FSA.[17] These warehouses are shown in Figure 4, and contain observations in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

Using the warehouses in Figure 4 as the origin, rail rates for the shipment of corn are collected between each location and the Gulf Coast.[18] These rail rates are collected directly from the railroads via their websites, which allow for the query of rail rates given an origin and destination. Along with reporting the rate for the shipment in question, information is also reported about the length (in miles) of the movement on the railroad's network and how the rate varies based on the quantity shipped. All available rates were collected for each location, meaning that each origin may have multiple rates based on volume discounts and/or destination.[19]

In addition to the cost variables provided by the railroad itself, railroad markup variables are also collected in order to empirically estimate equation (3). These markup

[16] The Secretary of Agriculture licenses all warehouse operators who store agricultural products according to the U.S. Warehouse Act. Therefore, the raw data used for this analysis should include all warehouses used to store/ship agricultural commodities.

[17] Note that our random sample is over warehouses in towns with less than 10,000 people. This is done because in larger towns there will be more demand for rail traffic from non-agricultural shippers, and we want to isolate the impact of competitive pressures on pricing for corn shipments.

[18] Because of network differences, some rail providers are capable of shipping to the Gulf Coast but not New Orleans, LA. Therefore, some of the rail rates are to Mobile, AL or Houston, TX instead of New Orleans, LA.

[19] Many rail movements are transported by shuttle trains which are shipments of more than 100 cars that meet railroad requirements. The U.S. Department of Agriculture's (USDA) weekly Grain Transportation Report contains information on shuttle train rates versus unit train rates. In comparing the shuttle train rates contained in these reports with the rates collected for this study, the shuttle train rates are similar, but always below the unit train rates collected here; however, there is little variation in the difference across origin/destination combinations.

variables are intended to capture the competitive pressures present at the origin location of a shipment. As such, we include variables that capture both modal competition, and alternative markets for the crop being shipped near the originating location. Of primary importance to this chapter is the truck-barge alternative that rail competes with for long distance shipments. To control for competition from truck-barge, we use Geographic Information Software (GIS) to determine the truck and barge shipment lengths, and then use the U.S. Department of Agriculture's Grain Marketing Reports and the barge tariff rates to extrapolate the cost of trucking the shipment to the nearest barge loading facility and then shipping the commodity to the Gulf Coast via barge.[20] In addition, the warehouse data from the FSA states whether the warehouse has direct waterway access, meaning that it is located on the river system, in which case the barge alternative would have a dramatic constraining effect on rail rates. As such, we also include a dummy variable equal to one for any origins with direct barge access. Other than competition from the barge industry, the railroad also faces competition from other railroads, which is controlled for by including a dummy variable equal to one if the warehouse is served by more than one railroad.

The remaining markup variables are geared towards capturing the alternative markets available for corn shipments in the spatial vicinity of the shipper. In particular, we collect data on the capacity of ethanol plants as reported by the U.S. Department of Energy and shown in Figure 5. We then aggregate up the capacity of all ethanol plants within 100 miles of each warehouse as these plants serve as an alternative destination for corn shipments, and one that could potentially be served by truck transportation. Finally,

[20] It is noted, that virtually without exception, when corn "hits the water" it stays on the water to export elevators near New Orleans. See Boyer and Wilson (2004; 2005).

we also include the geographic distance from each warehouse to the nearest corn processing plant, regardless of distance, as this is yet another alternative destination for the commodity that could potentially be served by truck transportation.[21]

Using these data, the empirical model follows directly from equation (1), where the demand for rail transportation, and the subsequent price charged by railroad companies, is a function of cost characteristics of the shipment, and markup variables. We specify this model with a logarithmic form as:

$$\log\ (Rate\ Per\ \ Ton\text{-}Mile) = f(Cost\ Variables\ ,\ Markup\ Variables) \qquad (4)$$

The dependent variable for this analysis is the rail rate per ton-mile shipped for firm i to destination j by carrier k, measured in dollars.[22] Cost measures for each firm include: the *capacity* (measured in log tons) of the shipment, the *distance* (measured in log miles) of the shipment and whether the shipment is part of a *unit train* or not.[23] It is assumed that increases in *capacity* lower the rail rate per ton-mile as larger shipments have a minimal effect on the railroad's costs given that it is already moving between two points. Increases in shipment *distance* are assumed to decrease the rail rate per car mile, as a large share of the firm's costs is directly related to the distance being traveled. Finally, movements by unit train are assumed to decrease the rate per car, all else equal.[24]

Following the theory developed in the previous section, there are a number of

[21] We use the distance to the nearest corn processing plant, regardless of distance, because these plants procure a great deal of corn every year, and we want to capture the overall competitiveness of this alternative.
[22] We also ran this regression using the actual rate per car, and the results presented here are unchanged with this difference. In addition, we note that these corn shipments going onto the river are coming from different states and entering the waterway network on different rivers.
[23] These cost measures are common to this literature, and MacDonald (1987) has a detailed discussion regarding the expected signs of these cost measures. The rail rates collected from each railroad company vary based on the quantity being shipped. Capacity in this study is measured as the average quantity that can be shipped at the given rate.
[24] A unit train is a shipment of a set amount of cars where one shipper uses all of the cars in the train rather than multiple shippers each using portions of the train.

potential variables that should act to reduce rail rates and each represents a potential constraint on the pricing power of the railroad. We expect that larger values of *truck-barge costs* increase the rail rate per ton-mile, as this variable measures the potential competition from the barge industry. Larger values of this variable point to shipper locations that are farther from the waterway system, and, therefore, face higher costs to get their shipments to a barge loading facility. Likewise, *direct barge access* is expected to negatively impact rail rates as origins with the capability of loading directly onto the waterway system represent a significant constraint on rail pricing. In addition to waterway competition to rail service, alternative railroads can also constrain rail prices. We measure this effect with a dummy variable that represents two cases. If a shipper has access to an alternative railroad, this variable takes a value of one, whereas if there is no alternative railroad, this variable takes a value of zero. Of course, it is expected that the existence of another *railroad alternative* may be a constraint on the rate another charges, and so, this variable should have a negative effect.

In addition to the rate constraining forces of inter- and intramodal competition, alternative markets for corn, which can be served by truck in a more cost effective manner also represent potential constraints on a railroad's pricing power. In particular, the emerging ethanol industry offers corn shippers an alternative destination for their product which should lower the rail price charged in areas with such plants as the railroad must compete with these facilities to procure the shipment. To measure this impact, we include the *capacity of ethanol plants within 100 miles* of the origin location as another markup variable in equation (4).[25] Finally, we note that the large corn processing plants in the Midwest are another alternative destination for corn shipments that can be serviced by truck transportation. Therefore, it is expected that increases in *distance to nearest corn processing plant* increases the rail rate charged as greater distances from the origin to one of these plants reduce the constraining power of these locations.

The mean values for each of the variables included in equation (4) are presented in Table 1. In addition, Table 1 shows the mean values for these variables for the 25% of the observations with the highest truck-barge costs and the 25% of the observations with the lowest truck-barge costs. Focusing on these two groupings of shippers, it is noted that the mean rail rate per car differential is $454.61 or a 15.6% difference from the high rate over the low rate.

## 4. RESULTS

The results of estimating equation (4) via ordinary least squares (OLS) are presented in three subsections. In the first subsection, the results on the impact of the cost parameters on rail rates is examined, while the second subsection focuses on the impact of the modal competitive pressure variables, and the third subsection examines the impact of the alternative market competitive pressures on rail rates.

### *The Impact of Costs on Rail Rates*

Table 2 presents the results of estimating equation (4) with only the cost parameters in column 1; with cost parameters and modal competitive pressure variables in column 2; and cost parameters with all competitive pressure variables in column 3.

[25] Ethanol capacity was collected in twenty mile increments extending out 200 miles from the origin facility. We use the 100 mile measure because corn must be transported to the ethanol facilities, usually by truck, and the cost of transporting the corn more than 100 miles may make the shipper unlikely to choose this option. See Dooley (2006) for a thorough discussion of the catchment areas of ethanol facilities.

The results are presented in this way in order to discuss the stability of our estimates across all three specifications. However, it should be pointed out that the results are very stable across all three specifications, and the added competitive pressure variables are generally statistically significant, causing us to focus most of our attention on the full model presented in column 3. Examining the estimated coefficients of the cost parameters in Table 2, we find that these results are robust to all three alternative specifications. In particular, the estimates on the impact of *capacity*, *distance* and the *unit train* dummy variable are all statistically significant, each having the aforementioned expected sign. Larger shipments, i.e., higher *capacity*, lead to a reduction in rail rates, as the increased cost to the railroad already offering the service from the origin to the destination from an additional ton shipped is minimal. In particular, a 1% increase in capacity leads to a 0.043 to 0.044 percent decrease in the rail rate per ton-mile, as coefficients on the logged value of variables, when the dependent variable is also in logarithmic form, measure elasticities. The results presented in Table 2 also indicate that increases in the *distance* of the shipment decrease rail rates per ton-mile, with a 1% increase in the distance of the shipment decreasing rates by 0.412 to 0.499 percent. Similarly, sending a shipment as part of a unit train is found to reduce the rail rate per ton-mile. In all, these results indicate that the cost characteristics of a given shipment including the size and distance of the shipment influence the rail rates charged per ton-mile as predicted in the market dominance theoretical model developed previously.

***The Impact of Modal Competition on Rail Rates***

In addition to the cost variables impacting rail rates, we showed in section 2 that the presence of competition for the railroad, regardless of its source, acts to potentially constrain rail rates. One form of such competitive pressure is modal competition from alternative transportation, which could mean an alternative mode of transportation entirely, such as barge transportation, or could mean alternative railroads competing for the same shipment.

While Figures 1, 2 and 3 indicate that many shippers have little to no alternative railroads available at their location, making them captive to only one railroad servicing their area, there are other locations that have multiple class 1 railroads available to handle their shipments. As such, we included a dummy variable in estimating equation (4) to capture this effect. Focusing on columns 2 and 3 in Table 2, it is shown that the estimated impact of rail competition--- while negative indicating that the presence of rail competition reduces rail rates--- is statistically insignificant.[26]

With a lack of constraining pressure from alternative railroads following the post-deregulation merger activity, the presence of truck-barge competition is likely the only alternative mode of transportation available to many shippers. As such, we previously showed how this alternative form of transportation may act as a constraint on the ability of a railroad to price shippers asymmetrically over geographic space. Our results presented in Table 2 support this hypothesis, indicating that a 1% increase in the *truck-barge cost* results in a 0.094 to 0.130 percent increase in the rail rate per ton-mile. Figure 6 illustrates this impact by showing the predicted rail rates per ton-mile over different truck-barge costs observed in the data at the mean values of all of the other explanatory variables. Note that this result implies that as shippers are located farther from the waterway system, the railroad price markup over marginal cost increases because the

[26] The statistical insignificance of this result is not surprising given that the mergers following the passage of the Staggers Act have left most shippers captive, with no rail alternatives.

shippers are not able to leverage truck-barge competition into a constraining factor on rail rates. In addition to the impact of the truck-barge alternative on rail rates, we also included a dummy variable for warehouse locations with direct barge access. The estimated coefficients on this variable in Table 2 indicate that these locations receive even lower rail rates, as barge is a highly competitive option for the shippers at these locations since they can avoid the higher cost truck rates while getting their crops onto the river system.

While the ability of the truck-barge alternative to constrain rail rates per ton-mile may seem economically insignificant, Table 3 shows how sizable these impacts are across the various corn shipping origin locations in the Midwest. In particular, differences in *truck-barge costs* account for up to a 13.9% difference in rail rates, which equates to a $415.03 per car cost difference. Since the average shipment size in the data is 50 cars, this implies a $20,751.50 difference in shipping costs attributable to differences in *truck-barge costs*. This result also calls into question the aforementioned assumption of rail rates being exogenous to barge pricing within the cost-benefit models being used to assess the impact of waterway infrastructure improvements.

***The Impact of Alternative Markets on Rail Rates***

While inter- and intramodal competition is a competitive constraint on rail pricing, it is also noted that shippers of corn have alternative markets to which they can send their crops. In particular, the emergence of the ethanol industry, and the existence of large grain processing plants offer these shippers alternative destinations for their commodities; destinations that can potentially be served by truck over short distances. As such, each of these markets offers a non-transportation constraint on railroad pricing.

To account for the emergence of the ethanol industry, we included the *ethanol capacity within 100 miles* of each location in equation (4). Our estimates on this variable presented in Table 2 indicate that ethanol does serve as a constraint on rail pricing, with a 1% increase in the ethanol capacity (within 100 miles) being associated with a 0.012% decrease in rail rates per ton-mile. Table 3 shows the economic significance of this result, as differences in *ethanol capacity* cause a 8.4% difference in rail rates which accounts for a $267.33 difference in shipping costs per car, or a $13,366.50 difference in shipping costs for a shipment of 50 cars. This result implies that the dramatic expansion of ethanol capacity in the Midwest, as predicted by USDA (2007), will put downward pressure on rail rates in this region, as the railroads need to compete with these ethanol facilities for corn.

Finally, we included the distance to the nearest corn processing plant in equation (4) to control for the existence of large grain processing plants which can serve as an alternative destination for corn shipments in much the same way as ethanol plants can. However, our estimates in Table 2 indicate that while the coefficient is positive, indicating that shippers located farther away from these plants receive higher rates since the plants are less competitive with rail, the estimates are statistically insignificant.

## 5. CONCLUSION

The focus of this study is on the ability of railroads to spatially price discriminate under different competitive pressures, most notably, truck-barge competition, and the existence of ethanol facilities as an alternative destination for corn. Using rail pricing data for corn shipments originating from a random sample of warehouse locations that are either first or second degree contiguous to the Mississippi River System, we find that increased barge competition leads to a decrease in the rail rate per car. In particular, differences in truck-barge costs are shown to cause rail rates to vary by 13.9%, which amounts to a $20,751.50 increase in revenues for a 50-railcar shipment accruing to the railroad because of their ability to spatially price discriminate. This result also calls into question the assumptions behind current benefit estimation models for waterway improvements. These models typically assume that the barge market and the rail market are independent rather than interdependent; an assumption that this study directly contradicts.

We were also able to estimate the impact of the emerging ethanol industry on rail prices, with our results indicating that ethanol acts as another constraint on railroad pricing. In particular, differences in ethanol capacity are shown to cause a 8.4% difference in rail rates. Over a 50-railcar shipment, this implies cost differences to shippers of $13,366.50. This result is of particular importance given the current sentiment towards increasing ethanol production across the U.S. as projected by the USDA.

Taken together, these results imply that, following the deregulation of the railroad industry and the subsequent merger activity, shippers who have a higher degree of “captivity” as measured by the availability of truck-barge transportation and the amount of local ethanol production, face significantly higher rail rates. However, a useful extension to this present study for policy makers would be to examine the interaction between barge and rail for other commodities.

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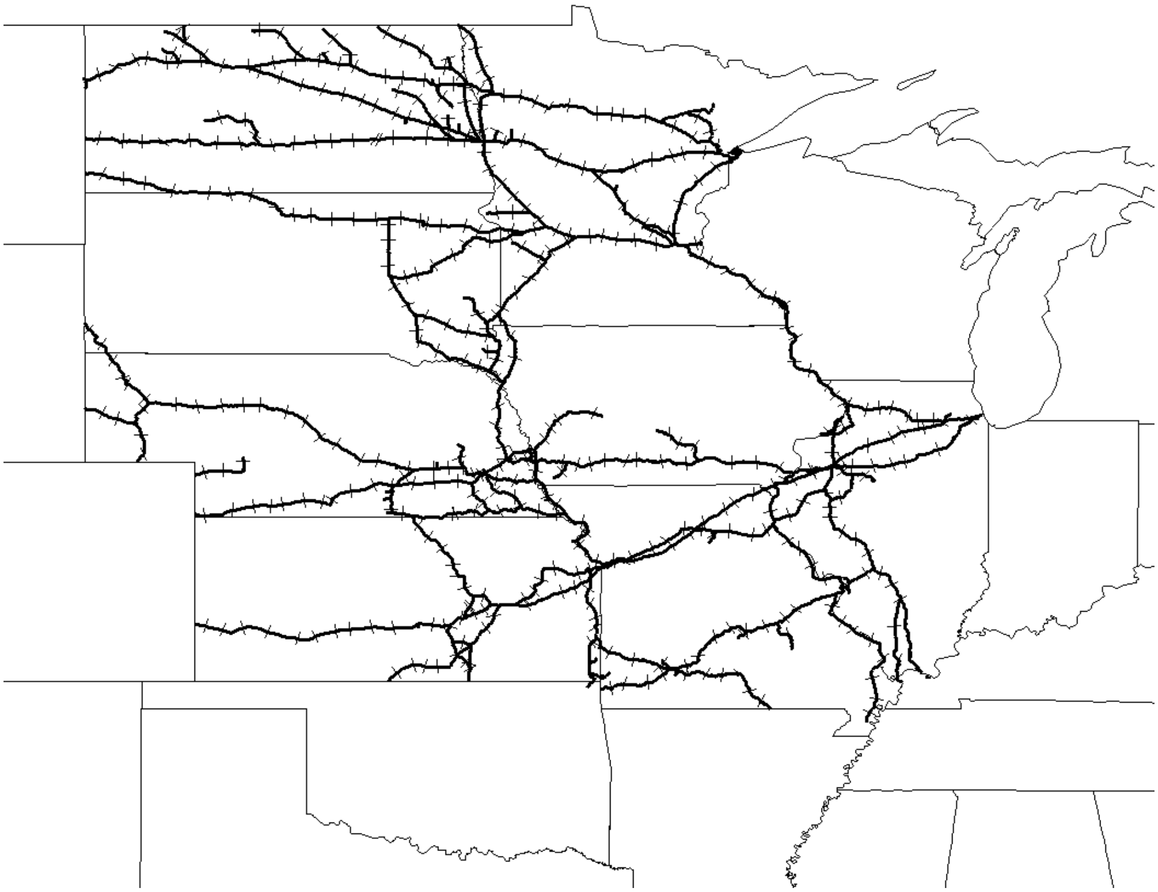

**FIGURE 1: Burlington Northern Santa Fe Railroad's 2011 Network in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota and Wisconsin**

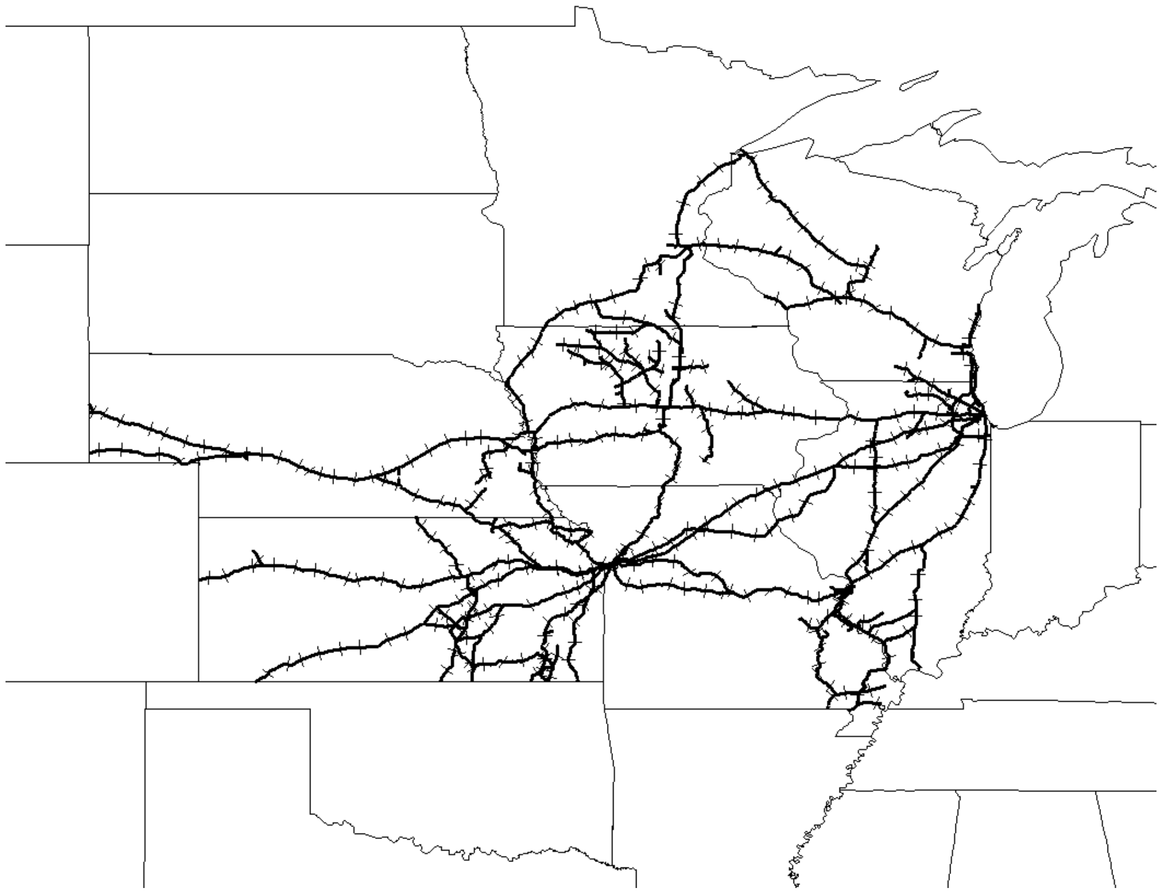

**FIGURE 2: Union Pacific Railroad's 2011 Network in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota and Wisconsin**

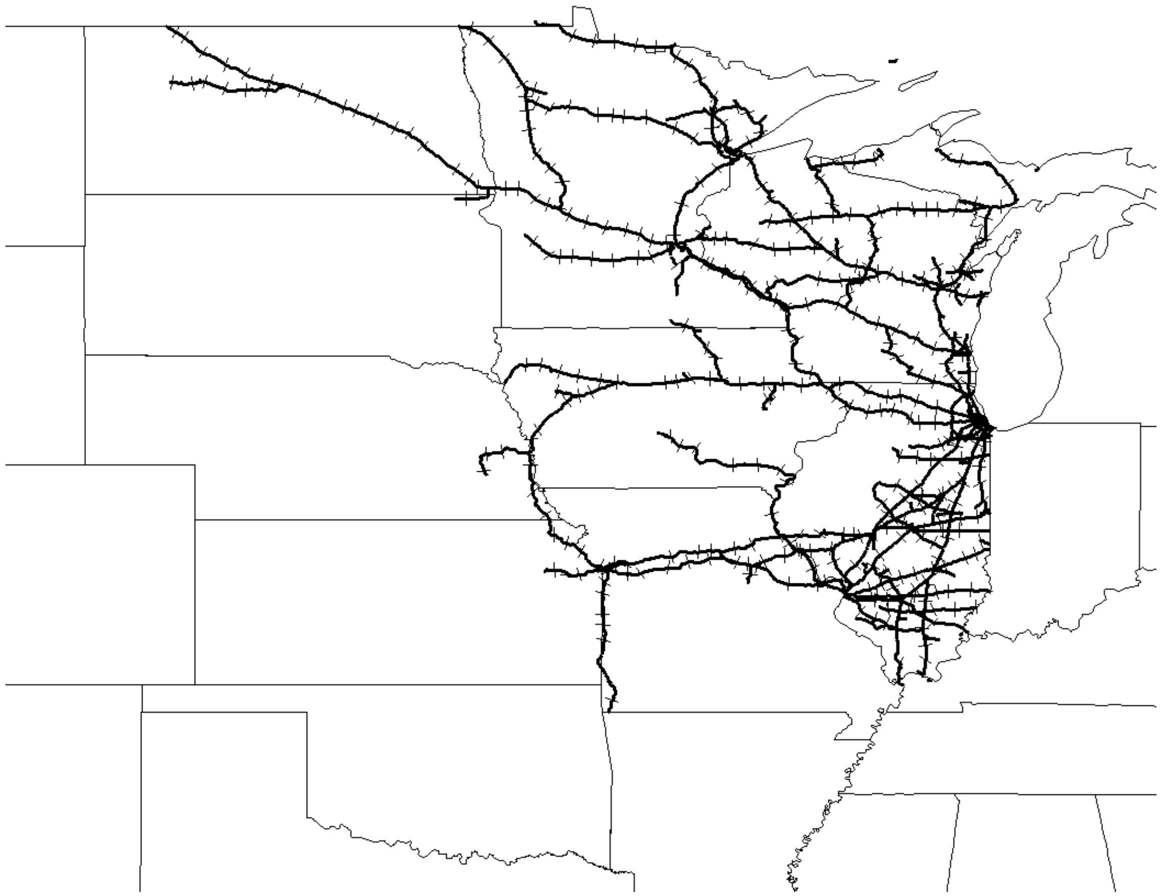

**FIGURE 3: 2011 Rail Network of Five Other Class 1 Railroads in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota and Wisconsin**

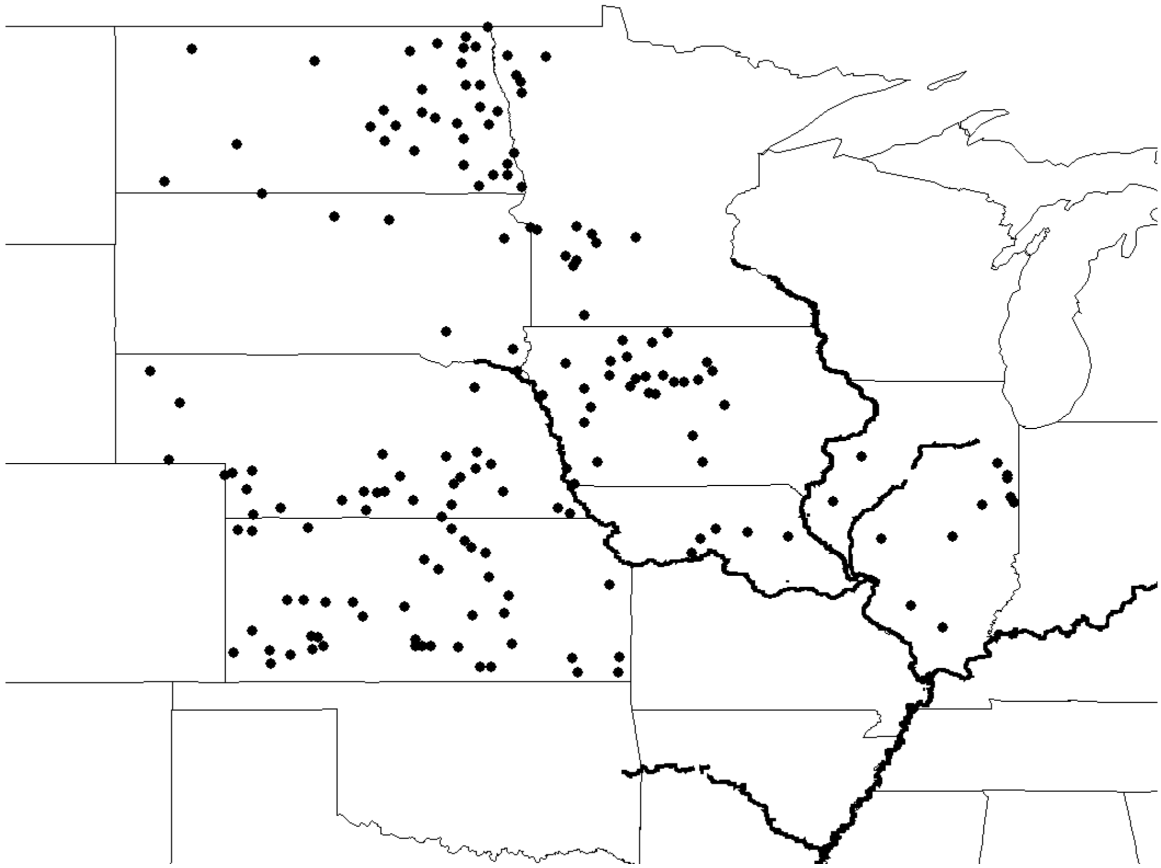

**FIGURE 4: Locations of Farm Service Agency Warehouses Used to Collect Rail Pricing Information**

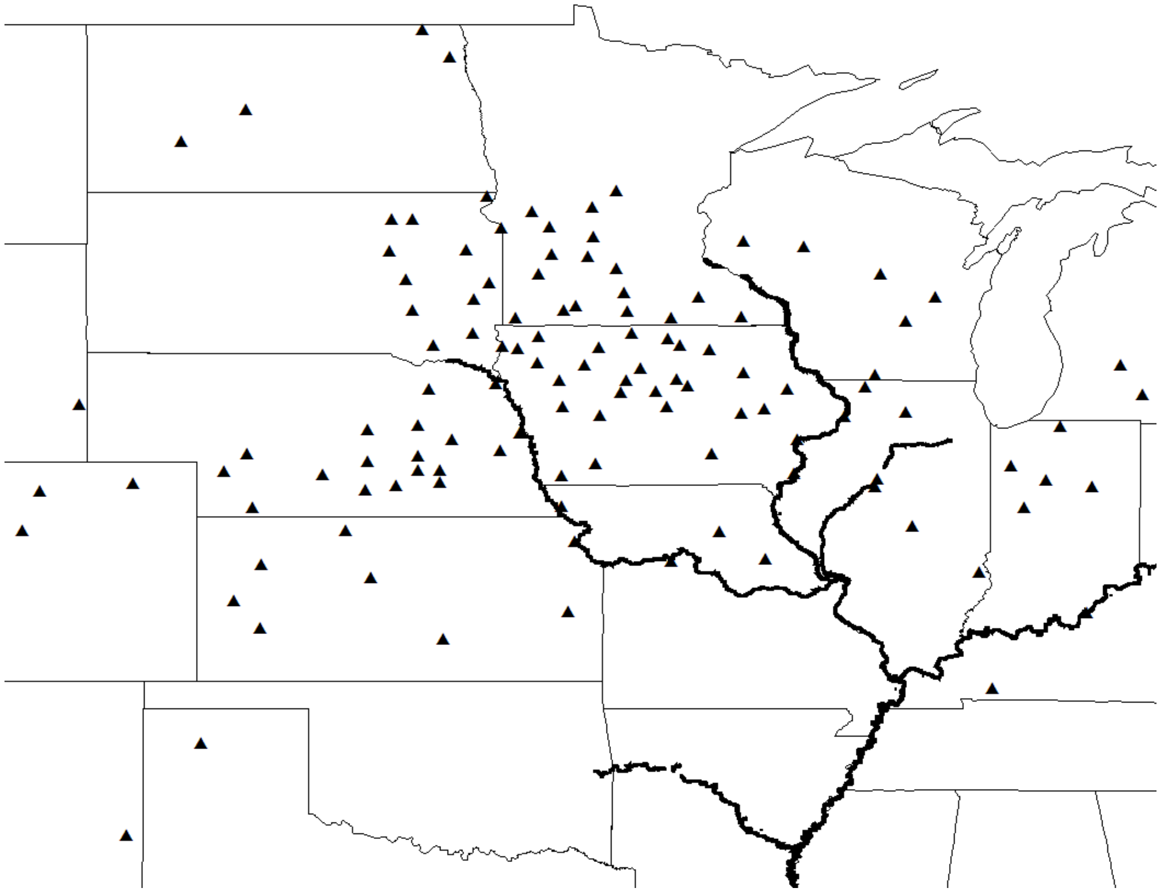

**FIGURE 5: Ethanol Plant Locations**

**Table 1: Summary Statistics**

| Variables | Mean | Mean (25% of Locations with Lowest Truck-Barge Cost) | Mean (25% of Locations with Highest Truck-Barge Cost) |
|---|---|---|---|
| Rail Rate Per Car | $3,277.55 | $2,907.11 | $3,361.72 |
| Rail Revenue Per Ton-Mile | $0.027 | $0.026 | $0.028 |
| Distance of Shipment (measured in miles) | 1,414.15 | 1,229.32 | 1,363.93 |
| Capacity of Shipment (measured in tons) | 7,056.32 | 7,787.45 | 6,751.39 |
| Rail Alternatives (equal to one if another railroad serves the same location, and zero otherwise) | 0.073 | 0.047 | 0.083 |
| Truck-Barge Cost Per Ton-Mile | $0.048 | $0.032 | $0.063 |
| Direct Barge Access (equal to one if the origin location has the on-site capability of loading onto the waterway, and zero otherwise) | 0.004 | 0.015 | 0.000 |
| Ethanol Capacity within 100 Miles (measured in millions of gallons per year) | 263.51 | 508.67 | 124.98 |
| Distance to Nearest Corn Processing Plant (measured in miles) | 134.90 | 77.52 | 236.41 |

**TABLE 2: Revenue Per Ton Mile Rail Rate Regression Results**

| | Cost Parameters | Cost Parameters & Modal Competitive Pressure Variables | Cost Parameters & All Competitive Pressure Variables |
|---|---|---|---|
| Log Capacity | -0.044*** | -0.044*** | -0.043*** |
| | (0.008) | (0.007) | (0.007) |
| Log Distance | -0.412*** | -0.479*** | -0.499*** |
| | (0.022) | (0.022) | (0.024) |
| Unit Train | -0.128*** | -0.095** | -0.117*** |
| | (0.041) | (0.039) | (0.039) |
| Rail Alternatives | | -0.026 | -0.011 |
| | | (0.020) | (0.021) |
| Log Truck-Barge Cost | | 0.130*** | 0.094*** |
| | | (0.021) | (0.026) |
| Direct Barge Access | | -0.528*** | -0.599*** |
| | | (0.086) | (0.087) |
| Log Ethanol Capacity | | | -0.012*** |
| | | | (0.004) |
| Distance to Nearest Corn Processing Plant | | | 0.004 |
| | | | (0.101) |
| Constant | -0.293 | 0.596*** | 0.659** |
| | (0.180) | (0.197) | (0.256) |
| R-Squared | .41 | .50 | .52 |
| Observations | 519 | 519 | 519 |

(.) contain standard errors. A * indicates significance at the 10% level, a ** indicates significance at the 5% level and a *** indicates significance at the 1% level.

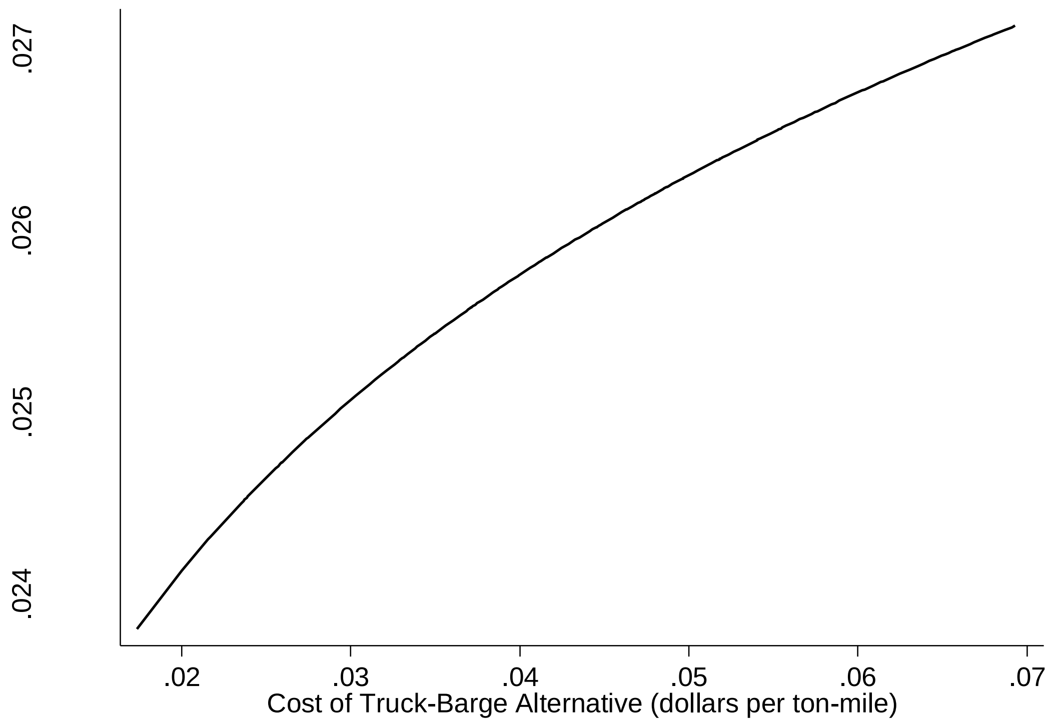


**FIGURE 6: The Predicted Impact of the Truck-Barge Alternative on the Rail Rates**

**TABLE 3: Impact of Competitive Pressures on Rail Rates**

| | Percentage Impact | Dollar Impact Per Rail Car | Dollar Cost Impact for 50 Rail Car Shipments |
|---|---|---|---|
| ***Modal Competition*** | | | |
| Rail Competition | No Effect | No Effect | No Effect |
| Truck-Barge Competition | 13.9% | $415.03 | $20,751.50 |
| ***Alternative Market Competition*** | | | |
| Ethanol Competition | 8.4% | $267.33 | $13,366.50 |
| Corn Processing Plant Competition | No Effect | No Effect | No Effect |