RAILROAD PRICING, MARKET POWER

AND

COMPETITIVE ALTERNATIVES OVER SPACE†

by

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ABSTRACT

Railroads produce with a network technology and serve a wide range of shippers (originator or receivers) by hauling a myriad of different commodities from a vast number of locations to other locations. Most of the movements are provided by one railroad, and shippers located over space may not have many other railway options. While for some movements, other modes may be an option, for the vast majority of rail movements, railroads have a cost advantage over alternative modes. In this study, we develop and estimate a model of railroad pricing wherein prices are determined by costs and competitive alternatives of shippers. The model is applied to the pricing of corn movements from locations in the Upper Midwest to the Gulf of Mexico. Originating shippers are located over space, and the set and effectiveness of competitive options varies considerably over space. We parameterize both costs and competitive options and find that the increase in corn based ethanol markets along with truck-barge rates have a commanding influence on railroad rates constrain rail rates by 7.4 and 10.1 percent, respectively.

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1. INTRODUCTION

In most modeling of markets, prices are established by the level of costs, demand, and some assumption of market rivalry. In this paper, we follow this same convention, but focus on the options of demanders. Specifically, we model a network technology wherein the firm (the railroad) prices transportation for the movement of a myriad of goods from one location to another. Demanders (shippers) have options and embedded in the demand for transportation by rail at each point are the options of shippers (receivers or originators). Empirically, railroads have a set of well identified cost determinants, but serve a wide variety of demanders over a network, each of whom have limited options in shipping or receiving their product. Indeed, most shippers have only one rail firm, which is often the low cost firm. However, most shippers can sell to (or receive from) a multiplicity of different markets, and with higher costs, they may be able to access other modes comprised of other railroads, truck, barges, ocean vessels or some combination. Since shippers ship different commodities and are located (generally) at different points in space, different patterns of prices result not only from differences in observed cost variables but also differences in the options that shippers have. We develop our model in terms of costs and the options of shippers over space, and apply the model to an analysis of corn rates to the Gulf of Mexico.

After 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. Hence, not only are there fewer options available to shippers (in the case of mergers that reduce the rail options at a point) there are also fewer options in the neighborhood of the shippers.

Railroads may or may not face competition at a point from other railroads, but at each point there are options open to shippers. In the corn market, there are two major options considered. First, the use of corn to produce ethanol in the Midwest states has resulted in a new destination market for corn, one which can be served by either rail or truck.[1] Second, the inland waterway system is a major source of competition for railroads for the shippers close enough to economically viable waterways. While there are previous studies that have studied "water compelled" rail rates, these studies typically use distance from waterway. Instead, we use a constructed measure of truck-barge prices to measure the effect. This is important in that it provides a monetized metric to measure the effect of truck-barge competition, which may be of use in studies of the benefits of infrastructure investment.

There are no studies, to our knowledge, of the effects of ethanol markets on railroad prices. The results provide strong evidence that both ethanol and waterway competition provides railroads' with pricing constraints, and that these vary over space. Specifically, rail rates are found to be lower in areas with high ethanol production, as ethanol facilities represent an alternative destination for corn. In addition, rail rates are shown to be higher in areas with high costs to using the waterway as an alternative mode of transportation, indicating that improvements to the inland waterway infrastructure would put downward pressure on rail rates.

Spatial price discrimination of this sort has a long history in the economics literature. While much of this research has been theoretical in nature (e.g. Holahan

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[1] 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.

(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)), there are also several examples of empirical spatial price discrimination including Greenhut (1981) who examines differences in spatial price discrimination across counties and Lindsey and West (1997) who look at the use of parking coupons.[2]

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 to "beat the competition" which happens "close to" the waterway. The present model is similar in the sense that that railroads price to "beat the competition" but is general enough to capture service characteristics (product differences) and adds an empirical application.

Empirically, water compelled pricing is a long standing fact in railroad economics. MacDonald (1987; 1989) and Burton (1995) each examine the effects or the waterway on railroad pricing.[3] Each of these studies uses the ICC's Annual Rail Waybill data set.[4] 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

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[2] For a detailed survey of the spatial price discrimination literature, see Philips (1983), Greenhut, Norman and Hung (1987) or Varian (1989).

[3] 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.

[4] MacDonald (1987) uses the Waybill Sample Master while Burton (1995) uses the Waybill public file.

moves away from the river.[5] He also finds that the rail rate is higher for "port" locations located within one mile of the waterway.[6] 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 insignificant for coal, metallic ore, chemicals, and scrap materials.

In the present application, theoretically, we combine the Wilson (1998) model of market dominance with the implications from Anderson and Wilson (2008) to frame an empirical application not unlike that of MacDonald (1987; 1989) and Burton (1993). But to the latter, we make a variety of contributions. 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 have a direct measure of model options (truck-barge costs) rather than railroad distance to market. This allows the responsiveness of rail prices to alternative mode prices 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. Using these data, we find that both barge competition and ethanol production impact rail rates, with waterway

[5] 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 tonmile (rate) by .086 for both corn and soybeans, a result similar to that found in this study.

[6] 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).

competition explaining 10.1% of the difference in rail rates and ethanol production explaining an additional 7.4%. Given that shippers are most often using numerous rail cars in a given shipment, this translates to a $15,739.50 and $11,715 difference in shipping costs per fifty cars for differences in waterway competition and ethanol production respectively.

The results of this study are also of import to policy-makers as they call into question the assumptions behind models currently being used by the Army Corps of Engineers for the benefit analysis of waterway improvements.[7] These models have an assumption that increases in the barge rate due to congestion on the waterway will lead to shipments switching from barge to rail without a response in price by the railroad. In other words, these models assume that rail rates are exogenous and not influenced by the barge industry. An assumption directly called into question by the results of this study, which indicate that the pricing decisions made by railroads are constrained by the availability of barge transportation.

The remainder of this study is divided into four sections. Section 2 presents a theoretical model of dominant firm pricing with heterogeneous goods. Section 3 then develops an empirical model stemming from the theory 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

For shippers of grain, there are three available modes of transportation which they use in some combination to get their crops to one of several potential markets: truck, rail

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[7] Note that many of these assumptions have been called into question previously by the National Academy of Science (NRC 2001, 2004).

or barge. Due to the costs of service, truck rates tend to be higher than either rail or barge rates, with this being especially true for longer shipments. 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 e.g., barge, unit trains, etc. Because of these differences in the costs of transportation by mode, most 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. 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.[8]

From the railroad's perspective, their ability to spatially price discriminate is constrained by the level of competitive pressures at their location. These pressures may take many forms, including: the ability of barge to compete with rail, the capacity of local ethanol plants, other railroads servicing the location, etc. The railroad's problem is then to charge the highest rate possible at each location subject to procuring the shipment, i.e. the shipper choosing rail as their mode of choice. As such, this model follows from Wilson (1996) which examines market dominance in regulating railroad rates.

Every potential rail shipment starts with shippers deciding between a variety of alternative markets (*d*) where they can sell their product, with a variety of transportation modes available to them either directly or through interchange. These alternative shipment plans are denoted by *m*. The initial starting point is to frame the discrete choices of a price-taking shipper. For each option available to the shipper, there is an associated maximum profit given prices represented in a profit function. This function is

[8] The appropriate model for this type of competition is a model of market dominance ala Wilson (1996).

given by where m defines the modal choice, P_d represents the price received at market d, and r_{md} represents the transportation rate by modal option m to market d. Given each shipper has multiple mode/destination choices, they then choose the option that gives the highest profit level.

$$\underset{m,d}{\text{Max}}\ \pi = \pi_{md}(P_d, r_{md}) \tag{1}$$

By Hotelling's Lemma, the demand for transportation by mode m to destination d can be derived from equation (1) as:

$$\frac{\partial \pi}{\partial r_R} = -X_R(P_d, r_{md}) \tag{2}$$

The railroad takes this demand function as given, and chooses the rate that maximizes its profit subject to the constraint that the option to the shipper involving rail must be preferred to other options. This means that the railroad's maximization problem may be constrained by the existence of alternative modes of transportation and/or destination markets.

This makes the railroad's profit maximization problem:

$$\begin{aligned} \underset{r_{Rd}}{\text{Max}}\ \pi \ = \ r_{Rd} X_{Rd}(P_d, r_{md}) \ - \ C(X_{Rd}(P_d, r_{md})) \\ \text{s.t. } \pi_{Rd} \geq \ \pi_i \ \forall\ i \ \neq \ rd \end{aligned} \tag{3}$$

Where $C(X_{Rd}(P_{dq},r_{mdq}))$ is the railroad's cost associated with the demand resulting from its choice of rail rate r_{Rd}. Also, it should be noted that the constraint on the railroad's maximization problem given by equation (3) requires that the profit that the shipper receives from shipping via rail is greater than, or equal to, the profit it obtains from any alternative mode of transportation i, i.e. the railroad procures the shipment.

The Lagrangian for the railroad's profit maximization problem given by equation (3) is:

$$L = r_R X_R(P_d, r_{md}) - C(X_R(P_d, r_{md})) + \lambda(\pi_R - \pi_i) \qquad (4)$$

With the first order conditions given by:

$$\frac{\partial L}{\partial r_R} = X_R(P_d, r_{md}) + r_R \frac{\partial X_R(P_d, r_{md})}{\partial r_R} - MC \frac{\partial X_R(P_d, r_{md})}{\partial r_R} + \lambda \frac{\partial \pi_R}{\partial r_R} \le 0 \qquad (5)$$

$$\frac{\partial L}{\partial \lambda} = \pi_R - \pi_i \ge 0 \qquad (6)$$

According to these results, the railroad must be the low cost mode of transportation to procure the shipment. Given that the railroad is the low cost mode, it prices at the maximum of the monopoly price or the constrained price. That is, the railroad prices at the monopoly level unless it is constrained by other alternatives that the shipper would choose at the monopoly price. If the railroad is the low cost producer and is constrained by the presence of alternatives, it prices between the monopoly price and marginal cost. In this model, the railroad charges different rates for movements that originate at different locations. The differences depend not just on cost differences but also on competitive pressures present at any given location. Since these pressures likely vary across spatial dimensions e.g., truck-barge is less attractive to shippers as the truck share of the movement increases, i.e. the railroad spatially price discriminates over shippers. In addition, as noted earlier, over the last several years, ethanol plant locations have evolved as an option for corn shippers, which adds another alternative available to shippers, impacting rail rates near ethanol locations.

The first-order condition above can be rewritten in a convenient form to evaluate markups and to help frame the empirical model. That is, equation (5) can then be rewritten as:

$$(r_{Rd} - MC)\frac{\partial X_{Rd}(P_d, r_{Rd})}{\partial r_{Rd}} = (\lambda - 1)X_{Rd}(P_d, r_{Rd}) \qquad (7)$$

Or,

$$\frac{r_{Rd} \ - \ MC}{r_{Rd}} \ = \ \frac{(\lambda \ - \ 1)}{\varepsilon} \qquad (8)$$

where ε is the price elasticity of the demand for railroad service. Notice that the left-hand side of equation (8) represents the difference between the rail rate and marginal cost, i.e. the Lerner Index of market performance. Equation (8) indicates that railroad's profit-maximizing rate is either the competitive rail rate $r_{Rd} = MC$, (λ = 1), the monopoly rate (λ = 0), or at some point between the competitive and the monopoly levels. Specifically, 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).[9]

En route to an empirical model, equation *(8)* can be written as:

$$r^*_{Rd} \ = \ \frac{MC}{1 \ - \ \frac{(\lambda \ - \ 1)}{\varepsilon}} \qquad (9)$$

This then can then be written as:

$$\log \ (r_R) = \log \ (MC) - \log \ (markup) \qquad (10)$$

[9] 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 rates could only be considered if the rates were first found to be market dominant.

where *markup* = *f*(λ, ε). Note that the markup term, representing the level of market dominance, is measured by lambda, which reflects the difference in profits between shipper alternatives and railroad cost dominated traffic. This difference depends critically on the spatial environment of these shipping alternatives. In particular, for shippers located near the waterway, ethanol plants or shippers who have alternative modes of transportation available, the railroad must lower its rate 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).[10] 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. These warehouses are shown in Figure 1, and contain observations in North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Illinois, and Wisconsin.

Using the warehouses in Figure 1 as the origin, rail rates for the shipment of corn are collected between each location and the Gulf Coast.[11] These rail rates are collected

[10] Note that 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.

[11] Note that 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.

directly from the railroads via their websites. Given an origin and destination, these websites allow for the query of rates. 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.[12] The average rate for each of these origins is shown geographically in Figure 2. Note that the average rail rate increases as one moves north and/or west, i.e. as distance from the Mississippi River increases, with the highest average rates being for locations in western North Dakota.

In addition to the cost variables provided by the railroad itself, railroad markup variables are also collected. These markup variables are intended to capture the competitive pressures present at the origin location of a shipment. As such, we include variables which capture both competition from other modes of transportation/destination markets and the demand for shipments from the originating location. Of principle importance to this study is the truck-barge alternative that rail competes with for long distance shipments. To control for competition from truck-barge, we use GIS software 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

[12] 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.

commodity to the Gulf Coast via barge.[13] Other than barge competition, the railroad also faces competition from other railroads, which is controlled for by including the number of other railroads that service the warehouse location. The remaining markup variables are geared towards capturing the spatial demand for rail service in different areas and the potential for an alternative market for corn. In particular, we collect the population in every origin city as a measure of the size of the market the railroad is serving, and we also collect data on the capacity of ethanol plants as reported by the U.S. Department of Energy, and the distance from each origin location to each ethanol plant.

Using these data, the empirical model follows directly from equation (10) above, 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:

$$Log(Rate\ Per\ Ton\ Mile) = f(CostVariables, MarkupVariables) \qquad (11)$$

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.[14] 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.[15] It is assumed that increases in *capacity* lower the rail rate per car as larger shipments have a minimal effect on the railroad's costs given that it is already moving between two points.

[13] 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).

[14] 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.

[15] 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.

Increases in longer shipments are assumed to increase the rail rate per car because a large share of the firm's costs is directly related to the distance being traveled, but lower the rate per ton mile. Finally, movements by unit train are assumed to decrease the rate per car.[16]

In addition to these cost variables, competition variables, which represent the markup term derived previously are included in equation (11). The first of these competitive measures is used to capture the strength of the truck-barge alternative, and is measured as the truck cost of getting a shipment to the river plus the barge cost of moving it to the Gulf Coast. This variable is expected to measure the constraint that waterway competition puts on rail pricing, and therefore, larger values of *truck-barge cost* are expected to increase the rail rate per ton mile. In addition to waterway competition to rail service, there is also competition from other alternative railroads. To capture this competition, we use define *railroad alternatives* as the number of additional railroads who serve the origin location, and this variable is another constraint on railroad pricing, meaning that it is expected that more alternatives will lower the rail rate per ton mile.

While both inter- and intramodal competition are likely to impact the ability of a railroad to spatially price discriminate, there is also the possibility that alternate markets for corn may impact the pricing decisions of railroads. 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

[16] 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.

capacity of ethanol plants within 60 miles of the origin location as another markup variable in equation 11.[17] To control for the overall size of the market at the origin of the shipment by including the *population* of the city, which is expected to increase the rail rate per ton mile.

The mean values for each of the variables included in equation (11) 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 average rail rate per car is $351 higher for the 25% of observations with the highest truck-barge costs.

4. RESULTS

The results are presented in the ensuring two subsections. In both sections, the model given by equation (11) is estimated via ordinary least squares (OLS).[18] In the first subsection, the results on impact of the cost parameters on rail rates is examined, while the second subsection focuses on the impact of the markup competitive pressure variables.

The Impact of Costs on Rail Rates

Table 2 presents the results of estimating equation (11). In this table, the results

[17] Ethanol capacity was collected in twenty mile increments extending out 200 miles from the origin facility. We use the 40 mile measure because corn must be transported to the ethanol facilities, usually by truck, and the cost of transporting the corn more than 40 miles may make the farmer unlikely to choose this option. See Dooley (2006) for a thorough discussion of the catchment areas of ethanol facilities.

[18] Comments on an earlier version of this paper caused us to examine the potential for differeing impacts of waterway competition depending on which river was closest. We used several empirical approaches to examine this possibility, with each indicating little to no difference between the various waterways. This lack of difference could be attributed to the fact that we are using the distance from the origin location to the nearest grain loading barge facility to calculate our *truck-barge cost*, which takes into account how far the shipment must move to get to a facility which can handle agricultural shipments, rather than simply the distance to the nearest river.

are presented both with, and without, the markup competitive pressure variables included to assess the stability of the cost parameter estimates, which are shown to be robust to the two specifications. In particular, the estimates on the impact of *capacity*, *distance* and the *unit train* dummy variable are all statistically significant at the 1% level of significance, each having the aforementioned expected sign.

That is, larger shipments, i.e. higher *capacity*, lead to a reduction in rail rates as the increased cost from an additional ton is minimal. In particular, a 1% increase in capacity leads to a 0.043 to 0.046% decrease in the rail rate per ton mile. The results presented in table 2 also indicate that increases in *distance* of the shipment decrease rail rates per ton mile, with a 1% increase in the distance of the shipment decreasing rates by 0.421 to 0.441 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 impact the rail rates charged per ton mile as was predicted in the market dominance theoretical model previously.

Impact of Competitive Pressures on Rail Rates

As noted previously, there are several markup variables included in equation 11 to analyze the railroads' ability to spatially price discriminate. In particular, the presence of truck-barge competition may act as a constraint on the ability of a railroad to spatially price discriminate. Our results presented in Table 2 support this hypothesis, indicating that a 1% increase in the *truck-barge cost* results in a 0.070% increase in the rail rate per ton mile. Figure 3 illustrates this impact by showing the predicted rail rates per ton mile at the different truck-barge costs observed in the data at the average values of all of the other explanatory variables. Applying this result to the geographic space in which the shippers are located, Figure 4 shows the predicted rail rate markup associated with truck-barge competition. Note that in Figure 4, as shippers are located further from the waterway system, the markup increases as the shippers are not able to leverage truck-barge competition into a constraining factor on rail rates.

In addition to barge competition, railroads face the emerging ethanol industry which acts as an alternative destination for corn, a destination which can be served by trucks. To account for this industry, we included the *ethanol capacity within 60 miles* of each location in equation 11. 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 being associated with a 0.012% decrease in rail rates per ton mile. This result can be seen geographically in Figure 5, which also shows the various ethanol plant locations. Notice that in Figure 5, the cost savings associated with having ethanol capacity within 60 miles is illustrated rather than the markup, as the availability of ethanol provides a constraint on rail pricing. In particular, Figure 5 shows that areas surrounding ethanol plants tend to face lower rail rates as the railroads have to compete to procure these shipments.

Increases in the *population* at the origin is shown in Table 2 to increase rail rates, with a 1% increase in *population* associated with a 0.005 percent increase in rail rates. The impact of rail competition on rail rates is shown in Table 2 to decrease rail rates, as previously hypothesized, however, this result is statistically insignificant.[19]

While the impact of each markup variable on rail rates per ton mile may seem

[19] The 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.

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 10.1% difference in rail rates, which equates to a $314.79 per car cost difference. Given that the average shipment size in the data is 50 cars, this implies a $15,739.50 difference in shipping costs attributable to differences in *truck-barge costs*. This result calls into question the aforementioned assumption of the cost-benefit models being used to assess the impact of waterway infrastructure improvements that rail rates are exogenous to barge pricing. Similarly, differences in *ethanol capacity* cause a 7.4% difference in rail rates which accounts for a $234.30 difference per car or $11,715 difference 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.

5. CONCLUSIONS

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 10.1%, which amounts to a $15,739.50 increase in revenue 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 7.4% difference in rail rates. Over a 50 railcar shipment, this implies cost differences to shippers of $11,715. 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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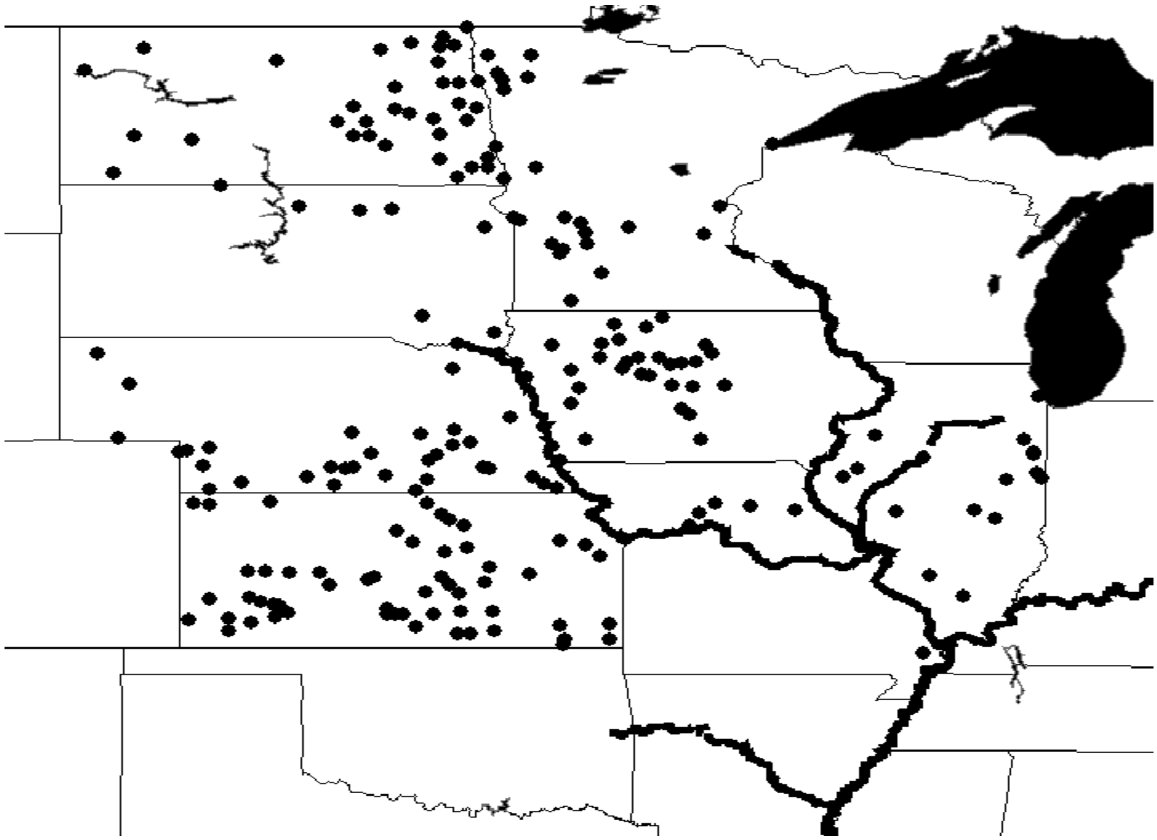

FIGURE 1: Locations of FSA Warehouses Used to Collect Rail Pricing Information

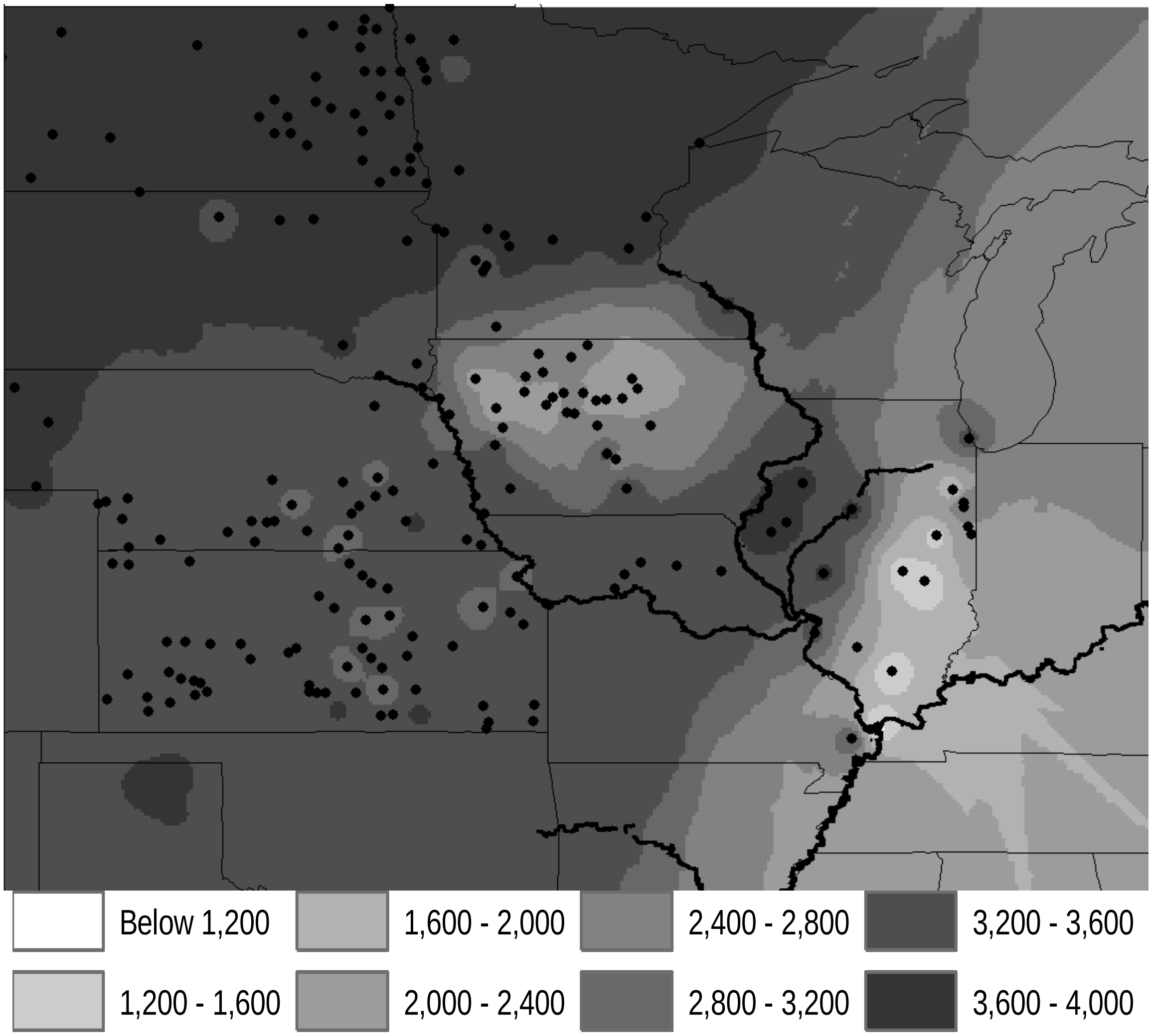

FIGURE 2: Average Rail Rate by Location

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	$3,261.87	$3,036.50	$3,387.46
Rail Revenue Per Ton-Mile	$0.027	$0.027	$0.028
Distance of Shipment	1,392.82	1,250.26	1,405.26
Capacity of Shipment	7,074.06	7,452.21	6,824.96
Population	51,262.43	142,589.60	2,927.23
Rail Alternatives	0.154	0.145	0.081
Ethanol Capacity within 40 Miles	44.41	58.21	17.82
Truck-Barge Cost Per Ton Mile	$0.046	$0.029	$0.061

TABLE 2: Revenue Per Ton Mile Rail Rate Regression Results

	Cost Parameters Only	Cost and Markup Parameters
Log Capacity	-0.046***	-0.043***
	(0.006)	(0.006)
Log Distance	-0.421***	-0.441***
	(0.019)	(0.019)
Unit Train	-0.136***	-0.141***
	(0.037)	(0.037)
Log Population		0.005**
		(0.002)
Rail Alternatives		-0.008
		(0.014)
Log Ethanol Capacity		-0.012***
		(0.002)
Log Truck-Barge Cost		0.070***
		(0.017)
Constant	-0.200	0.119
	(0.153)	(0.171)
R-Squared	.44	.48
Observations	677	677

(.) 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.

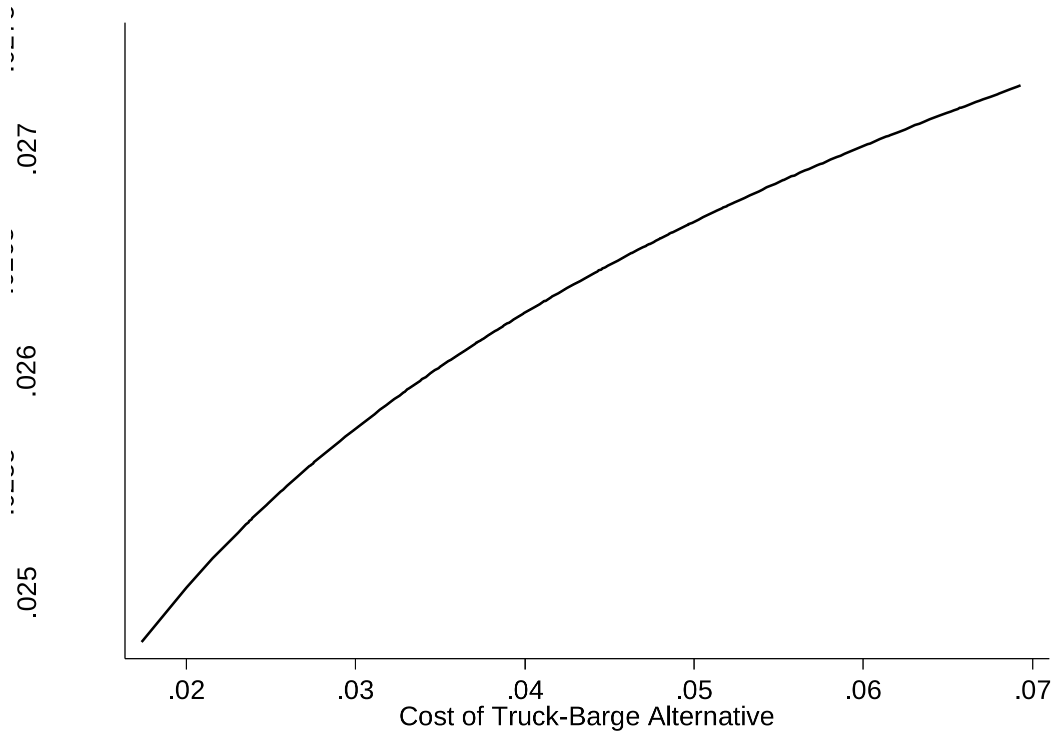

FIGURE 3: Predicted Impact of the Truck-Barge Alternative on the Rail Rate

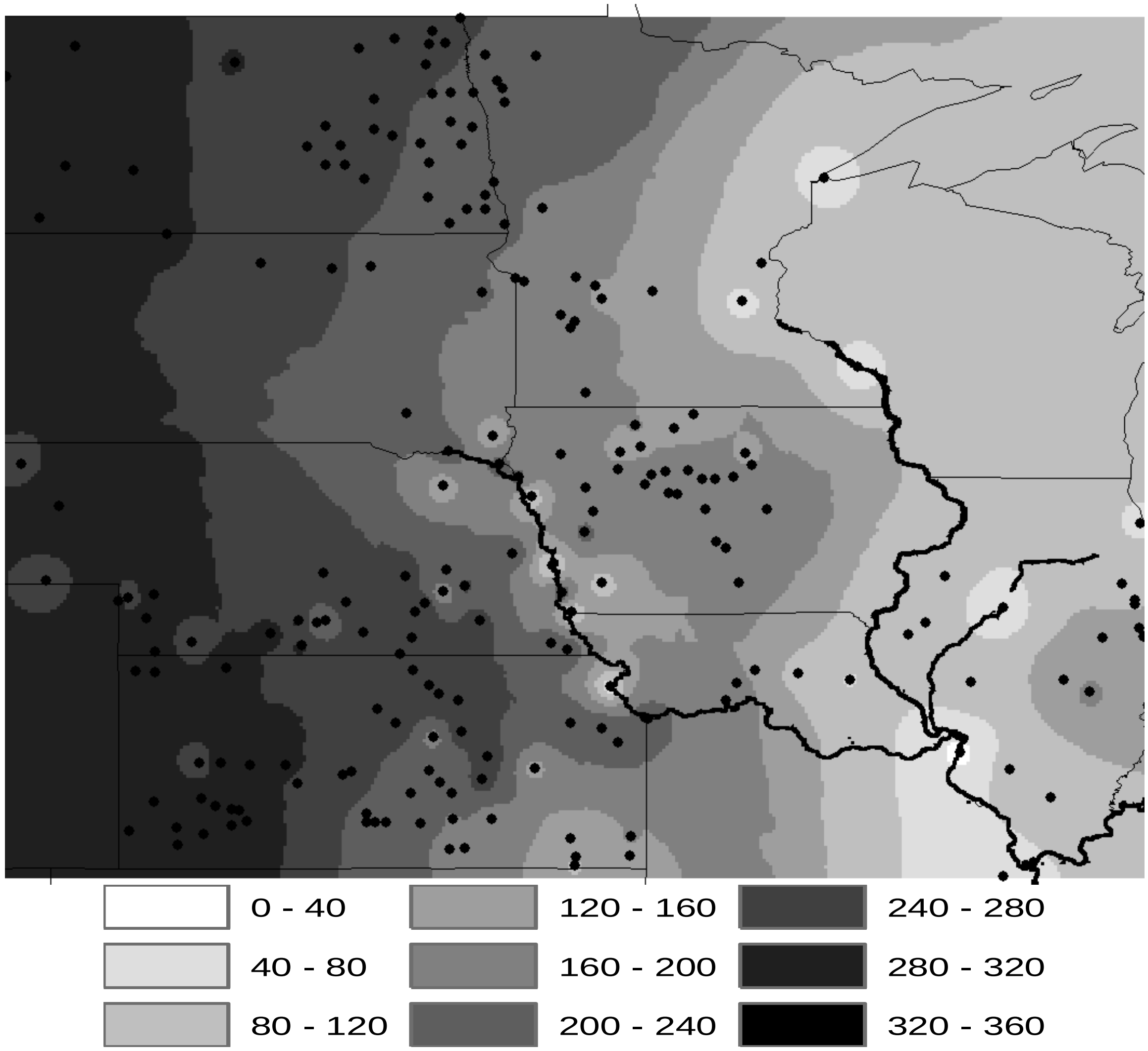

FIGURE 4: The Predicted Markup Associated with Truck-Barge Competition

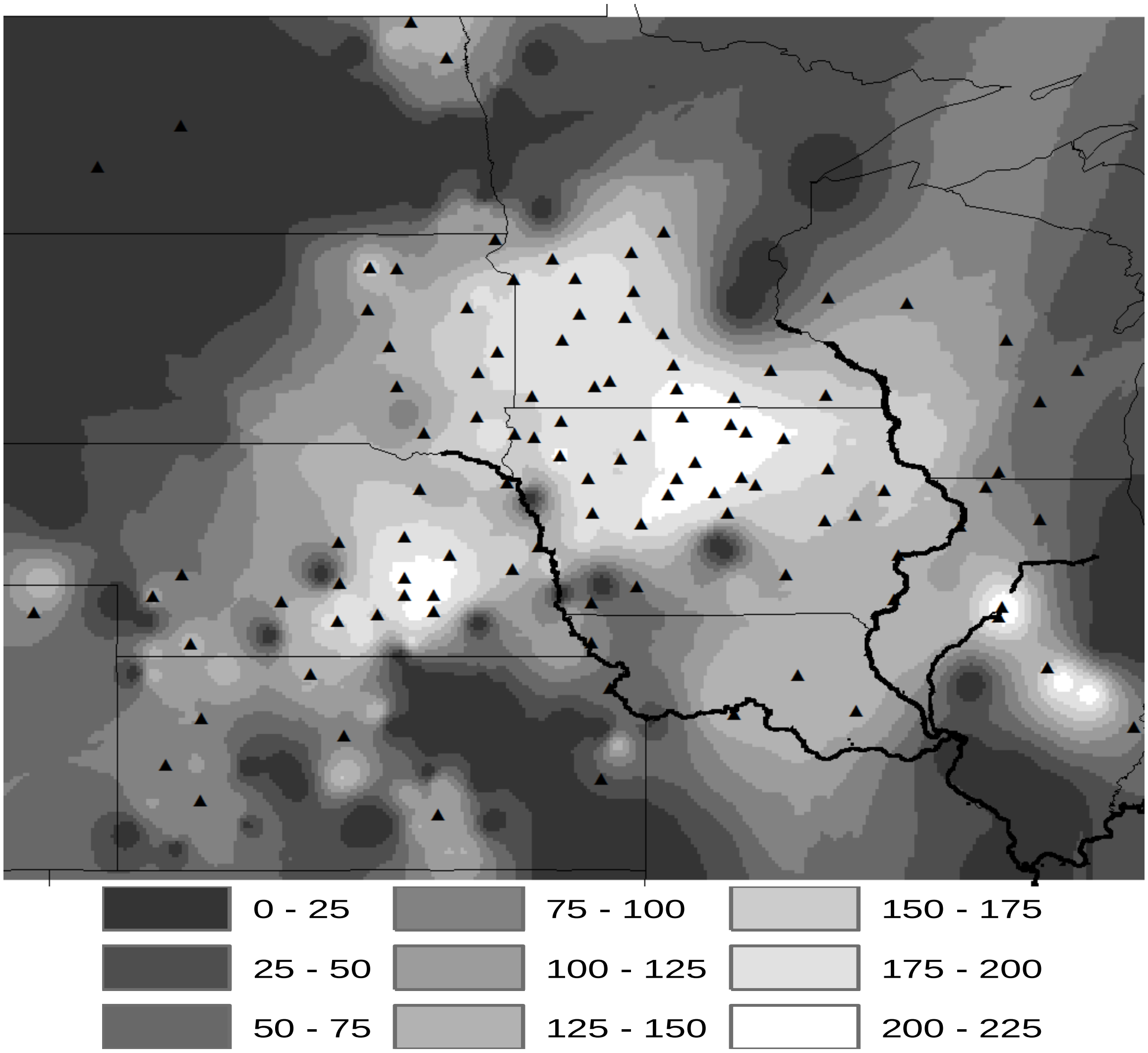

FIGURE 5: The Predicted Cost Savings Associated with Ethanol Competition

TABLE 3: Impact of Competitive Pressures on Rail Rates

	Percentage Impact	Dollar Impact Per Rail Car	Dollar Cost Impact for 50 Rail Car Shipment
Rail Competition	No Effect	No Effect	No Effect
Truck-Barge Competition	10.1%	$314.79	$15,739.50
Ethanol Competition	7.4%	$234.30	$11,715