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# Hard Red Spring Wheat Marketing: Effects of Increased Shuttle Train Movements on Railroad Pricing in the Northern Plains

by Elvis Ndembe

*Despite the widespread adoption of shuttle train grain elevators and their potential for reducing rates for grain transport, few studies have evaluated their impact on railroad pricing. The aim of this paper is to assess railroad pricing behavior as well as empirically examine the impact of shuttle train movement on hard red spring wheat transport from North Dakota over time. Ordinary least squares estimation of the pricing model has rate per ton-mile as a dependent variable and supply and demand determinants as regressors. Intermodal competition and shuttle trains were found to have played a significant role in rate reduction over time.*

## INTRODUCTION

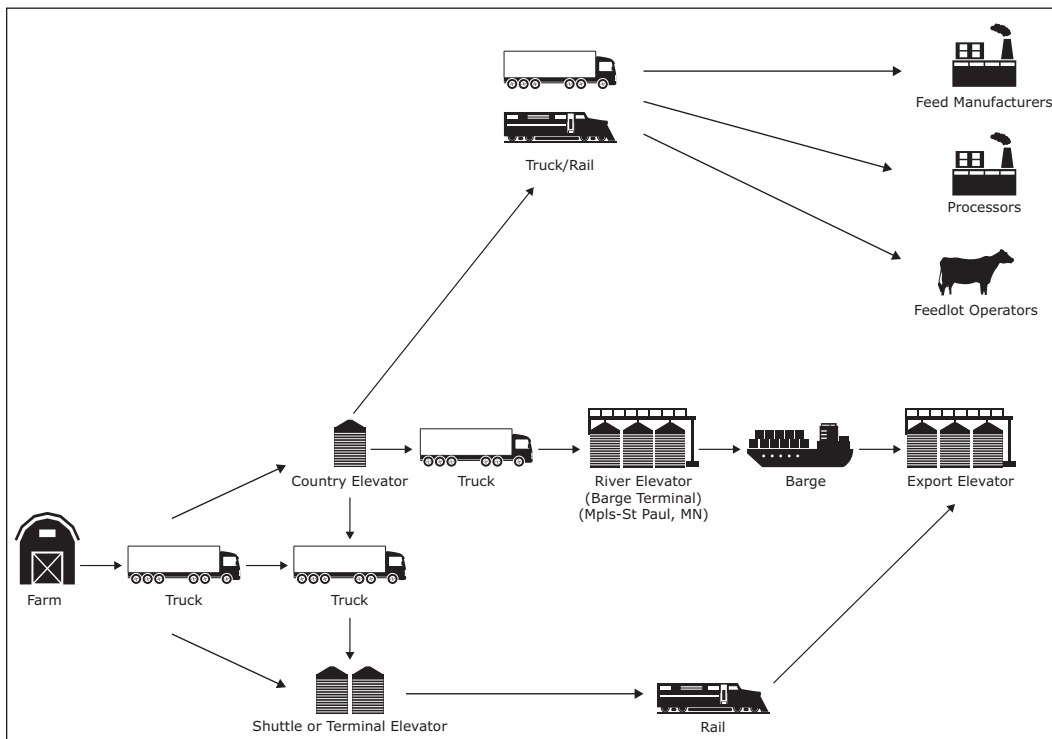
The widespread implementation and use of shuttle train grain elevators is affecting hard red spring wheat marketing in U.S. Northern Plains states like North Dakota where shippers are highly rail dependent. Shuttle trains are considered more efficient because of limited railcar switching requirements (movements often involve cycling between a single origin and destination). As such, they can potentially reduce rail carriers' cost with likely benefits transferred to shippers in the form of lower rates. U.S. Senate Committee on Commerce, Science, and Transportation, (2002) showed that the variable costs associated with shuttle movements were 47% and 15% lower than those for single-car (1 to 6 railcars) and unit-train (52 railcars) shipments, respectively.

Shuttle train rates were introduced by Burlington Northern (BN) (Burlington Northern Santa Fe [BNSF] since 1996) in the Northern Plains in the 1990s (NDDOT 2007). Prior to this innovation, unit-train services were considered the most efficient. An illustration of how grain is marketed in the United States is useful to understanding how railroad pricing affects hard red spring wheat producers in North Dakota.

Grain producers usually sell their commodities to local county elevators or grain sub-terminals that subsequently sell to terminals and export elevators. At the local or sub-terminal elevator, the producer is quoted the price at an export port (e.g., Portland Grain Exchange) less other costs, including transportation, loading, storage, and margin (Miljkovic 2001). Given that grain producers are responsible for transportation cost, in the short run, changes in rail rates could affect North Dakota hard red spring wheat producers in two distinct ways. Increases in transportation rates decrease producer profits, whereas potential reduction in rates stemming from efficient transportation increases profits. Such effects are likely to disproportionately impact agricultural shippers in North Dakota given that the state accounts for a large proportion of U.S. hard red spring wheat production and shippers in the state rely heavily on rail for grain shipments.

Some hard red spring wheat is shipped out of state by truck as well. Based on data from the North Dakota grain movement database, between 1999 and 2012, rail was responsible for 93.3% (62,296,905 tons) of all hard red spring wheat movements out of North Dakota while truck movements represented 6.7% (4,465,737.09 tons). This high reliance on rail suggests rail rates are likely one of the main determinants of prices received by producers. The market channel for North Dakota hard red spring wheat is shown in Figure 1.

**Figure 1: North Dakota Hard Red Spring Wheat Marketing Channel**



Source: Author

This study presents a railroad pricing model for hard red spring wheat shipments from North Dakota to all major domestic and export destinations. The pricing analysis is undertaken to determine if shuttle trains have had a significant impact on rail rates for the shipment of hard red spring wheat out of North Dakota, as well as to assess the comparative rate advantage associated with using shuttle trains relative to three other rail movement types: unit, multi-car, and single-car. The pricing model is similar to the dominant firm price leadership approach used by Koo et al. (1993) in their evaluation of railroad pricing in North Dakota. They argue that such a condition is likely because two railroads are responsible for all grain transportation out of state. The econometric procedure here is complemented with the inclusion of regional and service variables to capture likely differences in rail rates among regions and service types.

Several studies have dealt with the impact of shuttle trains on railroad pricing (Vachal and Button 2003) and grain movement (e.g., Vachal et al. 1999 and Sarmiento and Wilson 2005). Others have focused on their impact on truck movements and highway pavement damage (Babcock and Bunch 2003, Tolliver et al. 2006, and Bai et al. 2010). Vachal et al. (1999) assessed the potential of marketing hard red spring wheat in 100-plus car trains in North Dakota while Vachal and Button (2003) provided a market-based synopsis of the likely impact of shuttle rates on grain flow in North Dakota using different scenarios. Their overall conclusion was that shuttle elevators can play a role in grain procurement in the state by handling most of the grain produced. This paper differs from previous related studies because it explicitly assesses the impact of shuttle trains on railroad pricing. Apart from filling the lack of research in this area, an evaluation of this nature is important, given the value-added role railroads play in the grain supply chain by moving commodities for long distances from rural areas to consumption centers. This research also provides potential insight for public policy.

## BACKGROUND

The Staggers Act of 1980 partially deregulated the railroad industry and gave it more control to price its services. Following deregulation, U.S. Class I railroads adopted various cost reduction strategies to enhance their efficiency and increase profitability (Babcock and Bunch 2003). Gallamore (1999) observed that the pricing flexibility provided by deregulation has led to several innovations that have benefitted shippers. In agricultural transportation, railroads have increased emphasis on elevators with large capacities that can load and unload longer trains. An initial innovation related to longer train operations was the introduction of unit train rates (52 railcar shipments) shortly following deregulation. Prior to unit trains, multiple-car rates (6 to 49 railcars) and single-car rates (1 to 5 railcars) were the norms of the industry (Wilson et al. 1988). Following the adoption of unit trains, BN introduced shuttle rates (110 or more railcars) in the 1990s.

Shippers wishing to benefit from economies of shipment size through lower rates offered by shuttle services had to invest in track sidings, inventory, and storage capacity and, in some cases, construct new facilities able to accommodate and load longer trains. Incentives provided by this form of shipment led to increased adoption and use of shuttle elevators and shuttle trains to transport grains. USDA (2013) observed that shuttle train shipments of grain and oilseeds in tons increased by close to 37% between 1994 and 2011. In 2010, shuttle trains were responsible for approximately 51% of all U.S. grain and oilseed movements. While shuttle trains have witnessed a surge in use, all other service types have declined during the same time period. The effect of shuttle trains in North Dakota is reflected in the total tonnage of hard red spring wheat movements out of state. Shuttle train tonnage (representing 100 railcars and above) of all wheat movements increased from 9% in 1999 to 66% in 2012 based on waybill sample data from the Surface Transportation Board (STB).

The primary operational difference between shuttle and unit trains is side track capacity in terms of the number of railcars that can be loaded or assembled for loading. Side track capacity is measured in equivalent number of cars (NDDOT 2007). An elevator requires 6,600 feet of track space to hold 110 railcars (shuttle train) with the total track requirement exceeding 7,000 feet to accommodate dedicated locomotive power and spotting clearance (NDDOT 2007). Unit trains (typically 52 railcars) on the other hand, require half that amount of space. Additionally, The U.S. Senate Committee on Commerce, Science, and Transportation (2002) notes that unit trains typically have to be matched with one of a similar size or with several smaller multi-car blocks before a large grain train can be put together. Shuttle trains do not require putting a train together. Dedicated power, locomotives, and railcars involved in shuttle movements remain in a single block as they move from origin to destination, thus enhancing rail car utilization. Shuttle trains are a more dedicated service than unit train services.

The two Class I railroads responsible for all out-of-state grain movements in North Dakota have requirements that shippers must meet to participate in their shuttle programs. BNSF defines a shuttle train as one made up of 110 covered hopper cars, each with a capacity of 111 tons, and a shuttle elevator as one that has enough track capacity to accept 110 cars and load and unload them in 15 hours up to three times per month without clogging the main line (NDDOT 2007). On the other hand, SOO Line, the U.S. subsidiary of Canadian Pacific Railroad (CP), refers to shuttle trains as “efficiency trains” and defines them as trains with 100 cars and efficiency elevators as those that can load 100 cars within a 24-hour period without disruption to the main line. They added that a 110-car train made up of 111-ton covered hopper cars will carry 400,000 bushels of wheat. The required volume and the time for loading and unloading make production and storage capacity an important aspect of the shuttle program (NDDOT 2007).

North Dakota led U.S. hard red spring wheat production within the analysis period based on data from the United States Department of Agriculture, National Agricultural Statistics Service (USDA NASS). As a percentage of U.S. production, North Dakota’s production ranged from 33% in 1999 to 50% in 2009. In fact, on average between 1999 and 2012, North Dakota accounted for close

to 44% of all U.S. hard red spring wheat production similarly based on USDA, NASS data. This high volume production corresponds to the state's role both in U.S. consumption and export demand as well as potential effects of railroad pricing on grain producers. Hard red spring wheat has the highest protein content of all other wheat types produced in the United States, and is preferred for making bread (North Dakota Wheat Commission 2015). Bread is an important dietary component around the world.

Shipper pricing complaints are prevalent in the railroad industry. In fact, railroad pricing complaints from captive shippers was one of the rationales behind the 1887 Interstate Commerce Act that established the Interstate Commerce Commission (ICC) and gave it the authority to regulate railroads. The ICC was replaced by the Surface Transportation Board (STB) in 1996. North Dakota is used extensively as a captive market in theory (Koo et al. 1993). Policymakers are often interested in equity issues and the wellbeing of shippers. Potential effects from shuttle train implementation can help inform policy makers about likely changes in railroad pricing and intermodal and intramodal competition in North Dakota over time.

The rest of this paper will proceed in the following manner. The next section will provide the theory of intermodal competition and model specification similar to that used by Koo et al. (1993). Data description, empirical results for the railroad pricing model, and study implications are highlighted in the final section.

## **THEORY OF INTERMODAL COMPETITION**

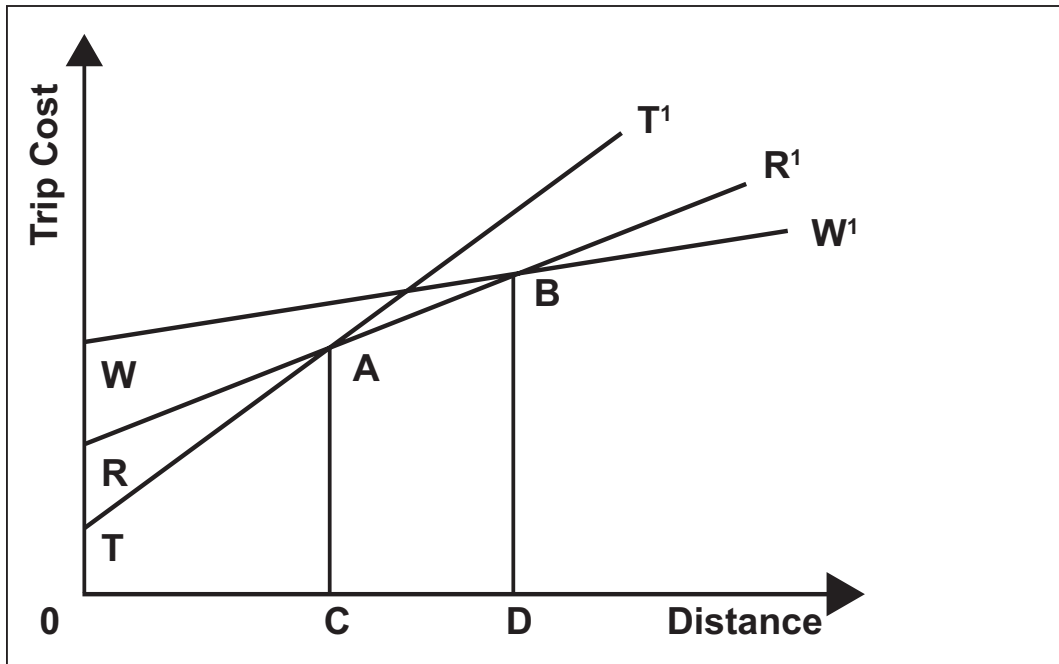
Three principal modes are used to transport agricultural and other commodities in the United States to export and domestic destinations: rail, truck, and truck-barge. Shippers' mode choice decisions are often based on the availability of a mode and its cost relative to that of others. Transportation cost, in turn, is a function of distance between an origin and destination.

Koo et al. (1993) and the Congressional Research Service (CRS 2005) provide a hypothetical cost curve for the three main modes shown in Figure 3 to illustrate competition between different modes according to distance between an origin  $i$  and destination  $j$ . Their illustration shows that, generally, trucking has a relative advantage for shorter-distance traffic while rail and barge dominate longer-distance hauls [(Koo et al. (1993), Congressional Research Service (2005)].

Potential trucking dominance of the short haul stems from the fact that it has relatively small fixed and terminal costs that offset comparatively higher linehaul cost over short distances. Linehaul cost refers to those costs that vary with operations (e.g. fuel, labor, tire wear). The hypothetical cost curve of trucking is shown as  $TT'$ . The cost curve for barge traffic, depicted as  $WW'$ , suggests that water transportation has the lowest distance-related unit cost as well as higher terminal or fixed cost compared with other modes. Consequently, barge transportation has considerable advantages for long-distance trips relative to short-distances trips.

Barge operations are confined to U.S. waterways, including the Mississippi, Illinois, Ohio, Columbia, and Snake rivers. This benefits shippers in close proximity to these waterways. Given the lack of waterways in North Dakota, the only other mode comparable to barge serving shippers in the state is railroad transportation. The cost curve for railroad traffic lies between that for truck and barge transportation. Koo and Uhm (1984) noted that the shape of the railroad cost curve is a reflection of the "rate taper" concept, which they described as rates that increase at a decreasing rate with distance attributable to economies of long haul. They noted that railroad firms realize economies of haul as distance increases specifically because fixed terminal cost can be spread over greater mileage.

Attention was also placed on the fact that several other factors affect rail rates, including volume, commodity characteristics, and weather conditions. However, if rail rates were determined entirely by cost, then the transportation market will be segregated between the three modes according to shipment distances. In that case, trucking will have natural dominance for traffic in the figure's OC

**Figure 2: Hypothetical Trip Cost Curve**

Source: Koo et al. (1993) and Congressional Research Service (2005)

market; rail in the CD market and barge for distances beyond OD. Koo et al. (1993) concluded that competitive factors, from intermodal and intramodal competition where they exist, play an essential role in shaping rail rates by constraining railroads' pricing behavior. This stems from the fact that railroads have an incentive to compete with other modes by using pricing to penetrate markets with traffic weakly dominated by other modes. For example, MacDonald (1989) observed that multi-car rates enabled railroads to regain medium-distance traffic from trucks on grain shipments from Minnesota and the Dakotas to Duluth, MN/Superior, WI. Deregulation also increased the importance of intermodal and intramodal competition. Burton (1983) observed that railroads have become more responsive to intermodal and intramodal competition since passage of the Staggers Act. This study extends the railroad pricing model undertaken by Koo et al. (1993). Contrary to their study, which uses cross-section data in their annual estimation, this study utilizes a time series technique to evaluate potential changes over time between 1999 and 2012. Additionally, the influence of volume on rates is explicitly analyzed by comparing shuttle train rates to those of other services. Finally, the railroad designated Bureau of Economic Analysis regions (BEA) are included to take into account potential regional differences in rates.

### MODEL AND EMPIRICAL SPECIFICATION

Prices for transportation of agricultural products are determined by demand and supply conditions similar to those obtainable in a competitive market system (Koo et al. 1993). They defined the demand for the transportation services of a railroad ( $Q_d$ ) as a function of the price a rail carrier charges for its services ( $R_1, R_2, R_3, \dots$ ), prices other rail carriers charge for their services, prices charged by other transportation modes ( $T_1, T_2, \dots$ ), and other factors influencing demand for transportation services ( $\theta$ ) as follows:

$$(1) \quad Q_d = f(R_1, R_2, R_3, \dots, T_1, T_2, \theta)$$

The supply of a rail carrier's freight transportation services is defined as a function of prices of all rail carriers' and other modes' freight transportation services ( $R_1, R_2, R_3 \dots T_1, T_2$ ) and related cost influences like distance ( $D$ ) and shipment volume ( $V$ ), and other related factors affecting the cost of transportation ( $Z$ ) as:

$$(2) Q_s = f(R_1, \dots, T_1, T_2, D, V, Z)$$

By combining equation (1) and (2) assuming the existence of equilibrium, ( $Q_d = Q_s$ ), price charged by railroad 1 for transportation services can be given as:

$$(3) R_l = f(R_2, R_3 \dots T_1, T_2, D, V, Z, \theta)$$

Considering other rail carriers' prices ( $R_2, R_3$ ) as intramodal competition ( $R_{com}$ ) and prices of other modes ( $T_1, T_2$ ) as intermodal competition ( $INT_{com}$ ) equation 4 can be rewritten as:

$$(4) R_l = f(R_{COM}, INT_{COM}, D, V, Z, \theta)$$

Koo et al. (1993), and other related research studies including Bitzan et al. 2003 and Macdonald (1989), used market concentration in the form of the Herfindahl-Hirschman index to measure intramodal competition (rail-to-rail). However, in the context of North Dakota, Babcock et al. (2014) noted that intramodal competition is very limited in the state. Regional and local railroads often act as subsidiaries for both Class I railroads, hence do not compete directly with them (Babcock et al. 2014). For example, Dakota Missouri Valley and Western (DMVW), a local subsidiary of Canadian Pacific (CP), serves areas in the state that BNSF does as well, but not CP (Babcock et al. 2014). As such DMVW competes with BNSF for this traffic. Additionally, the Red River Valley and Western (RRVW), a subsidiary for BNSF in North Dakota, operates in areas of the state where CP has a strong presence (Babcock et al. 2014). In that case, RRVW competes with CP for traffic. In this way, regional and local affiliates compete on behalf of both Class I railroads (Babcock et al. 2014). This fact makes it difficult to assess rail-to-rail competition ( $R_{COM}$ ). Since this paper is concerned with out-of-state movements undertaken by Class I railroads, intramodal competition was dropped. Equation 4 can be rewritten as:

$$(5) R_l = f(INT_{COM}, D, V, Z, \theta)$$

Equation (5) serves as the basis for the empirical model used in this paper. Multivariate regression in the form of ordinary least squares (OLS) is used to evaluate the comparative rate effect associated with using shuttle trains relative to other rail services, including unit, multi-car, and single-car. To do this, other factors influencing rail demand (including number of cars available), intermodal competition, distance of shipment, weight per car, and seasonal variables, are used as independent variables while revenue per ton-mile is used as the single dependent variable. Seasonal quarter dummy variables will allow a potential test for seasonality of rates while the time trend will indicate if rates are changing over time with shuttle use. Regional dummy variables are included to measure relative rail rates among the four main Bureau of Economic Analysis (BEA) regions in North Dakota used by railroads for assigning rates. These include BEA110 (Grand Fork), BEA111 (Minot), BEA112 (Bismarck), and BEA113 (Fargo-Moorhead). The dependent variable and all other continuous variables are transformed into natural logarithm, which allows for the coefficients to be interpreted as elasticities. The general mathematical representation of the model is:



$$(6) \quad \ln RRPTM = \beta_0 + \beta_1 \ln SHRT + \beta_2 \ln BDIST + \beta_3 \ln CARS + \beta_4 \ln LOAD + \beta_5 \text{Time} + \beta_6 \text{TIMESQ} + \beta_7 Q_1 + \beta_8 Q_2 + \beta_9 Q_3 + \beta_{10} \text{SHUTTLE} + \beta_{11} \text{OBEA110} + \beta_{12} \text{OBEA111} + \beta_{13} \text{OBE113} + \varepsilon$$

Where,

- RRPTM* = Real revenue per ton-mile (in 2010 prices)  
*SHRT* = Length of haul in short-line miles  
*BDIST* = Closest highway distance from barge loading facility weighted by total tons from BEA  
 (Calculated from North Dakota Grain Movement Database)  
*CARS* = Number of railcars in shipment  
*LOAD* = Load factor representing weight per railcar  
*Time* = Time trend, year of shipment  
*TIMESQ* = Squared time trend  
*Q<sub>1</sub>* = Dummy variable representing first quarter  
*Q<sub>2</sub>* = Dummy variable representing second quarter  
*Q<sub>3</sub>* = Dummy variable representing third quarter  
*SHUTTLE* = Dummy variable shuttle train shipment, include 100 cars or more  
*OBEA110* = Dummy variable representing origin-BEA (110)  
*OBEA111* = Dummy representing origin-BEA (111)  
*OBE113* = Dummy variable representing origin-BEA (113)  
 $\varepsilon$  = Normal effect error term

$$\text{Expected signs} = \beta_1, \beta_3, \beta_4, \beta_5, \beta_{10}, < 0. \\ \beta_2, > 0. \\ \beta_6, \beta_7, \beta_8, \beta_9, \beta_{11}, \beta_{12}, \beta_{13} < > 0.$$

From the specified model in equation (6), the natural log of length of haul in short-line miles is expected to have a negative effect on the natural log of real revenue per ton-mile. The literature on the influence of distance on transportation cost suggests that as distances increases, the rate per ton-mile of freight decreases. This is particularly the case with railroads because a significant part of rail shipment cost is constant regardless of the distance. MacDonald (1989) noted that cost components such as switching, classification, and loading of cars are not impacted by the distance of shipment. He added that some cost associated with movement between origins and destinations such as train speed does not increase at the same rate with mileage, consequently the rate per ton-mile decreases with distance.

Railroads previously used 100-ton covered hopper cars. However, because of innovations related to track composition, the weight limit and load per car has increased substantially. In the 1970s, a significant portion of rail branch lines were limited to gross car weights of 220,000 pounds, which permitted net loads of 70 to 80 tons (NDDOT 2007). Presently, Class I railroad main line tracks are able to support 286,000-pound cars, enabling freight loads of between 110 and 115 tons. Some railroads operate 315,000-pound cars with corresponding net loads of 125 tons in particular corridors. The increasing use of larger-capacity rail cars has led to increasing railroad revenue per car without a corresponding direct increase in cost to shippers (increase per car payload). These facts mean the natural log of rate per ton-miles should decrease at a decreasing rate with the increasing number of rail cars and load factor. The load factor measures the average weight per car. Because the shuttle dummy variable is a reflection of larger number of cars in a shipment, it is expected to have a sign similar to that for number of cars in shipment. Inclusion of the shuttle dummy will enable an assessment of its relative rate advantage over the other three principal rail services, including unit, multi-car, and single-car rail. The Soo Line shuttle train definition (100 cars and more) is used here

to properly reflect the two railroads responsible for grain movements out of North Dakota. Using the BNSF definition of 110 or more cars will exclude likely Soo Line movements.

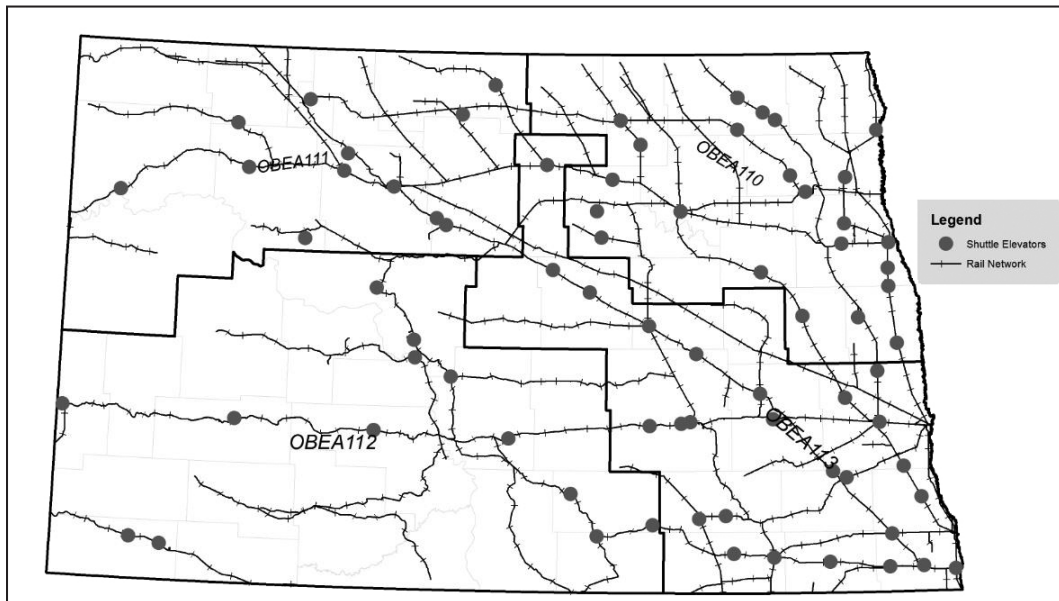
The U.S. Class I railroad industry moved from a cost-based structure in the regulatory era to market-oriented differential pricing in the deregulatory environment, which makes intermodal competition an important factor (Bitzan et al. 2003). Despite their observations that shippers in regions with less intermodal service might have benefited least from deregulation, MacDonald (1989) noted that deregulation might have more impact in such areas. As observed previously, the number of shuttle shipments of wheat from North Dakota increased substantially between 1999 and 2012. Shuttle trains are associated with lower cost; therefore, their increasing use potentially means shippers are paying lower rates over time compared with other services. The time trend is consequently expected to have an inverse relationship with the log of revenue ton-miles.

Intermodal competition is measured by the weighted highway distance to the closest barge-loading facility. The closest barge-loading facilities are located in Minneapolis-St Paul, MN. Intermodal competition can potentially reduce the pricing power of rail carriers (Koo et al. 1993). This is likely the case because barges can compete with rail for long-haul transportation of bulk commodities. Consequently, the viability of intermodal competition reflected in truck-barge combinations declines as the distance from barge terminal increases. As such, rates are expected to be positively related to BDIST.

To account for possible changes in rates between seasons, three seasonal dummy variables are included, with the fourth quarter of the year serving as the base period. Quarterly rather than monthly dummy variables are used for the analysis to better reflect various seasons (e.g., planting, harvesting, and off seasons). Hard red spring wheat is often planted from April to early June with harvest taking place between August and September. As such, the demand for rail transportation of hard red spring wheat is likely to increase in late September and peak in the fourth quarter (October, November, and December). Fourth quarter rates are expected to be relatively higher than those in the first three quarters of the year.

The rest of the variables are those with indeterminate relationships with the natural log of revenue ton-miles (relationship could be either negative or positive). The squared time trend was included to allow a changing time trend over time. The regional BEAs were included to account for potential spatial variability in rail rates stemming from geographic competition related to location of shuttle elevators and crop production. For example, there is a perceived notion among shippers in western North Dakota that they pay higher rates for shipping hard red spring wheat, particularly to the Pacific Northwest, compared with shippers in the eastern region. The U.S. Senate Committee on Commerce, Science, and Transportation, (2002) noted that one of the issues behind the spread of this belief is the fact that shuttle services (likely lower rates) have not been widely available to shippers in all areas.

Based on data from the North Dakota grain movement database, in 1999, there were 330 licensed grain elevators within the state. This number declined to 199 in 2012. This reduction is a reflection of increasing consolidation witnessed in the rail and grain elevators industries. An average of 53 licensed grain elevators scattered across the state had shuttle capabilities in 2012. The four BEA areas comprising the study area, rail network, and location of shuttle elevators are shown in Figure 3.

**Figure 3: Study Area, Rail Network, and Shuttle Elevator Locations**

Source: Author

## DATA AND DATA DESCRIPTION

Data used to estimate the model in this paper are from the rail public use waybill data and the North Dakota Grain Movement database between 1999 and 2012. The waybill sample contains railroad shipment data from a stratified sample. Railroads are mandated to submit this information to the Surface Transportation Board (STB) for regulatory purposes. Contrary to the master waybill file, which contains detailed information (e.g., contract rates), the public use file is masked to preserve such confidential information. For this reason, some, including Wolfe and Linde (1997), have argued that the waybill might not be an accurate reflection of railroad rates. This point is particularly concerning in the case of this paper because shuttle movements are not under the jurisdiction of the STB (contract rates). Given confidentiality issues, which make it impossible for most researchers to gain access to the master file, most transportation studies are based on the public waybill sample (Fuller et al. 1983, Kwon et al. 1994).

The grain movement database contains grain movement information reported by country elevators to the North Dakota Public Service Commission (NDPSC) with the most recent being for 2012. All movements are classified by elevator number, month, year, commodity, mode, and destination of movements. The mode includes truck and four rail services defined as: single-car (1-25 cars), multi-car (26 -50 cars), unit train (50-100 cars), and shuttle (100 or more cars) shipments. Grains destinations include those within the state and six aggregated destinations. These include Duluth, MN, Minneapolis, MN, other Minnesota (other cities in Minnesota), Gulf (e.g., New Orleans, LA; Galveston, TX), Pacific Northwest (e.g., Portland, OR; Seattle-Tacoma, WA) and other (all other U.S. destinations). The closest distance to barge loading facility is constructed using the grain movement database while all other variables are obtained or calculated from the waybill dataset. Descriptive statistics for variables used in the regression analysis are shown in Table 1.

**Table 1: Means for Continuous Variables Used in Regression**

Year	RRPTM*	SHRT	BDIST	CARS	LOAD
1999	0.05080	779.3	412.3	16	99.9
2000	0.04430	865.5	414.6	24	100.2
2001	0.04591	881.7	419.9	29	100.9
2002	0.04545	843.3	411.7	34	101.3
2003	0.04410	819.6	408.2	35	101.2
2004	0.04797	908.6	402.8	40	101.2
2005	0.08426	916.6	391.3	37	100.3
2006	0.05009	949.1	378.9	39	102.0
2007	0.03593	970.1	374.0	41	103.0
2008	0.03934	1027.6	376.5	38	102.3
2009	0.04581	913.6	367.5	34	103.5
2010	0.04871	929.7	377.1	34	102.7
2011	0.05179	916.3	377.7	33	102.9
2012	0.05258	941.3	366.5	39	103.6

\*Revenue ton-miles adjusted by GDP price deflator with 2010 base year

Source: Surface Transportation Board Public Use Waybill Sample.

The BEA unit area of analyses used in the public waybill sample encompasses several counties. The waybill sample splits North Dakota into four BEA regions (BEAs 110, 111, 112, and 113 describing the Grand Forks, Minot, Bismarck, and Fargo-Moorhead regions, respectively). Rather than use the centroid of the four BEAs as the origins to estimate distances to the closest barge loading facility, weighted average distances were calculated using elevators in each BEA as the origin. The zip codes for shipping grain elevator locations were used to estimate the highway distance from hard red spring wheat grain reporting elevators to one of the barge-loading facilities in the Minneapolis-St Paul area using PCMILER<sup>®</sup>. This distance was multiplied by the total shipments from that elevator for all elevators in the BEA. This is weighted by the total tons moved from that BEA to the barge destination by truck. The weighted average distance is calculated as:

$$(7) \quad BDIST_{bbl} = \frac{\sum_1^e [(TTons_{emin} * HD_{emin})]}{\sum(TTons_{bmin})}$$

Where,

$BDIST_{bbl}$  = Weighted average highway distance from BEA,  $b$ , to barge facility,  $bl$

$TTons_{emin}$  = Truck movements in tons from elevator,  $e$ , to MPLS-St Paul

$HD_{emin}$  = Highway distance elevator,  $e$ , to MPLS-St Paul

$TTons_{bmin}$  = Total truck movements in tons from BEA,  $b$ , to MPLS-St Paul

## EMPIRICAL RESULTS

The model specified in equation 6 is estimated using ordinary least squares with 1999 to 2012 data following the theoretical model and justification by Koo et al. (1993). To account for potential bias in selection of shuttle elevators, the shuttle dummy variable was instrumented using a binomial logit regression and the predicted values used to replace the shuttle dummy variable in equation 6. Econometric diagnostic tests are conducted to ensure the validity of the estimated parameters. The

Durbin Watson (DW) test for autocorrelation (DW = 1.73) suggest the absence of serial correlation at the 5% level of significance. Estimation results are presented in Table 2.

**Table 2: Regression Estimates**

Variable	Parameter Estimates
Intercept	3.7985* (0.0001)
Short-Line Miles	-0.4916* (0.0001)
Distance from Barge Facility	0.0866* (0.0090)
Number of Rail Cars	-0.0424* (0.0001)
Load Factor	-0.8794* (0.0001)
Time	-0.0337* (0.0001)
Time Squared	0.0036* (0.0001)
First Quarter Dummy	-0.0174** (0.0379)
Second Quarter Dummy	-0.0162*** (0.0598)
Third Quarter Dummy	-0.0163** (0.0484)
Shuttle-Train Dummy (100 or more cars)	-0.0700* (0.0001)
OBEA110	-0.0406* (0.0002)
OBEA111	0.1441* (0.0001)
OBEA112	0.0309 (0.1128)

Adjusted R<sup>2</sup> = 0.709

Observations used = 6160

P-values in parentheses

\* Significance at the 1% level

\*\* Significance at the 5% level

\*\*\* Significance at the 10% level

The adjusted R-squared of 0.709 indicates that variables included in the model explain at least 71% of the variation in revenue per ton-mile. All explanatory variables have their expected signs with most of the variables significant at the 1% level. The distance variable (length of haul) has a negative sign and is significant at the 1% level. Therefore, as length of haul increases, rate per ton-mile decreases. The observed decrease in rates with distances is attributed to the spreading of fixed and terminal costs over longer distances. Parameter estimates on the other movement characteristics, including number of rail cars and load factor, all have their expected signs. The negative sign on the

number of rail cars indicates that rate per ton-mile decreases as the number of cars in the shipment increases. This is significant at the 1% level. Similarly, the load factor, which is a reflection of the weight per car, has a negative sign and is significant at the 1% level. This shows that rail rates decline with increasing weight per car. For example, shippers are often charged for total capacity so if \$3,000 is charged per car, then a shipper that loads 110 tons in a car pays \$27.2 per ton, whereas another shipper that loads 100 tons pays \$30 per ton. This way, the load factor is a reflection of rail car capacity utilization. The latter shipper pays for unused car capacity.

As expected, the highway distance from a barge-loading facility representing intermodal competition from truck-barge combination is positive and significant at the 1% level. This suggests that a 1% increase in distance from loading barge facilities will increase rates by approximately 0.087%. This also highlights the likelihood that railroad pricing behavior in shipping hard red spring wheat from the state is affected by intermodal competition from truck-barge combination.

As expected, the time trend is negative and significant at the 1% level. The negative sign on the time trend suggests that rate per ton-mile for shipping hard red spring wheat has decreased from year to year. However, the squared time trend variable, which measures the change in the time trend over time, suggests that the change in rate reductions over time may be increasing. Three seasonal dummy variables are another delineation of the influence of time on rail rates. The three dummy variables, including first, second, and third quarters, measure rates in comparison with the fourth quarter. All three quarterly estimates are negative. Both the first and the third quarter are significant at 5%, whereas the second is strictly significant at the 10% level. These results suggest that rates for all three quarters are lower than those for the fourth quarter. These results are intuitive given that the hard red spring wheat harvest usually occurs in late September. More grain is likely available following harvest in the fourth quarter of the year potentially satisfying shuttle service capacity requirements (e.g., a shuttle train requires 400,000 bushels of wheat to load).

Two of the three dummy variables accounting for relative rail rates stemming from potential spatial differences from geographic locations are significant at the 1% level. These three regions are compared to the Fargo-Moorhead region BEA113. These regional definitions are established by railroads for the purpose of rate determination. Results suggest that shippers in the Grand Forks region (BEA110) pay lower rates compared with those in BEA113. Shippers in the Minot region (BEA111), on the other hand, pay more than those in the Fargo-Moorhead area. No difference in rates exists between the Fargo-Moorhead region (BEA113) and the Bismarck region (BEA112).

Rail carriers publish rail rates based on the number of cars in a train. From these published rates, four main movement types can be delineated: single-car, multi-car, unit train, and shuttle train services. Shuttle trains, described herein as those with 100 or more rail cars, are viewed as the most efficient owing to their characteristics (e.g., less decoupling and quick turnaround at destination). A single dummy variable was introduced to assess if shuttle trains have a relative rate advantage over the other three rail service types for shipping hard red spring wheat out of North Dakota. The dummy variable for shuttle trains is significant at the 1% level. As expected, the sign of the parameter estimate is negative. This suggests that shuttle trains have a rate advantage over other rail services. A 1% increase in shuttle service used is associated with a 0.070% decrease in rail rates. In fact, it shows that this form of shipment has potentially played a role in reducing rates for shipping hard red spring wheat out of North Dakota over time.

## IMPLICATION AND CONCLUSIONS

This paper assessed railroad pricing behavior in North Dakota. Specifically, the primary aim was to examine the effect of shipping hard red spring wheat using shuttle trains to all out-of-state destinations using an econometric technique with time series data between 1999 and 2012. The use of shuttle trains required the construction and upgrading of elevators to increase grain capacity and rail track sidings to accommodate 100 or more rail cars. The loading of a shuttle train requires

about 400,000 bushels of wheat, making production an important determinant. In undertaking this evaluation, several other factors influencing rail rates and costs were included in the model.

As expected, cost factors, including distance, number of cars, and load, play an important role in reducing rates. Competitive factors, including intermodal competition, in this case by truck-barge combination, place downward pressure on rail rates. Rates were also observed to vary by month, which alluded to seasonality. The time trend pointed to a general decrease in rail rates from year to year. However, the regional dummy variables tend to indicate that rates vary for the four rail designated areas. It seems that rail rate concerns of hard red spring wheat shippers in the west with regard to paying higher rates are legitimate. Shuttle trains were found to play an important role in reducing rates to shippers. However, it is likely that not all regions have benefitted equally from shuttle rates due to the spatial distribution of elevators that can handle shuttle trains. Overall, results show that shuttle trains have influenced rate reductions. The trend in shuttle adoption and its increasing role, portrayed by the total tons moved relative to other modes and rail services, supports this finding.

These findings have widespread implications. One of the main rationales behind deregulation of the railroad industry was to increase operational efficiency. Deregulation gave the industry flexibility to innovate. Use of shuttle trains is one of the innovations that have enabled carriers to reduce costs. Some of these cost reductions are passed to shippers in the form of lower rates. North Dakota has often been used as an example of a captive transportation market for rail because it is located a significant distance from water transportation. It has been shown here that, despite the relatively longer distances from the closest barge facility, intermodal competition in the form of truck-barge combination has an influence on rail rates. Other research has noted the impact of shuttle elevators on local road degradation and increasing repair costs. Alternatively, findings here indicate that shuttle elevators can significantly reduce rail rates for North Dakota hard red spring wheat shippers. Whether the benefits to shippers outweigh related impacts to local communities is a question for further analysis. Accrued benefits to shippers from using shuttle trains are more important in regions like North Dakota because if benefits from this innovation are widespread, then shippers might not be as captive as previously thought.

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