Executive Summary

The production and transportation of grain and soybeans, especially in the North American western regions, are undergoing significant restructuring driven by the desire and need to achieve economies of scale and reach export markets. Within the framework of the Northwestern University Transportation Center (NUTC) study that is focused on gaining insight into the restructuring process via (1) modeling grain[1] and soybean transportation service and (2) analyzing the grain industry and its transportation needs, this third and final track of the study focuses on rail freight rates. The objective of the third track is to understand the *direction* and *magnitude* of rail transportation rates over time and the *predominant factors* impacting the rates in a statistical sense.

Understanding and capturing the dynamics behind freight rates, as this work seeks to do, is both important and complex. It is important for many reasons such as the implications for rail competitiveness and market share, the economic viability and global competitiveness of the United States grain sector, and the relationship between the grain industry and the transportation sector. As previous tracks of the analysis have shown, understanding and capturing the dynamics behind rates is complex because providing transportation service depends on a multitude of factors occurring in dynamic contexts. These factors are often hard to isolate and capture, and rates in general, in any given service and sector, are the result of a range of variables, market circumstances, and management discretion.

Over the past four decades, freight railroad rates have evolved considerably both in terms of their magnitudes and the freedoms/restrictions that federal regulators have placed on railroads in terms of rate discrimination. Often, in discussions of rail transport rates two regimes are identified for context: before and after the Staggers Act of 1980[2]. The Staggers Act gave

[1] In this report, the term 'grain' refers to bulk grains and bulk oilseeds (i.e. corn, wheat, and soybeans).

[2] Winston, Clifford. "The Success of the Staggers Rail Act of 1980." *AEI-Brookings Institute Center for*

[2] Winston, Clifford. "The Success of the Staggers Rail Act of 1980." *AEI-Brookings Institute Center for* *Regulatory Studies* (2005): <http://www.brookings.edu/~/media/research/files/papers/2005/10/railact-winston/10_railact_winston.pdf>.

railroads considerable freedom in terms of which shipments to provide service to and the rates charged to those shippers. Conversely, prior to Staggers Act, railroad companies were required by law to service certain shipments regardless of their relative profitability and without total control over the rates charged to shippers.

Instead of comparing those two regimes, this study focuses on the years between 2001 and 2013. The results uncovered in this analysis should be placed in the more recent context of the restructuring process of both production and grain logistics. The data used in the analysis were obtained through the publicly available carload waybill sample (CWS) that the Surface Transportation Board (STB) collects from major railroads.

In this report we perform an in-depth analysis of rail transportation rates using the CWS. The analysis examines all shipment types but emphasizes bulk grain shipments and shipments originating in the Upper Midwest (North Dakota, South Dakota, and western Minnesota). The analysis attempts to uncover trends in rail transport rates for (a) all shipments, (b) specific commodity-types including grain, and (c) specific regions of the country including two regions that produce a large amount of grain, the Upper Midwest and the I-states (Iowa, Indiana, Illinois, and Missouri). The analysis additionally attempts to examine (a) the shipment characteristics that impact rail revenue per ton-mile (RPTM) and revenue per carload-mile (RPCM), (b) how the impact of the characteristics differ as a function of commodity-type and region of origin, and (c) how the impact of the characteristics fluctuated between 2001 and 2013.

The key explanatory variables used in this study were chosen based on an extensive literature review of rail transportation rates. The literature review revealed that predominant factors affecting rail freight rates include: **distance traveled, shipment weight, carload number**, **commodity-type, export vs. domestic, and route density.** Those variables, along with freight rates, were examined in a two-step process. First, a *preliminary analysis* was conducted to understand correlations and trends in the CWS data. This paved the way to a more robust analysis of freight rates and their determinants through *multivariate regression models*.

The exploratory analysis included first a *correlation study* of major relationships in the data. The emanating results showed that **freight revenue per ton-mile (RPTM)** is *negatively* correlated with (1) **distance,** (2) **weight,** (3) **carload number,** (4) **route density,** (5) **grain shipments,** (6) **car capacity,** (7) **exports,** and (8) **number of interchanges.** This implies that *longer distance shipments, larger shipments (heavier shipments and more carload shipments), higher volume routes*, and shipments going through *more interchanges* were associated with *lower RPTM*. With the exception of the number of interchanges (which is not addressed in the literature), these relationships confirm literature findings. Correlation tests between the variables also showed that **weight** and **carload number** are highly correlated, suggesting that one of the two is sufficient to model RPTM and RPCM. Additionally, **higher route density** is associated with **longer distance shipments** and **fewer interchanges. Coal shipments were** strongly correlated with **carload number** and **shipment weight,** perhaps reflecting the fact that most coal is shipped using shuttle trains.

The exploratory analysis also examined trends in relevant variables. In general, shipment distances varied minimally over time; the average shipment distance in a given year ranged from 1,150 miles to 1,214 miles over 13 years. Moreover, a large percentage of the shipments in the data (around 30%) traveled between 250 and 800 miles. The average *shipment weight* in the data ranged between 87 tons and 100 tons. Shipment weights, like distances, were stable over time. Furthermore, most shipments in the CWS data were *one-carload* shipments (98%). Moreover, the majority of shipments in the data *did not go through any interchanges* (88% of shipments do not go through any interchanges). As for route density, the majority of the shipments in the data traveled on routes with *medium or heavy* density (i.e. between 1,000 and 100,000 M railcars) with 65% of shipments in this range. Finally, shippers' behavior changed in terms of choosing to use fewer railroad-owned railcars over time. The share of railroad-owned railcars in 2013 amounted to 17%, compared to 29% in 2001.

As for freight RPTM trends, preliminary results suggest that average RPTM for coal shipments was lower than the RPTM for grain shipments, and the RPTMs for coal and grain shipments were both lower than the RPTM for all shipments (including grain and coal). Nominal RPTM for coal increased from 1.7 cents per ton-mile in 2001 to 3.1 cents per ton-mile in 2013. Nominal RPTM for grain increased from 2.0 cents per ton-mile in 2001 to 3.6 cents per ton-mile in 2013. However, RPTM for **coal** had the highest compound annual growth rate (CAGR[3]) between 2001 and 2013 at 5%, followed by **grain** with a CAGR of 4.7%. The CAGRs for grain and coal between 2001 and 2013 were slightly higher than the CAGR for all shipments in the data (4.6%). Furthermore, the analysis showed that RPTM was lower for export shipments than all shipments. Within export shipments, RPTM was highest for coal shipments, followed by all-commodity exports, and finally grain exports. RPTM for coal exports increased at the highest pace (8% annually); the CAGR for both grain exports and all exports was 4.7%.

The regression models presented in the second phase of the analysis build upon the results presented in the exploratory phase. The regression models aim to determine trends in average RPCM for rail transport between 2001 and 2013 for (a) all shipments, (b) shipments of a specific commodity-type including bulk grain and coal, and (c) shipments originating from specific regions of the country including the Upper Midwest and the I-states. Regression modeling techniques allow one to determine the trends in RPCM while controlling for changes in shipment characteristics over time. The second purpose of the regression models is to examine the impact of shipment characteristics and other exogenous factors on RPCM for rail transport. Aside from commodity-type and origination region the analysis examines distance, shipment weight, carload number, route density, railcar ownership, number of railroad interchanges, and export vs. domestic. We segmented the data by commodity-type, origination region, and year in the analysis to determine how shipment characteristics impacted RPCM differently for various commodities and origination regions and how the impacts fluctuated over time.

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[3] Compound annual growth rate (CAGR) is calculated as follows: $CAGR = \left(\frac{final\ value}{initial\ value}\right)^{\frac{1}{num\ years}} - 1$

Important and notable model results are highlighted below.

All Waybills

- Average RPCM[4] (after controlling for shipment characteristics and other exogenous factors):
  - was relatively constant between 2001 and 2006
  - noticeably increased between 2006 and 2012.
  - leveled off between 2012 and 2013
- The following shipment types were associated with lower RPCM:
  - Long distance shipments (exerts very large effect)
  - Shipments traveling between a high density origination-termination region pair
  - Large shipments (i.e. high carload number)
  - Export shipments
  - Railroad-owned railcars
- After controlling for shipment characteristics, the model results suggest that grain shipments were associated with lower RPCM than every other commodity-type examined, including: crude oil and natural gas, coal, coal and petroleum products, food products, non-grain agricultural products, chemicals, and pulp and paper.

Grain Waybills Only

- Average RPCM for grain shipments increased significantly between 2004 and 2011.
- The RPCM for export grain shipments was lower than the RPCM for non-export grain shipments in the early 2000s. However, in 2012 and 2013, the RPCM was higher for export grain shipments than non-export grain shipments.
- Route density did not have a consistent and significant effect on the RPCM for grain shipments
- RPCM was similar for 6-49 carload shipments, 50-90 carload shipments, and 90+ carload shipments between 2010 and 2013 for grain shipments. This result contradicts the model results for all waybills and economies of scale typically associated with rail transportation.

Upper Midwest Waybills Only

- Average RPCM for shipments originating in the Upper Midwest increased steadily between 2008 and 2013.
- The RPCM for grain shipments in the Upper Midwest was consistently lower than the RPCM for every other commodity-type examined between 2001 and 2013.
- Between 2001 and 2003 the RPCM for shipments on very high density routes (100,000+ shipments annually) was significantly higher than the RPCMs for all lower density route categories. Conversely, between 2004 and 2013, the RPCM for very high density routes was lower than the RPCMs of all lower density route categories.
- The RPCM for export shipments was consistently lower than the RPCM for non-export shipments in the Upper Midwest.

In summary, the econometric model results indicate that average RPCM increased significantly in real terms between 2001 and 2013 with most of the increase occurring between 2006 and 2012. Further analysis showed that although average RPCM increased in the Upper

[4] All revenues and RPCM were adjusted for inflation

Midwest and for grain shipments; the increase was consistent with a general increase in average RPCM for all shipments during the period from 2001 to 2013. The regression model results show that the RPCM for grain shippers was lower than the RPCM for many other commodity-types. The econometric regression models exhibited the aforementioned results while simultaneously taking into account and measuring the impact of shipment characteristics. Many of the shipment characteristics associated with lower RPCM in the econometric regression modeling analysis (long distance shipments, shipments on high-density routes, large shipments, and railroad-owned railcars) conform to previous findings in the literature[5]. In addition, the econometric analysis determined that the RPCM for export shipments was consistently lower than the RPCM for domestic shipments between 2001 and 2013 for all commodity-types. However, in 2012 and 2013 the RPCM for export grain shipments was higher than the RPCM for non-export grain shipments. The methodology presented in the report provides a systematic means of determining trends in not only overall rail transport rates but also the shipment characteristics and exogenous factors that impact rates in different segments of the data.

The analysis presented in this track of the NUTC study complemented the work completed in the previous two tracks; it combines both railroad operations and grain industry characteristics in an analysis of actual, observed rail freight rates. Through a two-step process of first understanding correlations and trends in the data and second studying the determinants of freight rates, this study uncovered major trends in rail freight rates and determinants of rail freight rates between 2001 and 2013. The results emanating from this analysis have important implications for both grain industry stakeholders as well as transportation providers.

Finally, the NUTC research group identified two potential areas for future research. The first, and most obvious path, requires access to the STB's confidential waybill sample. The confidential waybill data include a number of fields that would improve the regression model developed in the second part of the report, including: *fuel surcharge, estimated railroad variable cost, and better and finer geographical information.* The second opportunity to improve the regression model involves combining outside data sources with the CWS. For example, other researchers have examined how potential freight transport competition influences rail transport rates. They combined the CWS with information related to the nearest navigable inland waterway from the shipment's origin and termination points, and the number of competing railroads that could potentially serve the demand. Other data sources that could be integrated with the CWS include fuel prices, and aggregate rail indices.

[5] References to the existing literature are provided in the main report.