



COMPENDIUM OF AGRICULTURAL TRANSPORTATION RESEARCH



WILLIAM SECOR, PHD, ASSISTANT PROFESSOR
TULSI THAPA, GRADUATE STUDENT
DAVID WYCHE, FORMER GRADUATE STUDENT

DEPARTMENT OF AGRICULTURAL AND APPLIED ECONOMICS
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF GEORGIA

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PREFACE

This publication compiles summaries of over 20 published, academic journal articles related to agricultural transportation research. The focus is on recent research, spanning roughly the last 6 years, from 2015 to 2020. The compendium's primary goal is to spotlight the main findings and methods of recent peer-reviewed agricultural transportation research in an easy-to-read, accessible format. Each summary is about 1 to 1.5 pages.¹

Fourteen years ago, members of the Agricultural and Rural Chapter of the Transportation Research Forum (TRF) Michael Babcock and Mark Berwick released a compendium of agricultural and rural transportation research.² Their aim was to update TRF members on their colleagues' work and facilitate an exchange of ideas. Their document collected journal articles, book chapters, working papers, and other materials, largely published from 2004 to 2006. One motivation for the 2021 publication is to update the 2007 compendium and carry on its work. Like the 2007 publication, the current compendium aims to enhance idea-sharing among researchers and encourage future collaboration. Another aim is to make the research accessible to non-academic audiences through high-level summaries and plain descriptions so all stakeholders may benefit.

A few key points should be kept in mind when reading the 2021 *Compendium of Agricultural Transportation Research*:

- These summaries capture the study authors' work at the time of their research efforts. For example, one study examined the impact of expanded interswitching limits in Canada (Section V), but those limits are no longer in effect as of 2021.
- These summaries attempt to stay within the bounds of the research presented in each article. That is, the editors tried to remain faithful to the original publication and its conclusions.
- The work summarized in this document includes only published, academic journal articles from 2015-20, with one from 2021. This publication does not include high-quality research that is not yet a journal article or has not yet made it through the peer-review process. Furthermore, the compendium does not include seminal articles (published before 2015) that represent the foundation for the more recent research.

The Compendium sections are structured around specific modes of transportation, as follows:

- Section I covers multimodal and supply chain research.
- Section II summarizes inland (barge and lake) water transportation research.
- Section III summarizes marine (ocean and port) water transportation research.
- Section IV summarizes truck research.
- Section V contains summaries of U.S.-focused rail research.
- Section VI concludes the compendium with summaries of Canadian rail research.

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Disclaimer: The opinions and conclusions expressed in this report do not necessarily represent the views of USDA or AMS.

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1 More specifically, each summary provides overarching results ("Main Results" subsection) from the original work, describes the underlying issue ("Background and Motivation" subsection), presents the main goals of the original research ("Objectives" subsection), further describes what was found ("Summary of Findings" subsection), and includes a reference to the original published paper ("Citation" subsection). In addition, where it fits the nature of the original research, a "Study Scope and Dimensions" subsection was added to most summaries, outlining the study period, geography under study, and methods used.

2 This publication is available online via the University of Minnesota's AgEcon Search: <https://ageconsearch.umn.edu/record/258297>.

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SECTION I

MULTIMODAL TRANSPORTATION AND SUPPLY CHAIN RESEARCH



AGRICULTURAL GRAIN TRANSPORTATION: ARE WE UNDERINVESTING AND WHY?

Main Results

- Sufficient investment and support were not provided to sustain productivity of various modes of grain transportation.
- Intramodal competition, consolidation of rail lines, and fuel prices affect railroad services in agricultural transportation.

Background and Motivation

Transportation is an indispensable part of agriculture as it moves immense amounts of agricultural products over long distances. The cost of transportation significantly determines the price received by producers. Effective and efficient transportation networks make agricultural product handlers and processors more productive, which in turn, improves the welfare of farmers. U.S. agriculture has largely benefited from significant investments made in different modes of transportation in the 19th century. However, investments and support to highways, railroads, and waterways have slowly declined. Considering the importance of transportation to agriculture, the study on major agricultural transportation issues applies both to policy makers and stakeholders.

Objective

- To introduce major issues related to agricultural grain transportation.

Summary of Findings

The author introduces relevant research papers, a few of which are summarized in this compendium, to identify pressing issues in agricultural transportation. Services provided by several transportation modes had deteriorated with lack of investment, with this article focusing on rail performance and rates. Many miles of rail line were abandoned while short-lines rail grew. At the same time, mergers occurred among Class I railroads, which some evidence suggests led to a loss of rail competition.

Citation

Casavant, K.L. 2015. "Agricultural Grain Transportation: Are We Underinvesting and Why?" *Choices* 30 (3).

Main Results

- Transportation costs strongly influence the prices of agricultural commodities, which are low value (by volume), bulky, and perishable. In their report, Beghin and Schweizer recommend incorporating measures of infrastructure and policy into research methods to capture the impacts of variation in transportation costs on trade flows and costs.
- Traditional border measures are being replaced by bi- and multilateral trade agreements. Beghin and Schweizer recommend research should work to capture the patchwork of these agreements.
- Non-tariff measures (i.e., regulatory standards) are often protectionist in nature. The authors recommend incorporating measures of regulatory transparency into research methods.

Background and Motivation

This paper is a review of transportation costs, border measures, and standard-like nontariff measures affecting agricultural commodity trade. Agricultural trade costs, as a share of the total value of commodity shipments, are substantial. While agricultural trade costs have decreased over time, their composition has changed. Tariff-related costs have become less common. However, non-tariff measures (i.e., phytosanitary standards) are increasingly common.

Objectives

- Provide guidance on how to better characterize and measure trade costs.
- Review various proposals for reducing trade costs and provide direction for conducting research on agricultural trade costs.

Summary of Findings

Agricultural commodity transactions (low-value by volume, bulky, and perishable) are impacted significantly by trade costs. Related to the transportation industry's role in these international transactions, this report recommends that research should attempt to capture variation in transportation costs, transportation infrastructure, and transportation policy to better integrate transportation costs into agricultural trade models. Non-tariff measures represent an increasingly common burden to trade, even at a time when traditional mechanisms, like tariffs, are being reduced. This report recommends incorporating measures of transparency to account for impacts of such non-tariff measures on trade flows and costs. One key concluding recommendation includes better incorporating the transportation system, within countries and internationally, into research models of international trade.

Citation

Beghin, J.C., and H. Schweizer. 2020. "Agricultural Trade Costs," *Applied Economic Perspectives and Policy* 43(2):500-530.

REVISITING CONCENTRATION IN FOOD AND AGRICULTURAL SUPPLY CHAINS: THE WELFARE IMPLICATIONS OF MARKET POWER IN A COMPLEMENTARY INPUT SECTOR

Main Results

- With respect to primary input suppliers (e.g., farmers), market power exercised by suppliers of a complementary input (e.g., railroads) generates a larger negative effect than the same level of market power exercised by downstream firms (e.g., grain elevators and handlers).
- Regulation of the complementary sector (to achieve competitiveness) may result in more benefits being accrued to downstream firms (e.g., grain handlers) than to primary input producers (e.g., farmers).

Background and Motivation

The grain handling and transportation sector is made up of three industries. Farmers (i.e., an upstream firm) produce grain that grain handlers (i.e., a downstream firm) buys. In order to produce grain for purchase by grain end-users (e.g., ethanol plants or food manufacturers), grain handlers often need to purchase transportation services from railroads or other carriers (i.e., a complementary firm).

Market concentration, measured by the average four-firm concentration ratio (the sum of the four-largest firms' market shares), tends to be high in both downstream and complementary sectors of vertical food chains. The combined impacts of concentration in freight transportation and downstream agricultural product handlers and processors have not been assessed for welfare implications. This paper is primarily concerned with the North American grain-handling and transportation system, as grain logistics and freight services have major implications for the economic performance of this industry and for producer welfare.

Study Scope and Dimensions

- Period: N/A.
- Geography: N/A.
- Empirical method(s): Theory-focused paper using a model of imperfect competition with vertical relationships.

Objectives

- Present a stylized model of market power in a commodity industry to capture relationships between buyers and sellers of the commodity along with complementary service/product suppliers.
- Consider three groups participating in a market: (1) downstream firms (e.g., grain elevators) making a product using two inputs, (2) upstream firms (e.g., farmers) producing the primary input for the downstream firms, and (3) complementary firms (e.g., railroads) producing complementary inputs/services for the downstream firms.³
- Use comparative statics and numerical simulation to conduct an economic welfare analysis and compare equilibrium outcomes for four cases with downstream firms and complementary firms having varying oligopoly/oligopsony market power.

Summary of Findings

Economic welfare losses associated with complementary firms' market power are greater to consumers and producers than welfare losses associated with the market power of downstream firms. In the grain handling and transportation system, this would suggest that market power in the transportation sector (e.g., railroads) may harm consumers and farmers more than market power in the grain handling sector.

³ For example, a downstream grain elevator at a port combines farm production (grain) with transportation (railroads) to form a product (grain ready for export).

For a proposed policy regulating the complementary sector, more benefits may accrue to downstream firms than to producers if the downstream sector is imperfectly competitive. Again, in the grain handling sector, this would suggest that a policy that reduces the market power of the transportation sector may benefit grain handlers (e.g., grain elevators) more than farmers. Effective policy targeted to enhance supply chain competitiveness will need to account for the relationships and market power of all supply chain participants.

Citation

Cakir, M., and J. Nolan. 2015. "Revisiting Concentration in Food and Agricultural Supply Chains: The Welfare Implications of Market Power in a Complementary Input Sector," *Journal of Agricultural and Resource Economics* 40(2):203-219.

ROBUST GRAIN SUPPLY CHAIN DESIGN CONSIDERING POST-HARVEST LOSS AND HARVEST TIMING EQUILIBRIUM

Main Results

- Risk-seeking processors had higher profit levels, but lower returns on investment as they built more facilities.
- Risk-seeking processors increased farmer profits and reduced transportation costs and post-harvest losses.

Background and Motivation

Post-harvest losses (PHL) occur from the time an agricultural product is harvested to the time it is consumed. The losses are of both quantity and quality. Total grain PHL are estimated at approximately 10 percent in developed countries and 20 percent in developing countries. Insufficient storage facilities and poor storage conditions are major factors leading to PHL, especially in developing countries.

Study Scope and Dimensions

- Period: circa 2008 for the Illinois case study, circa 2013 for the Brazil case study.
- Geography: Illinois and Brazil.
- Empirical method(s): The researchers developed novel conceptual models of grain supply chain systems (farmers, storage and processing facilities, and export markets), incorporating stochastic crop yields, post-harvest losses, and stylized risk preferences. The setup modeled a three-stage supply chain consisting of farmers, storage facilities, and export markets, while incorporating stochastic crop yields and post-harvest loss.

Objective

- Study a strategic grain processing/storage facility (PSF) location problem from the perspective of a processor for a Brazil-based firm and an Illinois-based firm.

Summary of Findings

In both the Illinois case and Brazil case, risk-seeking strategies by the processing firm tended to generate more production/storage facility construction than non-risk-seeking strategies. Although risk-seeking strategies led to more volatile profits for the processing firm, farmers received higher profits at the maximum, mean, and minimum, when using risk-seeking strategies. Additionally, under the risk-seeking scenario, PHL and transportation costs were lower because more PSFs are built. The paper proposes future research on transportation modes (only truck was considered in this study) and transportation routes (distance was used as a proxy in this study). The authors also suggest future research of potential subsidy schemes to balance gains and losses experienced by processing firms and farmers with various risk preferences.

Citation

An, K., and Y. Ouyang. 2016. "Robust Grain Supply Chain Design Considering Post-Harvest Loss and Harvest Timing Equilibrium," *Transportation Research Part E* 88:110-128.

ORIGIN AND EXPORT BASIS INTERDEPENDENCE WITH SHIPPING COSTS IN SOYBEANS: A PANEL DATA ANALYSIS

Main Results

- Origin and export basis for soybeans were determined simultaneously. That is, these markets are interdependent, and basis values are discovered by market participants at the same time.
- A \$1 increase in shipping costs was associated with a \$0.19 decrease in origin basis and an \$0.82 increase in export basis for soybeans.

Background and Motivation

Railroad deregulation (Staggers Rail Act of 1980) has led to the adoption of new pricing and service allocation mechanisms, such as the primary and secondary railcar markets. These mechanisms were designed to efficiently allocate cars among shippers and provide for risk management. The influence of these mechanisms was not well understood and seemed to be interpreted differently by grain traders and academic researchers.

Additionally, logistics emerged as an important strategic management area for companies in the agricultural supply chain, including grain merchandisers. Shipping costs were a major variable to manage, and these shipping costs influenced both origin and destination basis values (the price in each location minus the futures price).

Study Scope and Dimensions

- Period: 2004-16.
- Geography: 46 origin markets, with the Pacific Northwest, U.S. Gulf, and California export markets.
- Empirical method(s): A panel simultaneous-equations model.

Objective

- Examine the effects of shipping costs on the origin and export basis for soybeans, as well as the impacts on trading firms and other market participants.

Summary of Findings

The study supports the hypothesis that origin basis and export basis for soybeans are simultaneously determined. This means that basis values in both markets are influenced by each other contemporaneously. They find that a \$1 increase in shipping costs resulted in a \$0.19 decrease for origin basis and an \$0.82 increase for export basis for soybeans. The authors suggest that this may be analogous to a tax on buyers versus sellers, since the effect was higher at the destination than the origin. The fixed effects model was a better fit than the random effects model. This indicates that there were significant differences across origin markets. Late rail cars, an explanatory variable, lowered origin basis and raised export basis disproportionately—buyers were more adversely affected than sellers. Simultaneity provided an indication that traders could participate in all three markets discussed—origin, export, and rail-rate—to manage risk effectively.

Citation

Lakkakula, P., and W. Wilson. 2021. "Origin and Export Basis Interdependencies with Shipping Costs in Soybeans: A Panel Data Analysis," *Journal of Agricultural and Resource Economics* 46(1):69-84.

Main Results

- Operating a grain trading network jointly (as opposed to a series of independent elevators) created value by allowing grain traders to switch origins.
- Not considering this switching option could undervalue a network of grain facilities by 2 to 10 percent.
- The switching option value depended on the level of contracting, arbitrage margins (which were affected by prices and transportation costs), and how closely origin prices followed each other.

Background and Motivation

Trading firms, including grain companies—such as ADM, CHS, or COFCO—can create strategic opportunities to increase profits by expanding commodity origin networks through building new facilities or acquiring existing elevators. This is done through spatial arbitrage (buying low in one area and selling high in another area) and can allow for better customer service. Spatial arbitrage creates a “switching option”—firms can “switch” between different origins to meet the volume needs of a destination customer.

Conventional valuation techniques undervalue the switching option, often leading to underinvestment in network expansion. Traditional discounted cash flow analysis ignores the value of switching options, whereas real option analysis captures the value of optionality. Grain trading firms have traditionally been seen as having two factors that are important for their success: (1) unique and valuable information and (2) economies of scale. The fact that greater pricing and information transparency have eroded the first factor amplifies the need to protect economies of scale. These economies of scale take on the form of having larger facilities and, importantly for this study, many facilities around the world.

Study Scope and Dimensions

- Period: January 2008 - August 2013.
- Geography: The authors model a network of grain elevators in the United States (Pacific Northwest and Gulf), Brazil, and Ukraine for shipments to China.
- Empirical method(s): a stochastic binomial real options model. The empirical model values the switching option by estimating profits from operating these assets as independent elevators, versus operating them jointly and taking advantage of spatial arbitrage.

Objective

- Estimate the value of a grain company’s ability to switch among facilities in delivering grain to buyers.

Summary of Findings

First, the authors find that the switching option had value when at least some handling capacity was forward contracted. Conceptually, the switching option provided flexibility when required to ship contracted grain. As a result, as contracting increased, the switching option became more valuable up to a point. At some point, the contracting requirements did not allow for sufficient switching—that is when the switching option’s value started to shrink. If origin arbitrage margins became more correlated (resulting in fewer arbitrage opportunities), or if the variability in arbitrage margins declined, then the switching option value declined. The distribution of capacity and operating costs across different origins also impacted the option value. This research supports the hypothesis that traditional investment evaluation tools do not account for this option value, and so, undervalue networks, relative to the real option approach.

Citation

Johansen, S., and W. Wilson. 2019. “Valuing Switching Options in International Grain Marketing,” *Agribusiness: An International Journal* 35(3):423-438.



SECTION II

RIVER (BARGE) AND GREAT LAKES TRANSPORTATION RESEARCH



THE COST OF FORWARD CONTRACTING IN THE MISSISSIPPI BARGE FREIGHT RIVER MARKET

Main Results

- Grain elevators paid a risk premium to obtain future barge service 3-months out during storage and harvest seasons.
- Barge freight providers paid a risk premium in selling future barge service 3-months out during the growing season.
- Risk premium levels varied by season within a year and location, but there has not been a trend across years.
- Forward contracting may reduce barge transportation costs based on the season and the risk management strategy of the grain elevator and barge freight company.

Background and Motivation

The Mississippi River system is a vital and cost-effective way to transport grain to New Orleans for export. This system plays a role in maintaining the competitiveness of U.S. grain in global markets.

The barge freight market is one important market when analyzing the barge system. One part of this market is forward contracts that allow grain companies to lock-in barge freight costs via the barge freight market in advance. Forward contract prices for barge freight can be set up to 3 months in advance.

Relatively little research has been done to understand the barge freight market on the Mississippi River system. Additionally, this area of research is interesting because of the relatively small number of market participants. Overall, this research helps better understand forward contracts for services and helps better inform participants of the costs of forward contracting.

Study Scope and Dimensions

- Period: January 2004 - October 2015.
- Geography: 8 locations in the U.S. Mississippi River system: Twin Cities, Mid-Mississippi, Lower Illinois River, St. Louis, Cincinnati, Lower Ohio River, Cairo-Memphis, and Memphis-South (as defined by USDA-AMS data).
- Empirical method(s): Described barge freight markets, calculated the cost of forward contracting, and performed an analysis of variance (ANOVA).

Objectives

- Provide an institutional context to the Mississippi River barge market.
- Estimate the cost of forward contracting in the Mississippi River barge market by estimating the risk premium paid by barge companies and grain elevators, based on the season and origin of shipment.

Summary of Findings

The Mississippi barge freight forward market, as it relates to grain transportation, was characterized by three types of market participants—grain companies, barge freight companies, and barge freight brokers (with relatively few participants of each type). This forward market lets shippers and carriers arrange service at a future date. In addition to their traditional role as intermediaries for forward contracts, brokers often served as price discoverers by grain companies, rather than facilitators of physical transactions.

Using barge freight rate data from the U.S. Department of Agriculture's Agricultural Marketing Service, the researchers estimated the risk premium paid by market participants, based on the season and origin of a shipment using a parametric model. Grain elevators paid a risk premium to lock in 3-month forward contracts for barge freight for delivery during the storage and harvest seasons. Barge freight companies paid a risk premium to lock-in 3-month

forward contracts for delivery during the growing season. The researchers find the risk premium paid in the barge freight market varied significantly by season but did not vary significantly by location. The researchers find risk premiums had not changed significantly over time. A statistical analysis (analysis of variance) proved inconclusive in locating the major determinants of these risk premium differences.

One reason forward-contracting rates varied by season was the practice of staging barges upstream at the start of the harvest season. This practice usually created ample barge freight on the spot market. Additionally, at the start of the harvest season, the price risk was being transferred from the grain elevator to the barge company. As a result, the grain elevator needed to provide an incentive for the barge company to take on the risk. In contrast, during the growing season, barges were not pre-positioned upstream. As a result, barge companies needed to incentivize forward contracts with grain elevators by providing lower freight costs than the spot market provided.

These results indicate that forward contracting could lower average costs for market participants depending on the season of delivery. Grain elevators could lower average costs by forward contracting for barge freight during the growing season. During the harvest and storage seasons, grain elevators could use the spot market.

However, forward contracts are not just a pricing mechanism, but also a risk management strategy. As a result, some market participants may have found that the cost of forward contracting would make sense over time as part of a risk management strategy. This may be especially true for grain elevators in the barge freight market whose barge freight costs represent a small portion of their overall costs.

Citation

Isbell, B., A.M. McKenzie, and B. Wade Brorsen. 2020. "The Cost of Forward Contracting in the Mississippi Barge Freight River Market," *Agribusiness: An International Journal* 36(2):226-241.

Other Helpful Resources

Townsend, J., and B. Brorsen. 2000. "Cost of Forward Contracting Hard Red Winter Wheat," *Journal of Agricultural and Applied Economics* 32(1):89-94.

Main Result

- The saltie freight market for grains originating in the Great Lakes was not cointegrated (i.e., not connected in a statistically significant way) with the oceangoing shipping market for grains originating in the lower St. Lawrence.

Background and Motivation

The Great Lakes and St. Lawrence Seaway (GLSLS) provide a navigable waterway connecting the inland cities and industries of North America to the Atlantic Ocean. Many commodities traverse this waterway, such as grain, coal, iron, and petroleum products.

“Lakers” and “salties” are the two major types of ships that dominate transportation along the GLSLS corridor. The main difference is that lakers are limited to freshwater, and salties are able to transit the open ocean. Each method offers different advantages. For example, unlike lakers, small salties can pass through the various locks of the GLSLS and handle open seas, which eliminates the cost to transload grain onto oceangoing vessels. However, salties have significantly less carrying capacity than oceangoing vessels. As a result, for some movements, it may be more efficient to use lakers to move product on the GLSLS for eventual loading on a large oceangoing vessel.

Canadian grain producers in the Western prairies can ship their grains further west or east. If they ship east, they have two available transportation options relevant for the GLSLS corridor. First, they can ship their grain east to terminals on the Great Lakes by rail. There, lakers carry the grain to the Lower St. Lawrence, where it is transloaded onto oceangoing vessels. For example, export terminals in Quebec can load oceangoing vessels. A second possibility is to ship the grain by rail to the Great Lakes and then transload it directly onto salties for shipment to international consumers.

This study aimed to shed light on the structure of freight markets in this corridor.

Study Scope and Dimensions

- Period: 1996 - 2001.
- Geography: Great Lakes System and St. Lawrence Seaway in North America. (Rates were collected for the following ports: Thunder Bay, Duluth, and Lower St. Lawrence.)
- Empirical method(s): Regression, Engle-Granger cointegration test.

Objectives

- Examine whether the saltie freight market at the Great Lakes is cointegrated with the freight market at the Lower St. Lawrence.
- Explore if and how rates from these origination points relate over time.

Summary of Findings

The study found that the rates for salties originating in Duluth, MN, were not cointegrated with the oceangoing rates at the Lower St. Lawrence ports. The researchers posited three possible explanations for the lack of cointegration between these two seemingly linked grain transportation markets:

1. Although the freight market on the Great Lakes was open to various ship types, the locks of the Welland Canal and the St. Lawrence Seaway limited international competitors from entering the Great Lakes shipping market because of their size.
2. International saltie operators could incur an additional cost for specialized pilot service for navigating specific parts of the waterway system. The extra cost may have discouraged them from entering the saltie transport market in the Great Lakes.

3. Finally, the researchers found most of the salties transported foreign steel to U.S. Great Lakes ports and moved grain out of the Great Lakes as a “back-haul.” The back-haul rate for grain was low relative to the head-haul rates for inbound steel. Therefore, the back-haul issue might have been another potential reason for the lack of cointegration between the salties freight market and the oceangoing transport markets in the GLSLS.

Citation

Pizzey, L., and J. Nolan. 2017. “Pass the Salt: Markets for Grain Shipping on the Great Lakes,” *Journal of the Transportation Research Forum* 56(2):61-72.

REJUVENATING MISSISSIPPI RIVER'S POST-HARVEST SHIPPING

Main Results

- There was a significant positive relationship between river levels and barge rates. This finding suggests policies promoting dredging activities or increasing allowable drafts (the height of the barge beneath the waterline) may reduce barge rates.
- Such policies may be of greatest relative importance in the Lower Mississippi Segment.
- Increasing channel depth from 9 feet to 10 feet may reduce barge rates in key segments by 1.6 to 3.5 percent (resulting in a \$48 million to \$75 million decrease in transportation costs for covered hopper barges).

Background and Motivation

The Mississippi River efficiently carries bulk commodities and is vital to competing with foreign producers in the world market. Most research related to efficiency has focused on logistical challenges for transit times, such as delays and closures at river locks. That literature suggests a small relationship exists between delays and barge rates. However, little research has been done to assess the effect of barge-load size on efficiency.

Moving more freight (in the form of higher barge loads) relative to cost can expand efficiency. However, greater loads require increased barge drafts, which are vulnerable to grounding or being delayed in low water levels. For a standard barge, about 17 tons (roughly, a semi-truck load) contributes to 1 additional inch of draft.

Study Scope and Dimensions

- Period: July 2007 - February 2018.
- Geography: 5 Mississippi River System segments: Illinois, Upper Ohio, Lower Ohio, St. Louis, and Lower Mississippi.
- Empirical method(s): Time-series method using a vector autoregressive model.

Objectives

- Examine the hypothesis that river levels significantly affect barge transportation rates, using an autoregressive model with weekly barge rates in different segments as the dependent variable (draft depths by segment and other controls are also included).
- Seek to provide a foundation for future analysis that may include a detailed cost-benefit analysis of river channel maintenance.

Summary of Findings

The fact that all models had at least one significant river level variable indicates river levels affected barge rates. On all river segments, except the Illinois River, as river levels increased (especially on the Lower Mississippi segment), barge rates decreased. The authors suggest that this finding provides support for increasing the dredging depth to 10 feet.

Also, at least one historical barge rate was found to be a factor in setting current barge rates. This finding indicates historical prices play an important role in setting current barge rates. Highly significant predictors across all river segments include national corn stocks (an indirect indicator for potential barge demand); ocean vessels scheduled to be loaded in the next 10 days at Gulf ports (a proxy for barge demand); and grain movements through locks (a measure of transportation efficiency). Higher demand (i.e., reflected by smaller corn stocks and more ocean vessels) increased barge rates. Higher movement of grain through river locks reduced barge rates. Rail rates were not found to be an important factor in determining barge rates.

The study aims to provide support for increasing channel maintenance and dredging activities. The stated goal of this research and its policy suggestions are to maintain a competitive advantage for U.S. farmers over other agricultural exporters (e.g., Brazil, Mexico, and Argentina).

Citation

Wetzstein, B., R. Florax, K. Foster, and J. Binkley. 2019. "Rejuvenating Mississippi River's Post-Harvest Shipping," *Applied Economic Perspectives and Policy* 41(4):723-741.



SECTION III

OCEAN, CONTAINER, AND PORT TRANSPORTATION RESEARCH



THE EFFECTS OF PANAMA CANAL EXPANSION ON U.S. DAIRY TRADE FLOWS: WEST, EAST, AND GULF DISTRICT REGIONS

Main Results

- At the time the study was published, the Panama Canal expansion was expected to reduce transportation costs 10-15 percent.
- In their simulation of the Panama Canal expansion, the authors projected dry milk and butter exports would rise for the U.S. West Coast and Gulf Coast, while declining for the East Coast.

Background and Motivation

Trade agreements in the 1990s increased international trade for the U.S. dairy industry. The U.S. dairy industry accounted for 10 percent of total farm cash receipts and \$5.5 billion in 2014 export value. Export values and growth rates have been greatest from the West Coast, outpacing other U.S. dairy regions and the country as a whole.

The Panama Canal expansion allowed ships to carry more than twice the old “Panamax” cargo capacity. Before the expansion, approximately 66 percent of West Coast butter exports went to Africa and Europe transiting the Canal, while only 16 percent of East Coast butter exports traveled through the Canal. The U.S. West Coast region has a competitive advantage over the rest of the United States in the relative quality of its land for dairy production and ease of inland transportation.

Study Scope and Dimensions

- Period: 2010-14.
- Geography: Trade regions are Africa, two Asia regions (East and South East Asia), Europe, Oceania, North America, and three U.S. regions (U.S. West Coast, East Coast and Gulf Coast).
- Empirical method(s): Spatial equilibrium model and simulations of transportation cost reduction.

Objective

- Model the dairy bilateral trade flow impacts from the potential reduction in transportation costs from the Canal expansion.

Summary of Findings

Trade flows of food products were projected to benefit from the Panama Canal expansion, because transportation costs are significant. The U.S. West Coast region was estimated to significantly increase its exports, and the U.S. Gulf Coast was projected to increase its exports modestly, following the Canal’s expansion. However, results suggest that the U.S. East Coast exports would decline. The authors find reduced transportation costs through the expanded Panama Canal will allow the West Coast to exercise its competitive advantage over other U.S. regions when shipping to Europe and Africa. Additionally, the Panama Canal expansion will allow the Gulf Coast to exercise its competitive advantage over the East Coast in shipping to Asia.

Citation

Vorotnikova, E., and S. Devadoss. 2016. “The Effects of Panama Canal Expansion on U.S. Dairy Trade Flows: West, East, and Gulf District Regions,” *International Food and Agribusiness Management Review* 19(B):37-56.

Main Results

- A cargo preference in food aid (a policy requiring at least half of food aid to be shipped by U.S.-flagged vessels) added \$42 million annually to food aid costs.
- U.S.-flagged carriers charged \$50-\$60 per ton more than foreign-flagged carriers.
- U.S. Agency for International Development and large nongovernmental organizations (NGOs) incurred lower shipping costs than small aid providers.

Background and Motivation

Although the United States has been the largest provider of food aid for 60 years, it has been constrained by three food aid mandates:

- Cargo preference: this requires half of food aid to be shipped via U.S.-flagged vessels.
- Mandatory sourcing: U.S. aid agencies are required to source nearly all commodities from the United States, as opposed to the country/region of need.
- Monetization: some portion of food aid has to be sold in local markets to generate funding for program operation, and the aid applies only to nonemergency, development assistance projects.

Between 2012 and 2016, the United States spent \$9.6 billion on food aid, of which ocean freight accounted for only \$1.06 billion. Only one prior study in 2015 by the U.S. Government Accountability Office has used a shipment-specific dataset, others have used average shipping costs.

Study Scope and Dimensions

- Period: January 2012 - May 2015.
- Geography: Food aid shipments originating in the United States and going to nearly 60 different destinations.
- Empirical method(s): Reduced-form ordinary least squares regression with dummy variable controls for regional routes.

Objective

To investigate the following questions:

- Are U.S.-flagged freight rates for shipments under cargo preference higher than foreign operators' rates under open bidding, on a per ton basis?
- Does the experience level of an aid provider, in commissioning shipments, impact freight rates?
- Did the shift from 75 percent to 50 percent cargo preference affect freight rates?
- Are freight rates for aid shipments, either for U.S.-flagged vessels under cargo preference or foreign-flagged vessels, affected by commercial freight rates?

Summary of Findings

This research estimated reduced form equations for nominal freight rates as a function of many variables. The results indicate rates for U.S.-flagged carriers were higher than for non-U.S.-flagged carriers. Variables indicating the NGO entity in charge of the aid shipment were all positive, which suggests these entities paid more for freight. Lastly, indicator variables for each carrier were important for determining freight rates. Some drove rates higher; others were lower.

In a model that separated U.S.-flagged shipments and foreign-flagged shipments, the authors tested whether the commercial freight rate was an important determinant. In the estimation looking at foreign-flagged shipments only, the commercial freight rate was important. However, this variable was not an important determinant for U.S.-flagged freight rates. The authors suggest that this shows U.S.-flagged carriers were insulated from market forces and, as a result, charged higher rates, regardless of existing market pressure.

Citation

Mercier, S., and V. Smith. 2020. "Cargo Preference and U.S. International Food Aid Programs," *Applied Economic Perspectives and Policy* 42(4):759-776.

FACTORS INFLUENCING GULF AND PACIFIC NORTHWEST SOYBEAN EXPORT BASIS: AN EXPLORATORY STATISTICAL ANALYSIS

Main Results

- Average basis in soybean export markets is driven mostly by international and domestic competitive forces. Transportation variables (e.g., rail rates) are less important.
- Basis seasonality is not consistent across marketing years. Additionally, each export market (the U.S. Gulf and Pacific Northwest) is influenced by factors in different ways and to different degrees.
- Factors that influence seasonality for both export markets include logistics variables and location-specific export level indicators.

Background and Motivation

Basis—the difference between the local cash price and the futures prices—for agricultural commodities at export markets is typically volatile. Most agricultural commodity basis research has focused on origin or delivery markets. The use of seasonal analogs to assess price volatility was rather new. The use of seasonal analogs allows marketing years to be grouped similarly based on within-year changes in basis. This grouping provided additional observations to be used when analyzing within-year basis changes. An improved understanding of volatility in soybean export markets has implications for risk management, trading, transportation, and storage activities of the primary market participants (farmers, elevators, exporters, and carriers); the United States and Brazil as leading producers; and China as the world's largest buyer.

Study Scope and Dimensions

- Period: Marketing years 2004/05 - 2015/16.
- Geography: U.S. Gulf and Pacific Northwest (PNW) port soybean basis values. Other data include U.S. national average variables (e.g., U.S. soybean oil price) and international variables (e.g., Brazil basis).
- Empirical method(s): Partial-least-squares (PLS) regression to analyze basis across marketing year averages, clustering to create seasonal analogs, and statistical tests to analyze seasonality across analog years.

Objectives

- Analyze effects of market and logistical (shipping and storage) variables on marketing-year (MY) average basis, as well as on seasonality, at the two primary U.S. soybean export markets—the Gulf and PNW—from MY 2004/05 to MY 2015/16.⁴
- Test relationships between the export bases in these two locations and a set of 27 explanatory variables (pared down using cross-validation methods) via PLS regression.

Summary of Findings

There were many significant explanatory variables in both MY models, as well as the seasonal analog models. The MY average basis was primarily driven by supply-and-demand competitive pressures both domestically (i.e., futures spreads and U.S. soybean meal price) and internationally (i.e., export basis in Brazil). These findings were consistent across both export locations, but the degree of influence for most variables were higher for PNW basis. The authors suggest the higher degree of influence for PNW basis may support the idea that PNW basis levels are more volatile.

Seasonality in both markets was not consistent across marketing years but can be captured by seasonal analogs. These seasonal analog patterns were primarily driven by market-specific factors, such as the level of export activity; pace of marketing activity during the marketing year; and logistical conditions. The impact of these factors changed

⁴ Seasonality is dissected using an agglomerative hierarchal clustering to group marketing years by common seasonal patterns, called seasonal analogs—a new application of analogs.

across the seasonal analogs and ports. However, the analysis did not determine in what direction these variables influenced basis. Instead, these variables were found to be significantly higher or lower for a given seasonal analog. For example, the number of railcars placed was significantly lower than average for one analog year, but significantly higher in another analog year.

Results also reflect the market conditions of the study period (which preceded the U.S.-China trade war). The analytical methods employed are novel applications in the body of agricultural marketing literature. Categorizing seasonality as analogs contributes a unique model for determining factors impacting these characteristics.

Citation

Bullock, D.W., and W.W. Wilson. 2020. "Factors Influencing Gulf and Pacific Northwest Soybean Export Basis: An Exploratory Statistical Analysis," *Journal of Agricultural and Resource Economics* 45(2):317-334.



SECTION IV

TRUCK TRANSPORTATION RESEARCH



FOOD AND AGRICULTURAL TRANSPORTATION CHALLENGES AMID THE COVID-19 PANDEMIC

Main Results

- Human resources (e.g., truck drivers, warehouse workers, logistics managers, farmworkers, etc.) have been the largest risk to the U.S. food supply chain and business operations.
- The agriculture, food, and transportation sectors experienced a range of logistical challenges, including sharp changes in consumer demand for grocery store versus restaurant products and worker absenteeism.
- Labor shortages were more acute in the processing industries (e.g., meatpacking) than trucking.

Background and Motivation

Social distancing to curb the COVID-19 pandemic significantly affected people's behavior and movement, which affected consumer demand for goods. In the food sector, the pandemic also affected the supply chain, including (among their logistical challenges) the ability of some supply-chain workers to do their jobs. On March 19, 2020, the U.S. Department of Homeland Security classified food, agriculture, and transportation systems sectors as "critical infrastructure" during the pandemic. This study explored critical issues, such as the availability and accessibility of food and logistical challenges induced by the pandemic.

Study Scope and Dimensions

- Period: 2020.
- Geography: United States.
- Empirical method(s): Summary statistics and interviews with industry participants.

Objective

- Explore the challenges imposed by the COVID-19 pandemic on the U.S. food supply chain with a focus on food transportation.

Summary of Findings

The study found that the unprecedented disruptions of COVID-19 dramatically affected the demand and supply of food resources. The consumption of food at restaurants and other foodservice providers declined sharply in a matter of weeks and months. Industries with high concentrations of labor in shared work spaces, such as meat packing, were severely affected by labor shortages. Safety regulations and restricted movements reduced the efficiency of firms and increased the cost of production.

In Florida, shipments of cherry tomatoes declined by 50 percent, and those of grape tomatoes declined by 47 percent, from March-April 2019 to March-April 2020. The flexibility of the trucking industry was vital to the emergency relief response and distribution of necessary supplies. Vehicles and drivers involved in delivering emergency relief provisions were exempted from transportation safety regulations. The researchers find no shortage of drivers in the trucking sector during this time. However, there was disruption in normal trucking patterns and activity.

Citation

Walters, L., Wade, T., and S. Suttles. 2020. "Food and Agricultural Transportation Challenges Amid the COVID-19 Pandemic," *Choices* 35(3).

NORTHERN PLAINS GRAIN FARM TRUCK MARKETING PATTERNS

Main Results

- Truck marketing patterns differed among States, crops, and farm sizes.
- Most (66 percent) of the 2013 soybean crop was brought to market at harvest, compared to about one-third for wheat and corn.
- Market timing varied by State. For example, South Dakota farmers delivered almost half of their wheat crop at harvest, compared to one-third for other States.

Background and Motivation

Farm trucks in the Northern plains are an essential component of the grain marketing sector. These trucks are responsible for short-haul movement of grains or as a connecting link to other modes of transportation.

Little information about marketing grain in the northern plains by truck was available. A detailed study of marketing patterns for grain farm trucks was necessary to devise effective transportation policies in areas of significant grain production.

Study Scope and Dimensions

- Period: 2013/14 marketing year, as surveyed in the summer of 2014.
- Geography: Northern Plains of the United States, including parts of Minnesota, Montana, North Dakota, and South Dakota.
- Empirical method(s): Survey of 6,000 farmers.

Objectives

- Understand farm truck movement patterns and trends in grain transportation.
- Identify grain marketing patterns in Northern Plains.

Summary of Findings

The researchers collected data on grain transportation and on-farm storage capacity by surveying 6,000 farm operators in the Northern Plains region about their crop practices in 2013. The study finds substantial differences in farm markets across States. The farms either short-hauled their grains to on-farm storage or long-hauled them to an elevator, feedlot, or processing facilities. Farm trucks covered an estimated 900 million ton-miles in moving grain from field to market delivery points. Marketing patterns varied by crop, crop producing region, and farm size.

On-farm storage allows producers to delay grain deliveries beyond the harvest season. Average on-farm storage capacity was highest in South Dakota and lowest in Montana. Across States, farms with more acres had significantly greater storage capacity volume than those with fewer acres. For example, farms with 300 acres or fewer had an average of 26,000 bushels of on-farm storage capacity, while farms with 1,501 acres or more had an average of 329,000 bushels of on-farm storage capacity. However, as the researcher points out, small farms may have been able to cope better with sudden additional demand for storage capacity because their storage covered a larger share of their production.

Timing for crop delivery varied with the size of the farms. Large farms tended to deliver a smaller share of their produce directly to market at harvest. The average share of the crop delivered directly to market from field at harvest was highest for soybeans at 66 percent, followed by wheat at 36 percent, and corn at 32 percent. South Dakota farmers delivered half of their wheat production to market at harvest, versus other States' farmers, which delivered from 31 to 36 percent. Of corn, roughly a third was immediately marketed at harvest (ranging from 32 to 39 percent). Of soybeans, the average share delivered directly to market at harvest was 66 percent—substantially higher than the marketing rates for wheat and corn.

In terms of buyers, elevators received about 79 percent of wheat and soybean production and 54 percent of corn production. Corn had a more diverse buyer set. A large proportion was sold directly to feed lots (4 percent) or used by farmers as feed on their own operations (10 percent). These were not significant uses for wheat or soybeans. Eleven percent of corn was sold directly to processors, the highest percentage for these three commodities.

The authors anticipate that the demand for truck transportation will change as grain production continues to increase (which would expand volumes hauled) and the industry continues to consolidate (which would likely increase shipment distances between farms and markets).

Citation

Vachal, K. 2015. "Northern Plains Grain Farm Truck Marketing Patterns," *Journal of the Transportation Research Forum* 54(3):85-98.



SECTION V
U.S. RAIL
TRANSPORTATION RESEARCH



AGRICULTURAL TRANSPORTATION BY RAIL: CONSOLIDATION, COMPETITION, AND FUEL PRICES

Main Results

- The U.S. rail industry structure changed dramatically after the Staggers Act of 1980—including major consolidation, line abandonment, and significant rate changes.
- These changes may have resulted in competition issues that increase rates, but the size of this issue may be small.

Background and Motivation

The U.S. rail industry has undergone significant changes since the Staggers Rail Act of 1980, which partially deregulated the industry. Major mergers, line abandonments, and rate changes all resulted from the reform. The result of these industry changes may create cost savings for shippers and carriers, reduce service for shippers, and/or reduce competition in the rail industry.

In the United States, the volume of agricultural products shipped by rail increased between 1990 and 2013. During that time, corn, wheat, soybeans, barley, and sorghum were the major agricultural commodities shipped and accounted for over 90 percent of annual farm product tonnages shipped by rail.

Because rail is a critical transportation mode for agricultural products, the study of the impact of the changes in the rail industry on transportation of agricultural commodities is significant. Additionally, more recent changes in the industry (e.g., fuel price increases) warranted an updated review.

Study Scope and Dimensions

- Period: 1980 - 2013.
- Geography: United States.
- Empirical method(s): Descriptive analysis covering rail volume, revenue, market concentration, rail rates, and other aspects of the rail industry.

Objectives

- Explore major issues related to agricultural shipments by rail.
- Identify various structural changes in rail industry and their impact on pricing behavior.

Summary of Findings

The Staggers Act of 1980 had a significant impact on the structure of the rail industry. Between 1990 and 2013, the number of Class I carriers decreased from 14 to 7. In the same period, track miles operated by Class I carriers fell from 168,838 miles to 120,658 miles. The miles of road and revenue ton-miles *per firm* increased as firms grew larger.

The authors measured rail competition in two ways. First, the authors find a reduction in the number of counties with competing Class I carrier service; that is, 14 percent of counties lost a competing Class I rail carrier between 1990 and 2013. Second, the authors show that Herfindahl indices (a market power index)⁵ for the railroad industry increased dramatically between the 1980s and early 2010s—from a little under 0.2 to over 0.4—indicating that the industry became much more concentrated.

5 The Herfindahl Index or Herfindahl-Hirschmann Index (HHI) is a measure of market concentration ranging from 0 to 1 with higher numbers indicating more concentration in an industry. It is calculated by squaring each industry participant's market share and then adding these squared shares together.

The authors obtain rail rates between 1990 and 2013 for corn, soybean, and wheat shipments. Rail rates declined from 1990 until the mid-2000s due to efficiency gains. However, rates then increased after this period, consistent with higher fuel costs.

The authors isolate the effect of competition on rail rates by controlling for numerous shipment characteristics, such as shipment size and length of haul. They find that rates are approximately 2 to 3.5 percent higher for counties with one Class I carrier and about 3 to 7 percent higher for counties with no Class I service, relative to counties with access to two or more Class I carriers. These findings do suggest that lack of competition may have been an issue; however, the size of the problem may have been small.

Citation

Henrickson, K.E., and W.W. Wilson. 2015. "Agricultural Transportation by Rail: Consolidation, Competition, and Fuel Prices," *Choices* 30(3).

ANALYTICAL MODELS OF RAIL TRANSPORTATION SERVICE IN THE GRAIN SUPPLY CHAIN: DECONSTRUCTING THE OPERATIONAL AND ECONOMIC ADVANTAGES OF SHUTTLE TRAIN SERVICE

Main Results

- The combination of large terminal elevator facilities and shuttle service were found to reduce costs, increase speed, and increase rail capacity compared to traditional grain supply systems.
- By three measures of efficiency (time, cost, and capacity), the shuttle train service enhances U.S. competitiveness on the global market.

Background and Motivation

U.S. grain production costs exceed those of South American competitors, but transportation is more efficient. One way railroads increase efficiency is by moving more cars on a single train. Railroads used to consolidate single- and multi-car shipments in classification yards. Recent developments that have increased transportation efficiency include shuttle train service and larger grain storage facilities. Shuttle train service directly assembles and moves 100+ rail cars of bulk commodities (e.g., coal or grain) from their origins to their destinations, bypassing intermediary classification yards. Larger terminal elevators have facilitated this type of service in the grain supply chain.

Study Scope and Dimensions

- Period: Circa 2010-15.
- Geography: Upper Midwest in the United States.
- Empirical method(s): Mathematical simulation models of grain shuttle and non-grain shuttle grain handling and transportation systems.

Objective

- Assess the costs of changes at the grain elevator level (e.g., longer trucking distances and off-loading times) and the benefits of increased efficiency within the grain supply system at the rail-level from the use of shuttle train service.

Summary of Findings

Three models were used to study the impacts of changing the rail transportation structure in the grain industry: time, cost, and capacity models. The time model measured the time it took for a ton of grain to move from a farm to the export terminal. It measured this time in three subcomponents: (1) the time from farm to elevator, (2) the storage time at the elevator, and (3) the time in rail transit to the export terminal. This model indicates that when rail transport demand was greater than 350 tons per day, rail shuttle service moved grain more efficiently than non-shuttle rail service.

The cost model measured variable engineering costs associated with moving grain from a farm to the export terminal. It included estimates for the following: (1) trucking costs, (2) elevator handling and storage costs, and (3) rail transportation costs. The costs associated with shuttle train service (\$/ton) were lower at all levels of demand per day than were costs for the non-shuttle rail service system.

While capacity can be defined several ways, the authors used a “throughput” perspective. Throughput measures the quantity of goods serviced per unit of time. The capacity model estimated the impact of shuttle service on throughput for the rail system. This model finds that shuttle service provided significant capacity advantages to the rail system by allowing shuttle trains to bypass classification yards.

Citation

Hyland M.F., H.S. Mahmassani, and L.B. Mjahed. 2016. “Analytical Models of Rail Transportation Service in the Grain Supply Chain: Deconstructing the Operational and Economic Advantages of Shuttle Train Service,” *Transportation Research Part E* 93:294-315.

GRAIN FREIGHT ELEVATOR CONSOLIDATION, TRANSPORTATION DEMAND, AND THE GROWTH OF SHUTTLE FACILITIES

Main Results

- Shuttle elevators used more rail transportation than non-shuttle elevators and depended more on rail transportation than non-shuttle elevators.
- Shippers using shuttle service saved an average of 24 percent per year in total transportation costs during the study period (2006-13).

Background and Motivation

Grain elevators and effective transportation help make U.S. grain producers and elevators competitive on the world market. Consolidation in the grain supply system has led to the creation of shuttle elevators and more streamlined transportation (e.g., shuttle rail service). Shuttle elevators typically have 1.5 miles of track, 12,000-ton capacity, and the ability to hold, load, and unload 100 or more cars in 24 hours. Rail carriers provide incentives to use these facilities.

The number of shuttle elevators increased during the 2006-13 study period. Other studies have found that shuttle elevator technology reduced rail rates observed in the market. Additionally, previous research has found that shuttle elevators have reduced costs for elevators.

Study Scope and Dimensions

- Period: 2006 - 2013.
- Geography: Northern Plains in the United States.
- Empirical method(s): A derived demand model using observed modal choices. It uses seemingly unrelated regression to estimate a total cost function.

Objective

- Explore the difference between shuttle and non-shuttle elevator transport demand.

Summary of Findings

Rail rates, truck rates, the distance from the elevator to the delivery point, and classification as a shuttle facility were significant in explaining transportation costs for elevators in the study. The authors find that elevators with a shuttle loader had 15 percent lower transportation costs than elevators without a shuttle loader.

Rail's factor share was 95 percent for shuttle elevators, but only 72 percent for non-shuttle elevators. Shippers and rail operators both viewed shuttle grain supply as efficient and favorable to conventional methods. Additionally, the advantage of shuttle service did not appear to diminish across the study period. Results were consistent with the idea that shuttle shippers received better service and viewed this option more favorably after adoption.

Citation

Ndembe, E., and J. Bitzan. 2018. "Grain freight elevator consolidation, transportation demand, and the growth of shuttle facilities," *Research in Transportation Economics, Journal of the Transportation Research Forum* 71:54-60.

HARD RED SPRING WHEAT MARKETING: EFFECTS OF INCREASED SHUTTLE TRAIN MOVEMENTS ON RAILROAD PRICING IN THE NORTHERN PLAINS

Main Results

- Shuttle trains were found to have significant influence for reducing rail freight rates.
- Intermodal competition (i.e., a truck-to-barge combination) exerted downward pressure on rail rates.

Background and Motivation

In the Northern Plains, marketing hard red spring wheat (HRSW) relies heavily on railroads. Between 1999 and 2012, about 93 percent (62.3 million tons) of all HRSW was shipped by rail. Thus, the price received by producers was significantly influenced by rail rates, as rail was the dominant mode of shipment.

Since deregulation in 1980, railroads experienced different evolutionary changes that reduced the cost of transportation. One innovation to reduce costs was the introduction of shuttle trains (trainsets of 110 covered hopper cars) introduced by Burlington Northern in the 1990s. In 2010, more than half (51 percent) of the total U.S grain and oilseeds were moved using shuttle trains.

Shippers took advantage of economies of size⁶ by adopting shuttle trains. Some of the cost savings were potentially passed back to shippers and farmers in the form of reduced rail rates. The research examines the impact of the shuttle trains on railroad pricing behavior during the 2000s. Furthermore, it assesses the value added by railroad for moving grain long distances from rural areas during this time, making this research relevant for public policy.

Study Scope and Dimensions

- Period: 1999 - 2012.
- Geography: North Dakota.
- Empirical method(s): Ordinary least squares regression.

Objectives

- Study the impact of shuttle trains on rail rates.
- Examine the relative benefit of using shuttle trains as compared to other rail movement types (single, multi-car, and unit trains).

Summary of Findings

The authors analyze North Dakota grain movement data (1999 to 2012) and rail rates per ton-mile. The study finds that rail rates per ton-mile decreased with the length of haul. In addition, more cars per train reduced the rail rate per ton-mile. If the distance from a barge loading facility increased by 1 percent, then the rail rate per ton-mile increased by 0.087 percent. The trend of rail rates was negative, implying that rail rates had declined over time.

The results also indicate that rates varied seasonally and across different areas in the region under study. The authors suggest that shuttle trains had a comparative rate advantage over other rail types. The rate per ton-mile decreased by 0.070 percent for a 1-percent increase in shuttle service. Overall, shuttle trains likely contributed to the reduction in rail rates over time and benefited shippers and farmers through lower rates.

Citation

Ndembe, E. 2015. "Hard Red Spring Wheat Marketing: Effects of Increased Shuttle Train Movements on Railroad Pricing in the Northern Plains," *Journal of the Transportation Research Forum* 54(2):101-115.

⁶ Economies of size or scale occur when average costs per unit decline as more units are produced.

INTRARAILROAD AND INTERMODAL COMPETITION IMPACTS ON RAILROAD WHEAT RATES

Main Results

- Railroad wheat rates were inversely related to the distance from origin to destination and the total shipment weight.
- As the distance from origin to the nearest barge-loading location increased, railroad wheat rates increased.
- The degree of intrarailroad competition varied by State and was present across most crop-reporting districts, though the relationship was not statistically significant in the model.

Background and Motivation

In 2013, about 51 percent of all wheat shipments were transported by railroads, which indicates the wheat industry's dependence on rail transportation. These railroads moved bulk volumes of agricultural commodities over long distances. In 1980, the Staggers Rail Act deregulated the rail industry. As a result, the industry underwent significant changes, which included the mergers of different Class I railroads and the abandoning or leasing of rural-area branch lines to short line railroads.

Most major wheat-producing States (9 out of the top 10) were more than 150 miles from barge transportation to move grains over long distances to domestic processors and export ports. Where shippers had ready access to inland waterways, barge transportation posed significant intermodal competition to railroads' pricing behavior.

In each major wheat-producing State, local and regional railways acted as bridge carriers for Class I railroads and induced some intrarailroad competition. Most major wheat-producing States (except Idaho, Montana, North Dakota) were served by a Class I duopoly of roughly similar-size firms. As a result, the degree of intrarailroad competition varied among States and potentially within States. Thus, the study of how intrarailroad and intermodal competition affects the railroads' pricing behavior is relevant to producers, shippers, railroads, and policy makers.

Study Scope and Dimensions

- Period: 2012.
- Geography: 9 major wheat-producing states in the U.S. (Idaho, Kansas, Minnesota, Montana, North Dakota, Oklahoma, South Dakota, Texas, and Washington).
- Empirical method(s): Descriptive analysis with ordinary least squares regression.

Objectives

- Determine the impact of intermodal competition on railroad wheat rates.
- Identify and measure the major cost factors of railroad wheat rates.
- Examine whether there is intramodal competition within States.

Summary of Findings

The research finds that increasing the distance of the shipment from origin to destination and increasing the total shipment weight had the effect of reducing rail wheat rates on a per ton-mile basis. As the shipment distance and weight increased, the costs accruing to the railroad declined per ton-mile, which led to lower rail rates. As distance to barge transportation increased, upward pressure on rail rates increased. Barge transportation was cheaper than rail freight, so access to nearby barge transportation reduced the rail rate of a location relative to a location further away from barge freight service. Most major wheat-producing States were served by at least two Class I railroads, indicating the presence of intrarailroad competition. The measure of industry concentration indicates significant intrarailroad competition within States. Competition among rail carriers (or lack thereof) had no statistically significant effect in determining rail rates for wheat in 2012.

Citation

Babcock, M.W., and B. Atems. 2015. "Intrarailroad and Intermodal Competition Impacts on Railroad Wheat Rates," *Journal of the Transportation Research Forum* 54(3):61-84.

A METHOD FOR PROCESSING THE CONFIDENTIAL CARLOAD WAYBILL SAMPLE FOR RAILROAD FREIGHT ANALYSIS

Main Results

- The Oak Ridge National Lab (ORNL) outlined a process to obtain spatial insights from the Surface Transportation Board's (STB) confidential Carload Waybill Sample (CWS) data.
- The researchers find several challenges in the availability and usability of CWS data, such as its small sample size and delayed release.

Background and Motivation

The STB requires railroad companies moving at least a moderate amount of freight to provide information on a sample of their waybills (shipment records). A waybill is a document prepared from a shipment's bill of lading and contains information describing the shipment, such as volumes, routing characteristics, revenues, and fees. Each year, STB's CWS compiles a sample of waybills representing roughly 1 to 3 percent of all traffic moved by rail and containing about 500,000 to 700,00 records. The CWS is the principal source of data about freight rail shipments. Data reflecting a given calendar year are not released until the following year.

While the CWS contains some spatial information (e.g., the origin, destination, etc.), it is not immediately consumable in a visual (map) form. ORNL developed and outlined a way to process the CWS for use in spatial visualizations. To do so, ORNL connected the CWS to its rail network data. The ORNL rail network dataset spans 143,000 miles and includes 94,000 links and 45,000 nodes.

Objective

- Outline a process to extract, clean, and organize the CWS data in a way that it can be assigned to a rail network for visualization using geographic information system (GIS) applications and further analysis.

Summary of Findings

A process was developed to first convert raw waybill data into a database that mapped to the ORNL network using several steps. These included data conversion, extraction, and cleaning steps. The final output of this process was a final comma separated value (csv) file that a GIS program can use.

The authors had to overcome several challenges. The junction information in waybills was not always realistic and did not always correspond to precise interchange activity. Railroads were not consistent in reporting methods for creating waybills. Accurate routes (origins, destinations, and junctions) were difficult to determine when crossing the U.S.-Canadian border multiple times.

Citation

Fialkoff, M.R., K.L. Hancock, and S.K. Peterson. 2018. "A Method for Processing the Confidential Waybill Sample for Railroad Freight Analysis," *Research in Transportation Economics, Journal of the Transportation Research Forum* 71:34-43.

MODERNIZING U.S. FREIGHT RAIL REGULATION

Main Results

In their summary of a landmark study by the Transportation Research Board (TRB), Schmalensee and Wilson highlight several recommendations made by TRB to Congress:

- Direct the Surface Transportation Board (STB) to develop, test, and refine competitive rate benchmarking methods.⁷
- Remove the rate reasonableness process currently in place and institute final offer arbitration in contested rate cases.
- Allow reciprocal switching as a remedy for unreasonable rates.⁸
- Transfer review of mergers and acquisitions to traditional antitrust regulators.
- Perform a strategic review of STB data collection, allowing for improved pricing schemes and period reviews/analysis of the industry.

Background and Motivation

The U.S. railroad industry was first regulated in 1887 by the Interstate Commerce Act. This legislation was designed to stabilize prices. By the 1970s, the railroad industry was in financial distress, and Congress passed three acts to support the industry without nationalization—the 3-R Act (1973), the 4-R Act (1976), and the Staggers Rail Act (1980) (Staggers). The most impactful of these acts, Staggers, aimed to place greater reliance on market-based rates, reduce regulatory control, and protect shippers against unreasonable rates.

Objective

- Summarize and discuss a congressionally ordered and funded study undertaken by the TRB (one of seven major divisions of the National Academies of Sciences, Engineering, and Medicine) on trends in the railroad industry and current regulatory landscape.

Summary of Findings

Staggers allowed for pricing innovations, use of larger rail cars, consolidation of traffic, and other efficiency gains. Staggers also facilitated railroad consolidation, allowing economies of density to be realized. While Class I rail line mileage has decreased over the past 40 years, ton-miles of traffic have increased.

Staggers allowed railroads greater freedom to set rates. At the same time, it provided protections to shippers using common carrier (public tariff/non-contract) service, allowing them to challenge the reasonableness of a rate under certain conditions. Namely, to challenge a rate, a shipper must show that: (1) the market lacks effective competition (that is, the railroad has “market dominance”), and (2) the shipment’s revenue exceeds its variable cost by 180 percent. STB measures variable costs through the Uniform Rail Costing System (URCS). However, the authors point out that URCS is inherently flawed—there is no unarbitrary way to allocate common costs to obtain the true variable cost of the shipment. To address the issue, the authors recommend abandoning URCS and implementing competitive benchmarking methods to identify unreasonable rates.

Staggers reinforced revenue adequacy standards for the industry and facilitated merging of railroads. As a result, 40 Class I Railroads in 1980 were consolidated to 7 by 2016.

Citation

Schmalensee, R.L., and W.W. Wilson. 2016. “Modernizing U.S. Freight Rail Regulation,” *Review of Industrial Organization* 49:133-159.

Other Helpful Resources

National Academies of Sciences, Engineering, and Medicine. 2015. *Modernizing Freight Rail Regulation*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/21759>.

7 At the time of the study, STB was under the U.S. Department of Transportation.

8 Reciprocal switching occurs when an incumbent railroad transports a shipper’s traffic to an interchange point, where it switches the cars over to a competing railroad. The competing railroad pays the incumbent railroad a switching fee for bringing or taking the cars from the shipper’s facility to the interchange point, or vice versa, which is incorporated into the competing carrier’s total rate to the shipper. As of 2021, this practice is not common in the United States.

SECONDARY RAIL CAR MARKETS FOR GRAIN TRANSPORTATION AND BASIS VALUES

Main Results

- Soybean exports' basis in the Pacific Northwest (PNW) and secondary-market daily rail car values (DCVs) were determined simultaneously. If the PNW basis increased, secondary-market rail car values increased (and vice versa).
- Other exogenous variables were significant, including rail velocity, the pace of farmer marketing, futures spreads, and ships due at the Gulf port in 10 days.

Background and Motivation

The influence of shipping costs is frequently ignored in market analyses, but volatility in the markets for rail cars escalates risk for shippers. Deregulation of the railroads facilitated the development of primary and secondary rail car markets. Additionally, previous research has treated rail costs as an independent variable that can shock basis values. However, theory and practice suggest this may not be the case.

Study Scope and Dimensions

- Period: January 2004 - December 2016.
- Geography: PNW soybean export market.
- Empirical method(s): The authors used a full-information maximum-likelihood estimation because simultaneity was found to be an issue when estimating regression equation.

Objectives

- Estimate the determinants of and relationship between the PNW export basis for soybeans and rail car values in the secondary market and evaluate whether these values were simultaneously determined.

Summary of Findings

PNW soybean basis values and DCVs were determined simultaneously, suggesting freight and commodity markets were interdependent. If the PNW basis increased, secondary market DCVs increased (and vice versa). Notably, basis and DCVs did not adjust immediately to new market conditions. Previous basis values and previous rail car values affected current levels for these variables, which facilitated trading opportunities. Velocity (train speeds) significantly affected DCVs. As velocity increased, DCVs declined. Because the PNW basis was simultaneously determined, the PNW basis also decreased with increased velocity. Additionally, there were seasonal affects across most variables. For commodity shippers and traders, it is important to link trading and shipping functions when making decisions.

Citation

Wilson, W., and P. Lakkakula. Forthcoming. "Secondary Rail Car Markets for Grain Transportation and Basis Values," *Agribusiness: An International Journal*.



SECTION VI CANADIAN RAIL TRANSPORTATION RESEARCH



GRAIN HANDLING AND TRANSPORTATION POLICY IN CANADA: IMPLICATIONS FOR THE UNITED STATES

Main Results

- Provision of extended interswitching increased the degree of competition in Canadian railways.
- New regulatory oversight in Canada might be required to curb the grain companies' market power.

Background and Motivation

The Canadian grain handling and transportation system was in the midst of a major overhaul as the Canadian Wheat Board (CWB) ceased to exist in 2012 and rail regulations changed. The grain handling portion of this system was relatively concentrated, with just three grain companies handling 75 percent of grain exports. The transportation component of this system was also concentrated, with only two Class I Canadian railways in existence.

Large grain crops in marketing year (MY) 2013/14 combined with rail transportation issues to create a “perfect storm” of difficulties for the Canadian grain handling and transportation system. Moreover, it appeared that Canadian farmers bore the brunt of these issues, receiving very low grain prices. As a result of the ensuing bottlenecks, delays, and service problems, new rail regulations were implemented.

Study Scope and Dimensions

- Period: Circa 2000-14.
- Geography: Canada.
- Empirical method(s): Descriptive statistics and interswitching model using a geographic information system (GIS).

Objective

- Discuss Canadian rail regulation changes and how they might potentially apply to U.S. policymaking.

Summary of Findings

The main rail regulatory tool in Canada was the “maximum revenue entitlement” or a revenue cap on grain shipments. In this regulatory regime, each Class I carrier in Canada was entitled to a set amount of revenue from grain shipments each year. Initially suggested by rail companies in the late 1990s, farmers came to like the policy as rail rates stabilized. Rates declined in the early 2000s, likely from cost savings, but these rates have since increased.

An alternative tool, extended (reciprocal) interswitching, allows shippers to seek out alternative rail carriers within a specified radius of their location if they are restricted to just one local carrier. In 2014, legislation increased the range for an allowable interswitch from 30 kilometers (about 18 miles) to about 160 kilometers (about 100 miles) in the Western provinces. The authors posit this increase encouraged more inter-rail competition and generated more competitive freight rates. They estimate that the increased interswitching limit of 160 miles saved grain shippers between C\$15 (Canadian dollars) and C\$18 million in freight costs and covered approximately 70 percent of all grain elevators across the Canadian Prairies. The authors suggest that a similar reciprocal interswitching policy in the United States with a 50-mile limit could cover 75 percent of non-livestock farms in the Northern Plains.

As a result of the bumper crop in MY 2013/14 and the transportation issues, price differentials between port and on-farm prices were 200-300 percent wider than normal. The authors point to a study estimating that Canadian farmers lost C\$2 billion to C\$3 billion. With the revenue cap in place, the rail companies were unlikely to capture the wide spread (the differential between port prices and interior farm prices) that occurred that year. As a result, grain-handling companies were likely the beneficiaries. With the end of the CWB, consolidation may occur in the grain-handling sector to leverage economies of scale. Accordingly, policy makers should be cognizant of two industries (railroads and grain handlers) with market power in the grain-handling and transportation sectors.

Citation

Nolan, J.F. and S. Peterson. 2015. “Grain handling and transportation policy in Canada: Implications for the United States,” *Choices* 30(3).

SIMULATING CONTESTABILITY IN FREIGHT TRANSPORTATION

Main Results

According to a simulation model of the grain supply chain in Western Canada, the researchers find:

- A majority of grain shipment delays would occur at smaller and less centrally located grain elevators.
- Railways would need to increase freight rates by 20 percent to improve service at these smaller, less centrally located elevators.
- Consolidation in the grain elevator system would improve efficiency and throughput.

Background and Motivation

The Canadian grain handling and transportation system (GHTS) is a good example of a modern, large-scale supply chain. There was considerable controversy over the revenue-based formula for regulating rail transportation for grain, and how these policies affected grain shippers and railways. A large majority of Western Canadian grain was exported through West Canadian ports (e.g., Vancouver, Thunder Bay, or Prince Rupert). Open- or competitive-access policies under study in this research allowed for use of existing infrastructure by competing railways for a fee.

Study Scope and Dimensions

- Period: 2006 (30-year simulation using data on wheat production back to 1977).
- Geography: Western Canada (Saskatchewan).
- Empirical method(s): Stylized agent-based simulation model, including farms, grain elevators, and railways as agents. The pricing mechanism from Carlson and Nolan (2005) was used to simulate a rail access charge. The simulation also estimated the potential profitability for a new rail carrier entrant to service Western Canadian grain marketers.

Objective

- Simulate the Western Canadian GHTS to assess open-rail access policy to mitigate market power.

Summary of Findings

The simulation projected that 1 million tons (of the 13 million tons transported annually) of wheat would be delayed by the lack of timely railway availability stemming from an open-access policy. These delays would not be spread evenly over the area of analysis (Saskatchewan)—there was a 94-percent chance delays would occur at smaller and more geographically isolated elevators. The Canadian GHTS system worked well for larger and centrally located elevators. However, an open-access policy may not benefit these smaller and more isolated elevators. Even under ideal conditions, an entrant would need to increase freight rates by 20 percent to remain profitable by moving wheat delayed under the existing railway setup. These findings suggest that consolidation in volume and location of the grain elevator system would likely improve efficiency and throughput.

Citation

Lawrence, R., J. Nolan, and R. Schoney. 2016. "Simulating Contestability in Freight Transportation: The Canadian Grain Handling and Transportation System," *Journal of Transport Economics and Policy* 50(4): 325-349.

Other Helpful Resources

Carlson, L. and J. Nolan. 2005. "Pricing Access to Rail Infrastructure," *Canadian Journal of Administrative Sciences* 22(1): 45-57.

BRINGING IN THE SHEAVES: CHANGES IN CANADA'S GRAIN SUPPLY CHAIN THROUGH THE POST CANADIAN WHEAT BOARD ERA

Main Results

- The study finds that the Canadian Wheat Board (CWB) possessed significant market power that counteracted the market power of grain companies and railroads.
- Deregulation of the grain handling system appears to have initially benefited grain companies more than the farmers.

Background and Motivation

In 2000-15, farmers, elevator companies, railways, and terminal port operators were the major participants in Canada's grain supply chain. Grain production in Canada was concentrated in the northern prairie region, which is remote from export terminals. As a result, railroads were the dominant modes of transportation for long haul movement of grain.

In June 2000, Bill C-34 changed railroad policy from direct rate regulation to a revenue regulation through a policy known as "maximum revenue entitlement (MRE)." MRE incentivized railway companies to focus on larger train movement of grains to minimize the cost of transportation. Some of the cost savings were likely passed back to farmers in the form of discounted rail rates.

The former CWB was the "single desk" marketer of Canadian grains. CWB managed publicly owned rail cars and grain movement by rail. The marketing board also conducted negotiations between grain companies and railways. When CWB was disbanded, the behavior of participants in the new competitive Canadian grain handling system changed significantly. This study examines the role of CWB in the CWB era, as well as the distribution of the benefits among supply-chain actors in the post-CWB era.

Study Scope and Dimensions

- Period: 2000-15.
- Geography: Western Canada.
- Empirical method(s): Shapley values, a game theory metric.

Objectives

- Evaluate the role of CWB to check market power exerted by both grain companies and railways in the Canadian grain supply chain.
- Measure the extent of welfare changes among supply chain participants in the post-CWB era.

Summary of Findings

Shapley values (a game theory construct estimating the contribution a single participant provides to the outcome) were computed using industry level cost and production data from 2000 to 2015 to help determine the degree of market power exerted by various participants in the supply chain. The study finds that CWB seemed to possess significant market power in the grain supply chain. In the post-CWB era, farmers initially appeared to have significant market power because of increased competition between grain companies and railways. But over time, this power may have shifted from producers to grain companies. This analysis also indicates that the MRE policy had mitigated railway market power. The MRE policy caused railway companies to adopt new mechanisms to improve the efficiency of their grain transportation logistics.

Citation

Brewin, D.G., J.F. Nolan, R.S. Gray, and T.G. Schmitz. 2017. "Bringing in the Sheaves: Changes in Canada's Grain Supply Chain Through the Post Canadian Wheat Board Era," *Journal of the Transportation Research Forum* 56 (3):75-90.

COMPETITIVE PRESSURE AND TECHNOLOGY ADOPTION: EVIDENCE FROM A POLICY REFORM IN WESTERN CANADA

Main Results

- Higher freight rates, which translated into lower farm gate prices, induced farmers to adopt newer and more efficient production technologies, such as zero tillage.
- Over the long term, farms experiencing greater transportation-cost increases used more fertilizer and implemented more land changes.
- Over the long term, increased transportation costs induced less wheat production and more canola production.

Background and Motivation

Competitive pressures encourage technology adoption. As industries become more competitive, prices decline and margins shrink. New technology reduces costs and helps preserve margins at levels that allow firms to survive. However, a lack of sufficient control groups, selection issues, endogeneity, and data collection present obstacles to empirically assessing these phenomena. That is, there is rarely a good benchmark for what would have happened without the competitive change. This study aims to address these issues.

The subsidized rail rate, known as the “Crow Rate,” was removed. Its removal increased the cost of exporting grain by roughly 8-17 percent. Most importantly, the effects of removing this subsidy varied geographically—impacting most the locations that are farthest from port. Holding all else constant, the researchers examined the impacts of the subsidy.

Study Scope and Dimensions

- Period: 1991, 1996, 2001, 2006.
- Geography: Western Canada (Alberta, Manitoba, and Saskatchewan).
- Empirical method(s): Difference-in-Difference with several robustness checks.

Objectives

- Examine the effect of the removal of a rail transportation subsidy in Canada on farm technology adoption.
- Estimate changes in the adoption of various technologies (zero till, minimum tillage, summer fallow, and fertilizer use), as well as changes in agricultural production decisions (e.g., planting wheat versus canola) as a function of change in freight rates. Analysis was done from 1991-2001 and varied across Canadian Census of Agriculture Consolidated Subdivisions, a rural precinct or district of sorts.

Summary of Findings

A number of explanatory variables were found to be significant across many model specifications. Adding weather controls to the models increased the significance of the variables of interest and improved model fit. Effects of the change in freight rate on technology adoption and production practices were estimated for the subsequent 5, 10, and 15 years after the change in rail policy. In the long term (15 years), this analysis indicated more use of zero till and fertilizer, and less use of minimum tillage and fallow ground. Regarding production practices, the analysis suggests less wheat and more canola is expected to be grown in the long term.

Citation

Ferguson, S.M., and M.R. Olfert. 2015. “Competitive Pressure and Technology Adoption: Evidence from a Policy Reform in Western Canada,” *American Journal of Agricultural Economics* 98(2):422-446.